CHAPTER 8

Adopt Fast, Adapt Quick: Adaptive Approaches in the South African Context

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The Fourth Industrial Revolution (4IR): New Data Resources

We live in a world where resources are becoming scarce while human needs continue to increase. According to Arthur O'Sullivan, Steven Sheffrin, and Stephen Perez,[1] the resources that humans utilize for production can be broadly classified into three types:

1. Natural resource: land, mineral, oil, natural gas, water, and so on.
2. Capital resource: machines, durable equipment, tools, infrastructure, buildings, and so on.
3. Human resource: physical labor, intellectual effort, knowledge, skills, experiences, leadership, entrepreneurship, and so on.

4IR unveiled artificial intelligence (AI), machine learning, robots, intelligent machines, 3D printing, bioscience technologies, Internet of Things

[1] O'Sullivan, Sheffrin, and Perez, *Macroeconomics: principles, applications, and tools* (New Jersey: Pearson Education, 2014).

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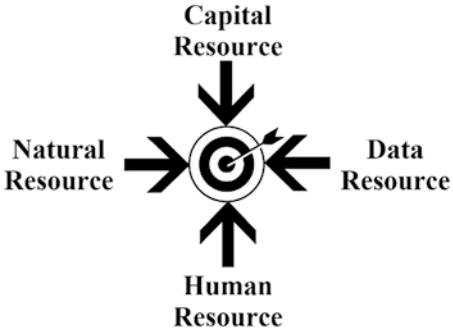

Fig. 8.1 New production resources: data

(IoT), and cyber-physical systems (CPSs). These developments are shaping a new data economy. As a new critical feedstock for this round of macro-economic developments (see Fig. 8.1), these data resources, though abundant and ubiquitous, constitute the 4IR inputs.

Approximately 100 gigabytes of data can be generated within a second of a self-driving car begining to operate. Some people refer to "Big Data" as "massive data." However, the most commonly used definition is called 3 Vs.[2] It was proposed by Doug Laney, a distinguished analyst at Gartner: Big Data is generally defined as "high volume, high velocity, and/or high variety information assets that require new forms of processing to enable enhanced decision making, insight discovery and process optimization."[3]

Without access to data and optimal use of it, machine learning and AI will not lead to new developments. Data are akin to raw material. They allow people to see beyond the digital world and pave the way to faster communications (e.g., customer-centered design), improved coordination mechanisms (e.g., smart logistics and smart factories), and innovative collaborations (e.g., new business and cooperation models across counties and continents).[4]

Companies have increased their capacity to analyze and make use of Big Data. For instance, Internet companies manage data that give them

[2] Ibar Yaqoob et al., "Big data: from beginning to future," *International Journal of Information Management* 36, no. 6 (2016): 1231–1247.

[3] "Big Data," Gartner, accessed January 10, 2018, https://www.gartner.com/it-glossary/big-data.

[4] Harvey Lewis et al., "Big data 2.0: new business strategies from Big Data," *Deloitte Review* 12, (2013): 1–17; James Manyika et al., *Big data: the next frontier for innovation, competition, and productivity* (New York: McKinsey Global Institute, 2011).

enormous power (e.g., Alphabet, Amazon, Apple, Facebook, and Microsoft),[5] while industrial and retailer giants collect data that make them more competitive (e.g., Siemens, GE, McDonald, and Tesla).[6] Data are said to be a driver of growth and transformation, the true invisible hand behind 4IR. It is emerging as a means for governments, private sectors, and organizations to improve accuracy and trustworthiness,[7] and it offers the hidden insights that have the potential to shape and influence the manufacturing, social, and service environments.[8] Therefore, harnessing the power of Big Data will determine enterprises' likelihood of success in the future.[9] Like previous sources of information, data are believed to promote neo-infrastructure, neo-businesses, neo-monopolies, neo-politics, and most importantly new economic models/systems. However, unlike earlier sources of information, data are extracted, mined, refined, assessed, purchased, and sold in distinct ways. In the 4IR age, property rights and use of data are likely to generate conflict.

The Fourth Industrial Revolution (4IR): Renewed Human Resource

Though the 4IR is staged to drive inclusive benefits, it could also challenge our society and hinder (social/socio-economics) development by replacing human capital with machines. The workforce, therefore, needs to have greater access to higher education and education of quality. Low-skilled work will become scarcer in the future as predictable tasks are replaced by machines. Both high-skilled and low-skilled workers need to be either retrained or educated differently. The fast advancement of various technologies has led to partial or full automation of many job positions. Although many of us worry about the possibility of a situation in which human labor is replaced by automation and 4IR technologies, it is also

[5] The Economist, "The world's most valuable resource," *The Economist*, May 6–12, 2017.

[6] Dominic Barton and David Court, "Making advanced analytics work for you," *Harvard Business Review* 90, no. 10 (2012): 78–83.

[7] IBM, *Understanding Big Data so you can act with confidence* (Somers: IBM Corporation, 2014).

[8] The Economist, "Fuel of the future," *The Economist*, May 6–12, 2017.

[9] Kazumasa Oguro, "Big data – key to the 4th industrial revolution," *Japan SPOTLIGHT*, (2016): 24–27; Lidong Wang and Guanghui Wang, "Big data in cyber-physical systems, digital manufacturing and industry 4.0," *International Journal of Engineering and Manufacturing* 4, (2016): 1–8.

important to recognize that job automation can be a positive change,[10] at least when:

1. Jobs are characterized by monotony and boredom: These kinds of jobs are typically based on a routine and demand more concentration than critical thinking (e.g., assembly line positions). Humans are prone to feeling dissatisfied when involved in monotonous and boring jobs, which could potentially result in absenteeism, high employee turnover, injuries, and health deterioration.
2. Jobs are full of unfavorable dangerousness: These jobs are common in sectors like manufacturing, mining, nuclear energy, and other heavy industries. Introducing automation could prevent unnecessary injuries and deaths while also increasing productivity.
3. Jobs involve simple-step transactions: Automatic teller machines (ATMs) are exemplar in this category, mainly because they operate 24/7. Similar advanced technologies could make simple-step transactions more efficient than when they are managed by conventional human operators.
4. Jobs that are unwanted by humans: It has become increasingly difficult to recruit qualified crew members willing to stay away from home for months while drifting at sea. When carrying non-perishable goods, autonomous cargo vessels are more convenient because they allow to save on accommodation expenses for the crew and remove the bulk of associated utilities (e.g., heating and plumbing).

With the above discussion as a backdrop, it becomes evident that investment in human capital is necessary for multiple purposes such as finalizing key decision making, problem solving, and process monitoring (e.g., onshore unmanned ship control room). Even in a fully automated working environment, humans are still indispensable. When new technologies are firstly introduced, humans are needed to finalize and coordinate implementation tasks. When systems are put into operation, people need to perform a set of non-straightforward maintenance duties. Humans also have the capacity to upgrade their skills by taking over the jobs when automation

[10] Jack Phillips and Patricia P. Phillips, *High-impact: human capital strategy: addressing the 12 major challenges today's organizations face* (New York: American Management Association, 2015); The Economist, "Technology quarterly: ghost ships," *The Economist Technology Quarterly* 410, no. 8877 (2014): 3–4; Pavel Tsvetkov, *Nuclear power – control, reliability and human factors* (Rijeka: InTech, 2011).

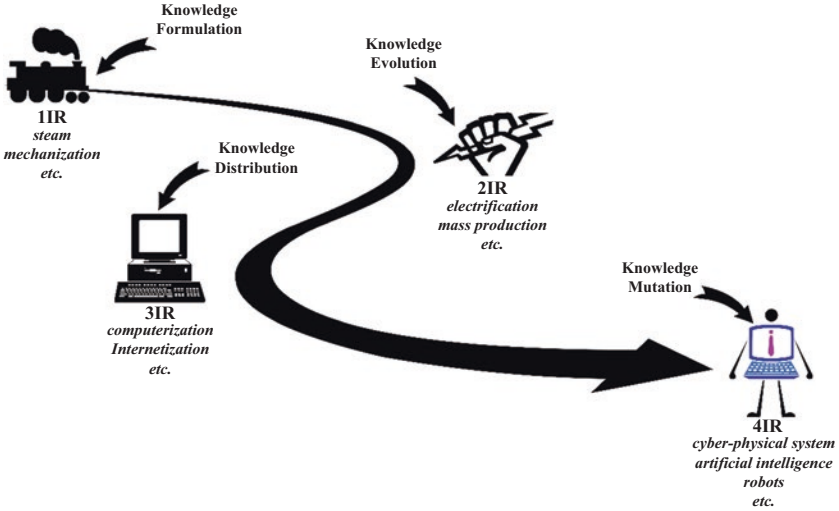

Fig. 8.2 4IR: Dissolving human and machine boundary

fails. This analysis can help us to reach the conclusion that human capital is not outdated in the era of 4IR, but it requires enhanced training.

From the first to third industrial revolutions, machines outperformed humans in terms of mechanical tasks. This led to a shift in the duties associated with human labor, from mechanical tasks to cognitive tasks in the service industry. 4IR technologies (see Fig. 8.2), with the advent of AI, are poised to outperform humans in cognitive tasks.

The current trend shows that AI-based algorithms for Big Data are becoming a substitute, in the workplace, for a wide range of non-routine cognitive tasks.[11] The computerization of jobs will leave a large proportion of human labor unemployed. Erik Brynjofsson and Andrew McAfee showed that there is a strong negative relationship between wages and educational attainment and the probability of computerization.[12] Future professionals will have to shift to new areas and types of work.

[11] Carl B. Frey and Michael A. Osborne, "The future of employment: how susceptible are jobs to computerisation?," September 17, 2013, https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

[12] Brynjofsson and McAfee, *Race against the machine: how the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming employment and the economy* (Lexington: Digital Frontier Press, 2012).

Minding the Truth and Fact Gap

Although the vast abundance of data resources and well-projected human resources illustrates a bright picture of the brave new world of 4IR, there is a looming gap between truth (how data resources are being exploited) and fact (how human resources are managing to adapt).

Upcoming Truth: Granular Computing Mereology

AI is a computerized process that mimics human behavior in problem solving. Though the early days of AI were full of failures, this research area resurfaced in the form of neural networking, thanks to numerous researchers devoting themselves to integrating rigorous mathematical theories (e.g., statistical inference approaches, topological representation, and relational matrix theory) in AI.[13] From the public viewpoint, AI appears powerful enough to trigger 4IR and automatically solve a wide range of global issues. Despite the fact that there is still a huge gap between computerized and humanized problem solving, scientists are trying very hard to close such gap.[14] According to Hobbs, an exclusive feature of human problem

[13] Tshilidzi Marwala, *Computational intelligence for missing data imputation, estimation and management: knowledge optimization techniques* (New York: IGI Global, 2009); Tshilidzi Marwala, *Finite-element-model updating using computational intelligence techniques: applications to structural dynamics* (London: Springer-Verlag, 2010); Tshilidzi Marwala, *Condition monitoring using computational intelligence methods: applications in mechanical and electrical systems* (London: Springer-Verlag, 2012); Tshilidzi Marwala, *Economic modeling using artificial intelligence methods* (London: Springer-Verlag, 2013); Tshilidzi Marwala, *Artificial intelligence techniques for rational decision making* (London: Springer International Publishing, 2014); Tshilidzi Marwala, *Causality, correlation and artificial intelligence for rational decision making* (Singapore: World Scientific Publishing, 2015); Tshilidzi Marwala and Evan Hurwitz, *Artificial intelligence and economic theory: skynet in the market* (Cham: Springer International Publishing, 2017); Tshilidzi Marwala, Ilyes Boulkaibet, and Sondipon Adhikari, *Probabilistic finite element model updating using Bayesian statistics: applications to aeronautical and mechanical engineering* (Chichester: John Wiley & Sons, 2017); Tshilidzi Marwala and Monica Lagazio, *Militarized conflict modeling using computational intelligence* (London: Springer-Verlag, 2011); Bo Xing and Wen-Jing Gao, *Innovative computational intelligence: a rough guide to 134 clever algorithms* (London: Springer International Publishing, 2014).

[14] Bo Xing and Tshilidzi Marwala, *Smart maintenance for human–robot interaction: an intelligent search algorithmic perspective* (Cham: Springer International Publishing, 2018).

solving is the ability to conceptualize the world in different levels and enjoy free mobility across them.[15]

Consider a well-debated smart factory scenario in 4IR. When a production manager is involved in drafting a production plan, he/she only needs a coarse-grained factory model during the early stage of mental planning. At this stage, the whole factory may be encoded as a rough block diagram composed only by key workshops while temporarily ignoring details. As soon as a sketched plan is available, our human manager will reconsider some previously neglected minutiae to form a fine-grained factory model. During this phase, if global information needs to be considered, he/she can swiftly switch back to the former coarse-grained model. This trait is the hallmark of human intelligence. However, when we turn our attention to our counterpart, intelligent machines, the situation changes dramatically. Although computers have almost every bit of data about a factory (e.g., machine conditions, worker profiles, tool availability, building environment, and inventory list) accumulated in their storage medium, it is still difficult for them to create different representation models based on these data, let alone switching back and forth among models with distinct granularity levels.

In this regard, humans have already embarked on solving this problem using their own intelligence. Although the physical implementation of intelligent machines is probably quite different from that of human brains, an in-depth understanding of the human brain's basic working rules is still an often-indispensable requirement when it comes to designing machines that use AI. Built on various efforts, granular computing slowly arises as a suitable candidate in fulfilling the requirement for understanding the genuine human intelligence. The core idea of granular computing is inspired by humans' capacity to process information in a multi-level granular manner. The foundations of granular computing can be traced back to the renowned mereological theory of things. Granular computing is made possible by breakthroughs in AI, fuzzy sets, and rough sets. Granular computing is helping machines better imitate humans' problem-solving capacity.

[15] Jerry R. Hobbs, "Granularity," (Paper, Proceedings of the 9th International Joint Conference on Artificial Intelligence, Los Angeles, CA, August 1985). https://www.ijcai.org/Proceedings/85-1/Papers/084.pdf.

Upsetting Fact: Gradual Commencing Ideology

4IR is gradually introducing a shift in the way in which production in the economy is conducted. Consequently, new jobs that are significantly different from those that currently exist will be created. Accordingly, the skill set that will be required in the new economic paradigm will also need to change. Thus, the new skill set will be driven by 4IR and drive the new economic paradigm. However, training and employment systems are currently structured in such a way that people spend their first 25 years training for jobs and spend the rest of their lives working. This is starting to change so that individuals continue to be trained and learn for the rest of their lives, which means that lifelong learning will no longer be reserved for the ambitious but will be a common feature required by every worker. However, this transformation is not easily achievable since everyone is a victim of a subtle force: lag. In 4IR, lag can be perceived as obsolesces, because most people who fall behind may feel that they will not be able to catch up. Some of them pretend to be adaptable by adopting new technologies and strategies early.

In this regard, the higher education sector must be responsive to this shift by not only adopting several new technological developments (e.g., digital open courseware and online educational resources) but also acknowledging the achievement gap—a disparity exhibited by different student groups in terms of enrolment and academic performance. In 4IR, university graduates must be significantly different from those of yesteryear. Any new training paradigm developed by higher education institutions needs to show a reasonable balance between two factors, namely, time-to-adoption (technology-related elements) and time-to-adaption (human-related elements).

Minting an ADAPTIVE Solution

The result of the three previous revolutions, for countries that were able to benefit from them, was a broadened provision of social services such as health care and education for their populations. This was the outcome of an increase in economic productivity (more resources to distribute among the population) and a more efficient distribution of the resources. Thus, it is expected that the South African higher education sector will be both a beneficiary and a driver of the 4IR. As such, this education sector is expected to use 4IR as a means to overcome some of the challenges that it

is currently facing. These challenges include but are not limited to, broadening access to higher education for South Africans living in poverty; a decline in state funding for higher education; and creating a larger pool of next-generation academics and improving the quality of higher education offered in the South African tertiary institutions. Amid these obstacles, the higher education system must grapple the notion of creating the future workforce. Indeed, the conjecture is that the 4IR will have a positive impact on all dimensions of higher education. To meet this expectation, we propose an ADAPTIVE solution in this section, which covers the factors of accessibility, digital literacy, acceleration, pan-regionalization, transformation, inclusiveness, vision, and engagement. The ADAPTIVE solution is presented in the following subsections largely determined by the alphabetically appearing sequence (acronym); however, some important overlapping themes are addressed across subsections. Although the University of Johannesburg (UJ) is intensively used (accompanied by other South African universities occasionally) for illustrative purpose, the scope and boundary of "ADAPTIVE" is by no means limited to any specific higher education institution or scenario.[16]

Accessibility

From a historical viewpoint, the developmental cycle of higher education has gone through elite, mass, and post-mass stages.[17] With the forthcoming 4IR, the higher education system is expected to enter its next stage (i.e., a scheme of universal education that intends to keep the whole population adaptable to dramatic societal and technological changes).[18] Our first ADAPTIVE factor, accessibility, is thus selected to address the issues that many modern higher education institutions are currently facing. The following two practices expound how UJ is striving to achieve this goal.

[16] University of Johannesburg, "University of Johannesburg Corp Video 2017," filmed July 2017 at Johannesburg, University of Johannesburg video, 5:52, https://www.youtube.com/watch?v=QF2hDivUhos.

[17] Jung C. Shin, Gerard A. Postiglione, and Futao Huang eds., *Mass higher education development in East Asia: strategy, quality, and challenges* (New York: Springer International Publishing, 2015).

[18] Molly N. N. Lee, "Higher education in Malaysia: national strategies and innovative practices," in *Mass Higher Education Development in East Asia: Strategy, Quality, and Challenges*, eds. Jung C. Shin, Gerard A. Postiglione, and Futao Huang (New York: Springer International Publishing, 2015), 105–118.

Accessible Environment

As more universities embrace strategic plans that assimilate digital technology and introduce more active learning in traditional lecture halls, they have also reconfigured their physical surroundings to spur these teaching and learning shifts. Educational arrangements are being adjusted to encourage project-based interactions that take a range of factors (e.g., mobility, flexibility, and multi-device usability) into account. Among myriads of redesigning and planning activities, educational practitioners should also acknowledge the importance of offering disabled students equal and integral access to higher education.[19]

At UJ, we fully recognize the central role of addressing disability in achieving our transformative goals and aspirations to offer full access to higher education. As such, all issues related to disability receive equal consideration from the perspectives of both UJ's policy and broader institutional mandate. In addressing disability, UJ operates through a holistic approach that emphasizes a continued improvement of disability-friendly infrastructure (e.g., the availability of assistive devices) through the adaptation to pedagogic approaches that support diverse learning needs (e.g., curriculum design, living environment, sporting facilities, online systems, and technological settings) in order to support diverse learning needs in a reasonably accommodating and practical manner.[20]

Accessible Curriculum

In the era of 4IR, lifelong learning becomes a necessity for humans to compete with machines.[21] Therefore, students (or more precisely people)

[19] Adams S. Becker et al., *NMC horizon report: 2017 higher education edition* (Austin: The New Media Consortium, 2017), 1–60; Laura Hartrey, Suzanne Denieffe, and John S.G. Wells, "A systematic review of barriers and supports to the participation of students with mental health difficulties in higher education," *Mental Health & Prevention* 6, (2017): 26–43; Daniel Mara, "Higher education for people with disabilities – Romanian education experience," *Procedia - Social and Behavioral Sciences* 142, (2014): 78–82.

[20] University of Johannesburg, "Annual report 2015," 2015, https://www.uj.ac.za/about/Documents/reports/UJ_AnnualReport2015ONLINE.pdf.

[21] "Lifelong learning: continuous training and development is the key to business success," *Development and Learning in Organizations* 27, no. 2 (2013): 23–25; Andries de Grip and Wendy Smits, "What affects lifelong learning of scientists and engineers," *International Journal of Manpower* 33, no. 5 (2012): 583–597; Tiffany D. Fishman and Linsey Sledge, *Reimagining higher education: how colleges, universities, business, and governments can prepare for a new age of lifelong learning* (New York: Deloitte University Press, 2014).

should be capable of learning and working anywhere, with uninterrupted access to study materials, and keeping their peers within reach. Higher education institutions thus need to make a great leap in creating more platforms for students and faculty to be collaborative and productive.[22] With this understanding, the Executive Leadership Group of UJ has recently made the pioneering decision to form a partnership with a leading international online education provider company to enrich curriculum offerings. Several pressing areas linked to 4IR (e.g., cyber-citizenship) are under careful consideration.[23]

Digital-Savvy

4IR is characterized by widespread advancement in digital technologies. Although the ubiquity of these technological and digital tools is already well documented, their usefulness and effectiveness are not yet clear. If those in possession of these new technologies cannot generate a meaningful use of them, then their spread will have less positive impact.[24] Our second ADAPTIVE factor—digital-savvy—is thus chosen to address this often-overlooked issue by many modern higher education institutions and invention workshops. The following two practices elaborate how UJ is exerting itself toward mitigating the negative side effects.

Digital Fluency

The workforce for 4IR is expected to be digital-savvy and seamlessly work with different media sources as well as novel technologies. An essential factor for cultivating a desired level of digital fluency is to recognize that superficial knowledge of a certain device or software is far from enough; students and faculty must possess the ability to make connections and

[22] Becker et al., *NMC horizon report*.

[23] University of Johannesburg, "Annual Report 2015."

[24] Gabriela Grosseck "To use or not to use web 2.0 in higher education?," *Procedia Social and Behavioral Sciences* 1, no. 1 (2009): 478–482; Lucinda Kerawalla et al., "An empirically grounded framework to guide blogging in higher education," *Journal of Computer Assisted Learning* 25, no. 1 (2009): 31–42; Agnes Kukulska-Hulme, "How should the higher education workforce adapt to advancements in technology for teaching and learning?," *Internet and Higher Education* 15, no. 4 (2012): 247–254; Paul A. Tess, "The role of social media in higher education classes (real and virtual) – a literature review," *Computers in Human Behavior* 29, no. 5 (2013): A60–A68.

perceive implications among the tools they use and their intended outputs. The accumulated knowledge and the resultant competence of leveraging technology in inventive means will allow people to quickly adapt from one scenario to another. The ownership of this campaign must be shared and sustained by all divisions within an institution, given that digital fluency affects almost every aspect of modern teaching and learning.[25] Bearing this in mind, UJ has been actively developing a rich collection of digital information resources and initiating various online presentations of electronic books throughout the past decade. In order to cope with the trend of high penetration rate of mobile technologies among students and staff, the functionality of our uLink (a primary portal for students and staff) has been upgraded to accommodate email and mobile registration and provide a new interface—uConnect. In addition, a series of efforts were made to release the newest version of UJ's app—uGo.[26] Apart from these, a lab under the Centre for Academic Technologies (CAT) was also established to foster innovation in teaching and learning, for example, developing media artifacts that facilitate one-on-one collaborative and interactive teaching and learning.

Digital Literacy

For people to succeed in the twenty-first-century workplace and beyond, innovative and productive technology usage that encompasses modern practices is vital. The importance of digital literacy lies in that it transcends the conventional technological skill-gaining process by offering a better understanding of digital surroundings, which in turn will equip people with an intuitive adaptability to new contexts and the ability to coordinate creatively with others.[27] To address this issue, UJ offers a set of in-depth digital literacy training sessions to first-year students. In response to the ever-increasing demand for these sessions, the following strategy was prepared and conducted: standardization of Library Information Literacy modules that cover the fundamental knowledge to make use of the library via textual display or video interaction.[28]

[25] Joanne Gikas and Michael M. Grant, "Mobile computing devices in higher education: student perspectives on learning with cellphones, smartphones & social media," *Internet and Higher Education* 19, (2013): 18–26.

[26] University of Johannesburg, "Annual Report 2015."

[27] Becker et al., *NMC horizon report.*

[28] University of Johannesburg, "Annual Report 2015."

Meanwhile, UJ reached a three-year collaboration agreement with the City of Johannesburg Metropolitan Government. Under the Digital Ambassadors program, approximately 3000 entrepreneurial youths from across the City of Johannesburg received dedicated training at the UJ via an open-sourced, cloud-based learning management system. Over a period of 18 months, the project deployed successful candidates across the Johannesburg city area to promote digital literacy among local residents to facilitate the use of various online tools and enable personalized benefits for their career development.[29]

Acceleration

Nowadays, new knowledge is generated and accumulated every day at an astonishing rate. Under these circumstances, it is necessary to nurture a novel breed of alternative educational modes. For instance, developing cost-efficient, shorter, weight-reduced, content-wide, and diverse learning modules.[30] In the hypercompetitive environment that we face with 4IR, accelerated learning and training are paramount.[31] Therefore, our third ADAPTIVE factor entails acceleration with the goal of eliminating the mismatch between demand and supply, that is, the heads that employers are eagerly hunting for and the mind-sets that students have forged upon graduation. The following two practices demonstrate how UJ is accelerating itself in accomplishing this transmutation.

Accelerated Learning

To meet such pressing needs, UJ has designed a set of short learning programs (SLPs) to acquaint participants with the new thinking methods in several fast-growing fields. In its essence, an SLP has a certain amount of credit values (e.g., less than 120 credits), lasts no more than six months in average, and is offered by various accredited content providers (inward or

[29] University of Johannesburg, "Annual Report 2015."

[30] Anya Kamenetz, "The $10,000 business degree," September 23, 2017, www.fastcompany.com/3015844/the-10000-business-degree; Francesca Pucciarelli and Andreas Kaplan, "Competition and strategy in higher education: managing complexity and uncertainty," *Business Horizons* 59, no. 3 (2016): 311–320.

[31] John S. Brown, "Learning in and for the twenty-first century," in *CJ Koh Professorial Lecture Series No. 4* (Singapore: Nanyang Technological University, 2013), 1–21; Fishman and Sledge, *Reimagining higher education*.

outward) in the target field. In addition, statistical results showed that the number of Continuous Professional Development (CPD) programs for accreditation from different service providers in South Africa has increased.[32]

By now, UJ has over 200 SLPs available within nine faculties all year-round. These courses include both face-to-face and e-learning components and are catered to both national and international participants. For example, UJ has partnered with several organizations such as the United Nations Economic Commission for Africa (UNECA), the Business Communication and Writings for Intergovernmental Professionals (BCWIP) course, the UJ International Office for the University of Johannesburg English Language Programme (UJELP), and Cornell University to establish an SLP in law. Overall, SLPs offer alumni, students, and staff the prospect to enhance their knowledge and develop a culture of lifelong learning.

Accelerated Profession Development

The insistence on introducing more hands-on, technology-assisted, and content-tailored learning activities has affected entire operational systems of many universities, specifically teaching practices. The traditional image of a university instructor was that of a sage enlightening the audience. However, with regular collaboration, interaction, and innovation among students, instructors have redefined themselves as guides, lightening on the side. Under this new normal, students need professional mentors and coaches who join them to explore new front-lines, solve problems, and obtain concrete skills. To enable this, institutions must provide professional development support to their faculty. In light of this requirement, UJ implemented the Accelerated Academic Mentorship Programme (AAMP) in 2015. This initiative was designed to facilitate a transformation of the academic cohort, particularly in the development of the next generation of academic leaders. The specific emphasis of the AAMP initiative was placed on the establishment of a far more diverse and representative academic cohort.

[32] University of Johannesburg, "Annual Report 2015."

Pan-regionalization

The consensus is that the landscape of higher education has been dramatically transformed during the last three decades, after the international dimension was added in the picture. As the world becomes more interrelated, globalized, and integrated, universities, businesses, and governments delve deeper into relationships and opportunities with their peers. The most recent effort has been to focus on regionalized institutional cooperation and exchange. In Africa, various regional organizations (e.g., African Union, Association of African Universities, and the Association for the Development of Education in Africa) are actively supporting the "African Higher Education Harmonization" movement. The growing significance of higher education pan-regionalization is testified by the establishment of regional institutions such as Pan-Atlantic University, Pan-African University, and Pan-European University and numerous intra- and inter-regional alliances and agreements.[33] Our fourth ADAPTIVE factor is thus dedicated to pan-regionalization. In line with this trend, UJ has established an Institute for Pan-African Political Thought and Conversation, which is regarded as an activating agent that positioned UJ as the African epicenter for critical thinking and conversation. Meanwhile, UJ partnered with Nanyang Technological University (NTU) in Singapore, to establish the Johannesburg Institute for Advanced Studies (JIAS). The JIAS is the first Pan-Africa-Pan-Asia establishment that aims to generate global advancement by offering spaces for leading world thinkers to deliver crucial reflections.

Transformation

In the 4IR, a cultural transformation is indispensable to promote progressive learning. In other words, the structure of institutions must be organized in a way that spurs the development and intersectionality of new concepts, popularizes successful cases inside or outside of the university enclosure, and rewards student-focused teaching innovation.[34] Accordingly, we choose transformation as our fifth ADAPTIVE factor. The following two aspects demonstrate how UJ is transforming itself inside out.

[33] Fishman and Sledge, *Reimagining higher education*.

[34] Sharon Rider, Ylva Hasselberg, and Alexandra Waluszewski, *Transformations in research, higher Education and the academic market: the breakdown of scientific thought* (Dordrecht: Springer Science+Business Media, 2013).

Institutional Culture

In 2015, UJ celebrated its tenth anniversary. When UJ was officially established (a merger of three renowned higher education institutions) in 2005, it immediately set out on a path to steer the institution toward a transformative goal. Among various achievements, UJ has been recognized as one of the strongest university brands within South Africa. Transformation at UJ is mainly coordinated by the designated Transformation Unit with incoming contributions from many other divisions and units. The five carefully selected motifs covered by the Transformation Plan clearly indicate the depth and breadth of UJ's transformational determination—ranging from the underlying institutional culture through a shift toward active leadership and employment equity to the outpaced academic performance and a mission that holds student success at its core.[35]

In terms of institutional culture, UJ is committed to provide an empowering institutional environment and culture that promote diversity and consider the social, ethnic, and class representation of the Johannesburg metropolitan area. UJ's students and staff are as diverse as the community it serves. A tenet that has been embedded into UJ's institutional culture is innovation. Innovation is best nourished within a university when people with diverse cultures, views, principles, and attitudes can interact with one another with mutual understanding and a trustable spirit.

New Establishments

To cope with the potential disturbances brought by 4IR, UJ has also set up several new establishments for students to better seize the emerging opportunities out of the university fence. On July 1, 2017, UJ officially launched its College of Business and Economics (CBE), which is a strategic combination of the different innovative strengths of two UJ faculties: the Faculty of Management and the Faculty of Economic and Financial Sciences. The aim of CBE is to position UJ as a leader in African commerce by providing an excellent, practice-driven commerce education. UJ also aims to satisfy South Africa's need for additional medical practitioners and is working to establish the Johannesburg Medical School. After having successfully completed a series of benchmarking tests and in-depth analysis, UJ is positively approaching the goal of opening the doors of this medical school in the near future.

[35] University of Johannesburg, "Institutional transformation plan," 2011, https://www.uj.ac.za/about/Transformation-Unit/Documents/UJ_Institutional_Transformation_Plan.pdf.

Inclusiveness

The 2017 Summer Davos Summit was held in China, and the key theme of that forum was inclusiveness, that is, how the 4IR can be inclusive and not generate a situation where individuals fend for themselves. Aligned to this broad consensus and UJ's strategic goals of being globally excellent, the sixth ADAPTIVE factor is inclusiveness. This selection actually mirrors a unification between various activities that UJ is living up to, in order to address the need for further inclusion and UJ's unique institutional culture as reflected in its slogan: "Transformation through reconciliation—Together creating an inclusive and caring vibrant African city university."[36] In this regard, UJ has developed a new post-graduate diploma specialized in inclusive education. This new program offers an alternative to online distance learning.

Visionary

Today, learning has moved to the top of the business priority list in terms of sharpening skills, enlarging the leadership pipeline, and stimulating employee incentives. At times when every organization has to reassess its learning environment, a fresh vision needs to be implemented to create an optimized learning experience that touches everyone involved in a significant way.[37] The Chief Learning Officer (CLO)[38] is thus no more an envisioned position in many businesses when it comes to creating a suitable learning culture. Motivated by this new consideration, the ADAPTIVE solution encompasses vision as its seventh factor. The following two movements show how UJ is creating a vision for the future.

Internationalization

The internationalization division was formed to undertake a set of work that is central to UJ's vision of becoming "an International University of choice, anchored in Africa, dynamically shaping the future."[39] Through

[36] University of Johannesburg, "Institutional Transformation Plan."

[37] Abrie Olivier and Trevor Page, *Rewriting the rules for the digital age: 2017 human capital trends report for South Africa* (New York: Deloitte Touche Tohmatsu, 2017).

[38] Josh Bersin et al., eds., *Global human capital trends 2015: leading in the new world of work* (New York: Deloitte University Press, 2015).

[39] University of Johannesburg, "About Us," accessed January 10, 2018, https://www.uj.ac.za/about.

internationalism, UJ is poised to strengthen its scholarly engagement and soft power to influence transformative agendas on national, regional, and continental levels. UJ will also integrate to the immense global higher education landscape. The Executive Management Committee ensures that UJ's leadership fosters an environment where failure is normalized as part of the learning process. Some specific actions include recruiting students and faculty members from around the world, integrating them into UJ's life, decolonizing the curriculum, developing international partnerships, bolstering international collaboration, and facilitating student and staff mobility to name a few.

Expanding the Academic Core

In addition to normally practiced initiatives in contributing to an enriched learning experience through academic expansion, UJ's Global Excellence and Stature Fund also injected valuable academic resources into several flagship programs, like the newly established Institute for Intelligent Systems (IIS).[40]

South African universities are already involved in AI research. The University of Pretoria (UP) established a Computational Intelligence Research Group or CIRG based in the Department of Computer Science in 1998.[41] Its areas of focus include swarm intelligence, evolutionary computation, neural networks, and artificial immune systems. These techniques have been applied in this group for optimization (e.g., scheduling), classification, prediction, data mining and clustering, image analysis, bioinformatics, and financial analysis problems. The University of Cape Town established the Robotics and Agents Lab (RAL), which focuses on developing autonomous robots.[42] In 2011, the Centre for Artificial Intelligence Research (CAIR) was founded as a joint research center between the University of KwaZulu-Natal and the Council for Scientific and Industrial Research (CSIR).[43] CAIR is a national research network that undertakes foundational, directed, and applied research into numerous domains of AI. In 2016, CAIR was expanded to include universities: the University of Cape Town, University of KwaZulu-Natal, North-West University, UP,

[40] University of Johannesburg, "Dismantling data obstacles with intelligent systems for national benefit," November 13, 2017, https://www.uj.ac.za/newandevents/Pages/Dismantling-data-obstacles-with-intelligent-systems-for-national-benefit.aspx.

[41] University of Pretoria, "CIRG," 2017, http://cirg.cs.up.ac.za/visitPage.php?pageID=1701.

[42] University of Cape Town, "RARL," 2017, http://www.rarl.uct.ac.za/.

[43] CAIR, "CAIR," Accessed July 25, 2017, http://cair.za.net/.

and Stellenbosch University. CAIR is coordinated and funded by the CSIR Meraka Institute and Department of Science and Technology (DST) respectively. These initiatives still have to find a place in the broader curriculum of several South African institutions.

In this regard, UJ has emerged as a leader in reengineering its curriculum so that it is centered on 4IR.[44] For example, UJ IIS focuses on systems intelligence and cognitive computing, Big Data analytics and deep learning, digital revolution and machine learning, and industrial application of intelligent systems and cognitive computing. UJ has committed to change the curriculum so that it ensures that graduates can participate in 4IR. Such changes include ensuring that engineers understand social sciences and humanities.[45] AI is a computerized process that mimics human behaviors in learning and solving problems. Accordingly, AI machines assume responsibilities in society that require them to be designed as moral entities. Therefore, an engineer and a computer scientist with a better understanding of the human moral framework (psychological and social) should be an average graduate from the higher education system. UJ also plans to introduce a degree in computer sciences and culture.[46]

At the same time, by making full use of the Strategic Tutor Fund in combination with other specifically allocated resources, UJ has established one of the largest tutor support programs in Africa. In stimulating the decolonization movement, which is expected to redirect the knowledge flow from the developed world to the developing world, UJ has also appointed Nobel Laureate Prof. Wole Soyinka to actively lecture and engage in public discourse on global politics and development. Having Soyinka at the university is a clear signal that Africans have the capacity to contribute to 4IR.

Engagement

It is widely agreed that organizations stand to harvest the benefits of having a highly committed workforce.[47] However, this sought-after commitment does not come from nowhere. Recently, both the business world and the academic research community have been particularly interested in taking

[44] Fengu Msindisi, "Forging a new academic path," July 2, 2017, http://www.news24.com/SouthAfrica/News/newsmaker-forging-a-new-academic-path-20170702-2.

[45] Msindisi, "Forging a new academic path."

[46] Msindisi, "Forging a new academic path."

[47] Astrid von Kotze and Shirley Walters, *Forging solidarity: popular education at work* (Rotterdam: Sense Publishers, 2017).

advantage of engagement (the integration of several classical commitment and motivation theories) to harness the power of commitment.[48] For instance, in Europe it is commonly believed that the universities' remarkably affluent intangible resources (e.g., knowledge and expertise) can and have to be better exploited to make a more visible contribution toward economic development and society as a whole, aside from preparing graduates, and that a wider engagement movement could stimulate this.[49] In line with the theme of this chapter, our ADAPTIVE formulation concludes by enfolding engagement. The following two types of engagements describe how UJ is deriving benefits from a broader engagement.

Community Engagement

As the third essential purpose of the university, community engagement (CE) is embedded in UJ's mission as indicated by the powerful declaration "inspiring its community to transform and serve humanity through innovation and collaborative pursuit of knowledge."[50] There are four key values that UJ highlights, namely:

1. Imagination: developing a cosmopolitan identity.
2. Conversation: engaging meaningfully with one another.
3. Regeneration: developing sustainability through creative contribution.
4. Ethical foundation: participating in and helping the community.[51]

In addition, UJ recognizes three types of CE, namely service learning, community-based research, and organized outreach. As an engaged university, UJ's goal is to use its learning, teaching, research, and CE capa-

[48] Josh Bersin, "Becoming irresistible: a new model for employee engagement," *Deloitte Review* 16, (2015): 1–19; Louis Efron, *Purpose meets execution: how winning organizations accelerate engagement and drive profits* (New York: Bibliomotion, Inc., 2017); Marylene Gagné, *The oxford handbook of work engagement, motivation, and self-determination theory* (New York: Oxford University Press, 2014); Keith J. Roberts, "Community engagement in Indian higher education: financial and partnership trends," *International Journal of Educational Development,* (forthcoming). https://doi.org/10.1016/j.ijedudev.2017.03.005.

[49] Simon Whittemore, "The JISC business and community engagement programme," in *Trends, Discovery, and People in the Digital* Age, eds. David Baker and Wendi Evans (Witney: Chandos Publishing, 2013), 185–203.

[50] University of Johannesburg, "Mission, Vision and Values," accessed January 10, 2018, https://www.uj.ac.za/about/Pages/vision-mission-and-values.aspx.

[51] University of Johannesburg, "Mission, Vision and Values."

bilities to make a substantial impact to the social, economic, and educational advancement of Johannesburg, the Gauteng province, South Africa, and beyond. For example, over the last eight years, UJ has held an annual event aimed at women's empowerment organizations. Other initiatives include the art for AIDS international organization workshop, the Nelson Mandela International Day initiative, and the UJ CE volunteer champion programs.[52]

Stakeholder Engagement

Stakeholder engagement (SE) impacts on UJ's reputation, both nationally and internationally. In this regard, UJ gathered media exposure, which promoted UJ's experts as thought leaders, ensuring a broader diffusion of the UJ brand to improve the university's profile. A number of international media houses, such as the BBC and CNN, have used UJ academics as experts. In addition, several initiatives have taken place within UJ in 2015, which included the Orange Carpet Open Day and the staff/teacher cupcake interactions program. On the other hand, the Institutional Advancement Division manages most of the non-academic SEs, some of which include 1001 Seats of Knowledge, the alumni relations event, the 555 project, and the "missing middle" initiative.[53]

Minuting: A Case Study in the Context of South Africa

Historically, the economic performance of the mining industry has been among the best in South Africa. Today, the mining industry continues to play an important role in promoting population growth, regional development, industrial diversification and growth, and research innovation. In terms of research innovation, in 2013, BASF Group launched a mining laboratory in Johannesburg to offer innovative solutions for mineral processing and extractive metallurgy, while South African universities and research organizations are focusing on projects that use satellite monitoring to detect the deformation of land surfaces, mitigate the environmental

[52] University of Johannesburg, "Community engagement report," 2014, https://www.uj.ac.za/about/Documents/reports/community%20engagement%20report%202014.pdf.

[53] University of Johannesburg, "Annual report 2015."

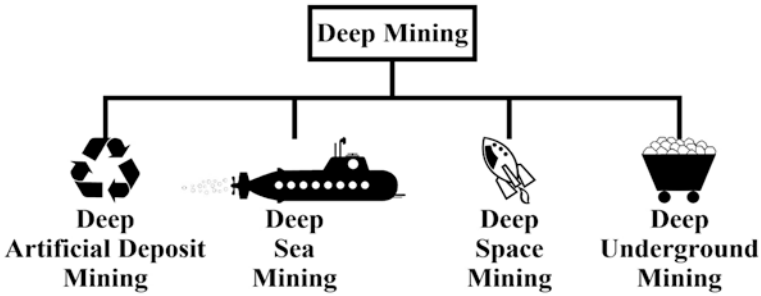

Fig. 8.3 Deep mining paradigm

impact of quarrying, and support the rehabilitation of post-mining processes.[54]

As several reports argue, it could change not only business, but many other sectors. It is a good opportunity for the mining industry to embrace new technologies, rethink their operating models, and find new productivity gains. Under 4IR, manufacturing is going digital and thus becoming smart. In light of this, a number of remarkable technologies like deep learning algorithms, mobile technologies, Big Data analytics, and automation are converging. For instance, engineers in big construction firms like Hitachi hosted a new project called "Smart Excavator" to deploy Big Data analytics to optimize the vehicle routing strategies at the coalface.[55] Another example proposed by Sweden's Lulea University of Technology is "smart Rockbolt," which focuses on using sensors to measure both vibrations and strain.[56] Indeed, mining's future depends on technological innovation (for both deep learning and deep mining, see Fig. 8.3). Neal Froneman, the CEO of Sibanye Gold, South Africa's largest producer of the metal, told the *Financial Times* on May 13, 2017: "with conventional mining, the mining industry can look forward a sharp

[54] Keith Campbell, "Space based: earth observation satellites starting to bring benefits to mining sector," *Mining Weekly*, June 2, 2017, http://www.miningweekly.com/article/earth-observation-satellites-are-beginning-to-bring-benefits-to-the-mining-sector-2017-06-02/rep_id:3650.

[55] Jamie Carter, "Deep learning: how the mining industry got smart," June 14, 2016, http://www.techradar.com/news/world-of-tech/deep-learning-how-the-mining-industry-got-smart-1322890.

[56] Carter, "Deep learning: how the mining industry got smart."

decline in gold production by 2019~20 and for mining to die out almost completely by 2033."[57]

Mingling "ADAPTIVE" Solution with Smart Mining

Mining the earth's natural resources, in addition to causing negative environmental impacts, is arduous, dangerous, and hazardous for people involved. Smart mining (with the ultimate goal of autonomous mining) is a viable alternative in the age of 4IR. Nevertheless, the automaton economy does not mean the complete elimination of humans from mining operations. A mine typically has a limited lifespan that ranges from short-term geographical investigation, possibility analysis, feasibility evaluation, through mid-term system design and construction, production initiation, equipment decommissioning, to long-term system disposition and environment protection. Thus, humans are still required at many stages of mining operations where the use of scientific methodologies is necessary to gain an in-depth understanding of the process. In this section, we demonstrate how the proposed ADAPTIVE solution is being implemented at UJ-Sibanye Mining Leadership program[58] to equip students with the necessary skills to cope with the smart mining future.

Accessibility

In 2017, in line with the requirements from the South African Department of Higher Education and Training (DHET), Council of Higher Education's (CHE) new Higher Education Quality Sub-framework (HEQSF), and Engineering Council of South Africa (ECSA), the Faculty of Engineering and the Built Environment (FEBE) at UJ introduced South Africa's first accredited Bachelor of Engineering Technology (BEngTech) degree and Built Environment Bachelors qualifications.[59] The new three-year BEngTech degree is specifically structured (as shown in Fig. 8.4) and is combined with the conventional Bachelor of Engineering

[57] Joseph Cotterill, "Mining's future depends on technological innovation," *Financial Times,* May 13, 2017.

[58] Saurabh Sinha and Hennie Grobler, "UJ-Sibanye engineering "mining leadership"," April 3, 2017, https://goo.gl/OPbzdI.

[59] FEBE, "The First in SA to roll out accredited BEngTech and built environment Bachelors qualifications," filmed October 2016 at Johannesburg, University of Johannesburg video, 2:26, https://www.youtube.com/watch?v=nvqeeVMTSSg.

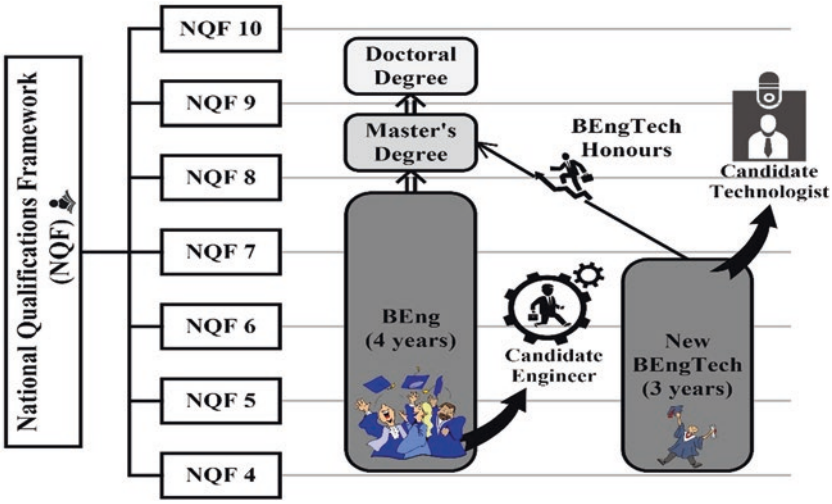

Fig. 8.4 The structure of UJ's new engineering and built environment qualifications

(BEng) degrees to cater for South Africa's in-demand technology occupations.

At the same time, several new master's degrees were introduced as follows:

1. Research-based degrees: Mineral Resource Governance and Sustainable Mining.
2. Coursework-based degrees: Structural Engineering, Sustainable Energy, and Sustainable Mining.

In terms of the enrolment in mining-related disciplines, UJ has also witnessed a dramatic increase over the past decade (see Fig. 8.5).

Digital-Savvy

With the growing popularity of wearable technology, CPSs will become a new norm in 4IR, elevating the role of numerical simulations in both education and practical applications. Among others, UJ has been implementing wearable technology to provide an immersion experience. It is actively exploring the possibility of introducing virtual reality (VR) assistive devices to enhance undergraduate exposure and employability skills in mining-specific domains.

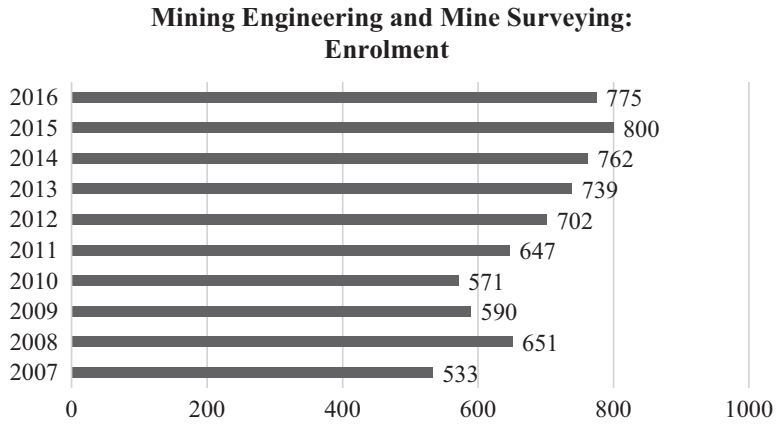

Fig. 8.5 The UJ's mining discipline: enrolment overview

Acceleration

It is widely agreed that the pedagogical shift toward authentic learning (e.g., project-based, challenge-driven, competency-involved) can trigger students' motivation to grasp wealthier hands-on, real-world experiences. As such universities have made active learning a priority over the outdated rote learning. Students are treated no more as passive participants and absorbers of knowledge. Instead, they stand at the center of the stage as active contributors to the ecosystem of knowledge production and use. In other words, there is no need for students to wait until graduation to test their skills since they applied them through various innovative means (e.g., practicing, experiencing, building, challenging, contesting, and demonstrating). To meet this requirement, UJ has built a mock mine environment at its Doornfontein Campus, which includes a 180-meter-long haulage connected with a 32-meter-high elevator shaft and a workshop complex. Such emulated facility can simulate real mining conditions that offer students an authentic mining learning experience through practical engineering, construction, and observation methodology during laboratory and tutorial sessions.[60] The mock mine further enhances the students' competitiveness by exposing them to other engineering disciplines (e.g., mechanical engineering, and electrical and electronic engineering).

[60] University of Johannesburg, "Annual Report 2015."

In addition to its educational purposes, the mock mine is also used for applied research objectives, developing and verifying smart mining-related technologies such as fiber-optical sensors, visible light and/or power line communications, indoor navigation techniques, and innovative urban mining mode (e.g., mine dumps and landfills).

Pan-regionalization

To increase UJ's regional impact, its Faculty of Engineering and the Built Environment also enabled a number of collaborative master's degrees with regional and international leading bodies:

1. Master of Foundry Engineering: Offered in collaboration with TU Berg Akademie Freiberg in Germany.
2. Master of Mineral Governance: Offered in Collaboration with the African Institute for Economic Development and Planning (IDEP).

Transformation

As an affirmation of UJ's strong research tradition, the South African National Research Foundation (NRF) has awarded several new research chairs to UJ, which deserve to be mentioned for the following reasons:

1. UJ was awarded five new South Africa Research Chairs in 2015.
2. UJ received the maximum that could be awarded within a particular year.
3. All five research chairs, including the industrial development chair, are held by UJ's stellar woman academics.

In addition to these recognitions, the newly NRF-funded Centre of Excellence of Integrated Mineral and Energy Resource Analysis (CIMERA) positions UJ as a leading institution in leveraging smart mining development. These transformative efforts have been fruitful. According to the recent QS World University Rankings by Subject, UJ has made a significant jump in its global ranking for mining engineering.[61]

[61] Sinha and Hennie Grobler, "UJ-Sibanye engineering "mining leadership."

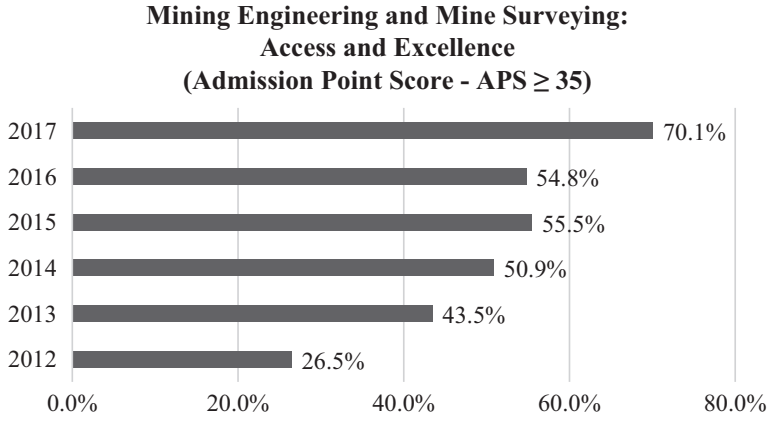

Fig. 8.6 The UJ's mining discipline: access and excellence overview

Inclusiveness

The transformation of both the mining industry landscape and the mining education system does not necessarily mean that the university has to leave any students behind. Conversely, UJ has experienced a steady growth in terms of high-achieving student enrolment and disadvantaged student enrolment (see Figs. 8.6 and 8.7).

Visionary

According to National Academies of Sciences Engineering and Medicine,[62] the future economic growth and competitiveness of a country largely depend on its innovation capacity, which is mainly sourced from the new knowledge and trained graduates produced by universities. However, the highly complex technical and societal problems that countries encounter can no longer be effectively addressed by a conventional higher education model. The single university research group led by an individual main investigator is likely not going to keep pace with the large-scale changes emerging in industry. Instead, these puzzles can be dealt with properly only when multiple institutions with different fields of expertise work

[62] National Academies of Sciences Engineering and Medicine, *A new vision for center-based engineering research* (Washington, D.C.: The National Academies Press, 2017).

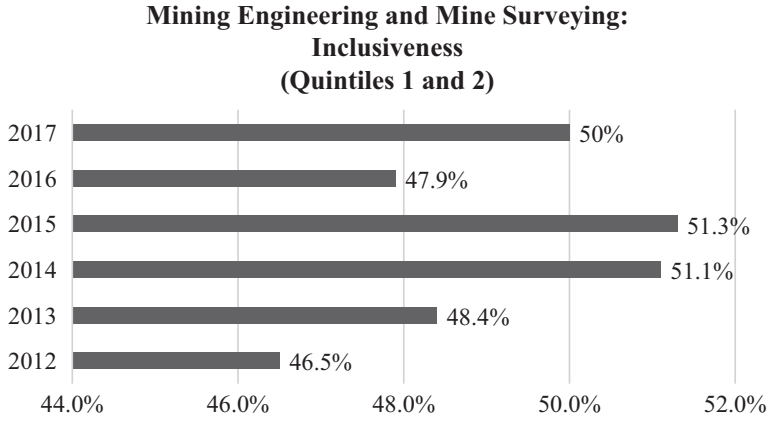

Fig. 8.7 The UJ's mining discipline: inclusiveness snapshot

collaboratively. The example of the Engineering Research Centre (ERC) in the United States is a positive example of the education opportunities that can be developed with government-university cooperation.

Many such collaborative opportunities are emerging in South Africa. For example, to ensure that South African universities continue to be a source of innovation, economic advancement, and educational excellence, the Gauteng University vice-chancellors signed a memorandum of understanding (MoU) at UJ on May 24, 2017, with the Premier of Gauteng, South Africa. The UJ's Vice-Chancellor together with Vice-Chancellors from other neighboring universities has come into an agreement to form a partnership with the Gauteng Provincial Government through collaboration on several key areas such as energy, security, and environment sustainability.[63] It is too early to tell what impacts such collaborations will have, but the preparation is essential as 4IR arrives in South Africa and around the world if we are to prepare a workforce of relevance.

[63] University of Johannesburg, "Gauteng University Vice-Chancellors partner with Government to strengthen research and innovation: The University of Johannesburg," May 25, 2017, https://www.uj.ac.za/newandevents/Pages/gauteng-university-vice-chancellors-partner-with-government-to-strengthen-research-and-innovation.aspx.

Engagement

In partnering with the DST via its Technology Innovation Agency (TIA), UJ has established a Process, Energy and Environment Technology Station (PEETS), which is committed to offer high-quality and professional engagement with stakeholders. Among different functionalities (e.g., training and demonstration, energy auditing, and environmental impact assessment), PEETS' main mission is to use suitable technological innovations to offer support to enterprise development in the energy and environment sectors.

Sibanye is an independent mining company based in South Africa, which holds and operates a portfolio of projects for high-quality gold and platinum group metals. Furthermore, Sibanye holds and manages significant extraction and processing facilities where gold-bearing ore is processed to yield gold. Sibanye is also currently investing in a number of long-term, sustainable organic projects. UJ is actively engaging with Sibanye to conduct mining-related research and innovation.

To engage with students, the newly forged mining degrees are also explained (by their academic leaders) through videos posted on popular online sites for the students' convenience. Some of them are listed as follows:

1. BEngTech degree in Extraction and Physical Metallurgy[64]
2. BEngTech degree in Mining Engineering[65]
3. BEngTech degree in Industrial Engineering[66]
4. BEng degree in Mine Surveying[67]

[64] FEBE, "Dr Didier Nyembwe - Bachelor of Engineering Technology in Extraction and Physical Metallurgy," filmed September 2016 at Johannesburg, University of Johannesburg video, 3:29, https://www.youtube.com/watch?v=DF76Z3zx-aM.

[65] FEBE, "Dr Steven Rupprecht – Engineering Technology (BEngTech) Degree in Mining Engineering," filmed October 2016 at Johannesburg, University of Johannesburg video, 4:05, https://www.youtube.com/watch?v=ct25c6yquaM.

[66] FEBE, "Dr Able Mashamba, Able – Bachelor of Engineering Technology Degree," filmed September 2016 at Johannesburg, University of Johannesburg video, 5:35, https://www.youtube.com/watch?v=UzetQwKRNOw.

[67] FEBE, "Dr David Wilson – Mine Surveying Bachelor's Degree," filmed September 2016 at Johannesburg, University of Johannesburg video, 4:10, https://youtu.be/VIPq7HXRHIs.

Conclusion

According to Jan Visser, human learning is related to human adaptive behavior, which can be identified at four levels[68]:

1. Preprogrammed and genetically transferable from one generation to another generation (e.g., fight and flight responses).
2. Inherited predisposition to acquire fundamental abilities (e.g., linguistic capability).
3. Commonly perceived learning level that involves deliberate acquisition of specific skills and knowledge. The outcome of this particular learning level may include motor skills, verbal abilities, knowledge acquisition, cognitive talent, and attitude capacity.
4. Transformed into a permanent disposition to interact with one's surroundings. Learning at this level is no longer limited to acquiring certain skills or knowledge pieces.

It is thus argued by Visser that true lifelong learning can only be achieved when one reaches the fourth level of learning.[69] However, since most people and societies have largely focused on the third level of learning, very little has changed over a long period of time. Now that 4IR is about to change many parameters of human existence dramatically, human learning should be treated as a complex system in which adaptive behavior is present in an integrated manner that comprises the four levels mentioned above. In this chapter, through the selected smart mining case, we emphasize how 4IR and specifically deep learning technologies are changing not only the mining sector but how learners are prepared to work in that sector. Through the ADAPTIVE strategy implemented in the UJ-Sibanye mining program, we illustrate how universities can help society to respond to such radical and sudden changes by deploying pedagogy that yields creative thinkers with practical skills.

[68] Visser, "The role of human learning in the information age: challenges and opportunities for Latin America and the rest of us," accessed December 28, 2017, http://www.learndev.org/dl/HumanLearnInfoAge.pdf.

[69] Visser, "Integrity, completeness and comprehensiveness of the learning environment: meeting the basic learning needs of all throughout life," in *International Handbook of Lifelong Learning*, eds. David N. Aspin, Judith Chapman, Michael Hatton, and Yukiko Sawano (Dordrecht: Kluwer Academic Publishers, 2001), 447–472.

Bibliography

Barton, Dominic, and David Court. "Making advanced analytics work for you." *Harvard Business Review* 90, no. 10 (2012): 78–83.

Becker, Adams, S. Cummins, M. Davis, A. Freeman, A. Hall, C. Giesinger, and V. Ananthanarayanan. *NMC horizon report: 2017 higher education edition*, 1–60. Austin: The New Media Consortium, 2017.

Bersin, Josh. "Becoming irresistible: a new model for employee engagement." *Deloitte Review* 16, (2015): 1–19.

Bersin, Josh, Dimple Agarwal, Bill Pelster, and Jeff Schwartz eds. *Global human capital trends 2015: leading in the new world of work*. New York: Deloitte University Press, 2015.

Brown, John S. "Learning in and for the 21st century." In *CJ Koh Professorial Lecture Series No. 4*, 1–21. Singapore: Nanyang Technological University, 2013.

Brynjofsson, Erik, and Andrew McAfee. *Race against the machine: how the digital revolution is accelerating innovation, driving productivity, and irreversibly transforming employment and the economy*. Lexington: Digital Frontier Press, 2012.

CAIR. "CAIR." Accessed July 25, 2017. http://cair.za.net/.

Campbell, Keith. "Space based: earth observation satellites starting to bring benefits to mining sector." *Mining Weekly*, June 2, 2017. http://www.miningweekly.com/article/earth-observation-satellites-are-beginning-to-bring-benefits-to-the-mining-sector-2017-06-02/rep_id:3650.

Carter, Jamie. "Deep learning: how the mining industry got smart." June 14, 2016. http://www.techradar.com/news/world-of-tech/deep-learning-how-the-mining-industry-got-smart-1322890.

Cotterill, Joseph. "Mining's future depends on technological innovation." *Financial Times,* May 13, 2017.

Efron, Louis. *Purpose meets execution: how winning organizations accelerate engagement and drive profits*. New York: Bibliomotion, Inc., 2017.

FEBE. "Dr Able Mashamba, Able – Bachelor of Engineering Technology Degree." Filmed September 2016 at Johannesburg. University of Johannesburg video, 5:35. https://www.youtube.com/watch?v=UzetQwKRNOw.

———. "Dr David Wilson – Mine Surveying Bachelor's Degree." Filmed September 2016 at Johannesburg. University of Johannesburg video, 4:10. https://youtu.be/VIPq7HXRHIs.

———. "Dr Didier Nyembwe – Bachelor of Engineering Technology in Extraction and Physical Metallurgy." Filmed September 2016 at Johannesburg. University of Johannesburg video, 3:29. https://www.youtube.com/watch?v=DF76Z3zx-aM.

———. "Dr Steven Rupprecht – Engineering Technology (BEngTech) Degree in Mining Engineering." Filmed October 2016 at Johannesburg. University of Johannesburg video, 4:05. https://www.youtube.com/watch?v=ct25c6yquaM.

———. "The First in SA to roll out accredited BEngTech and built environment Bachelors qualifications." Filmed October 2016 at Johannesburg. University of Johannesburg video, 2:26. https://www.youtube.com/watch?v=nvqeeVMTSSg.

Fishman, Tiffany D., and Linsey Sledge. *Reimagining higher education: how colleges, universities, business, and governments can prepare for a new age of lifelong learning*. New York: Deloitte University Press, 2014.

Frey, Carl B., and Michael A. Osborne. "The future of employment: how susceptible are jobs to computerisation?" September 17, 2013. https://www.oxfordmartin.ox.ac.uk/downloads/academic/The_Future_of_Employment.pdf.

Gagné, Marylene. *The oxford handbook of work engagement, motivation, and self-determination theory*. New York: Oxford University Press, 2014.

Gikas, Joanne, and Michael M. Grant. "Mobile computing devices in higher education: student perspectives on learning with cellphones, smartphones & social media." *Internet and Higher Education* 19, (2013): 18–26.

Grip, Andries de, and Wendy Smits. "What affects lifelong learning of scientists and engineers." *International Journal of Manpower* 33, no. 5 (2012): 583–597.

Grosseck, Gabriela. "To use or not to use web 2.0 in higher education?" *Procedia Social and Behavioral Sciences* 1, no. 1 (2009): 478–482.

Hartrey, Laura, Suzanne Denieffe, and John S.G. Wells. "A systematic review of barriers and supports to the participation of students with mental health difficulties in higher education." *Mental Health & Prevention* 6, (2017): 26–43.

Hobbs, Jerry R. "Granularity." Paper presented at the Proceedings of the 9th International Joint Conference on Artificial Intelligence, Los Angeles, CA, August 1985. https://www.ijcai.org/Proceedings/85-1/Papers/084.pdf.

IBM. *Understanding big data so you can act with confidence*. Somers: IBM Corporation, 2014.

Kamenetz, Anya. "The $10,000 business degree." September 23, 2017. www.fastcompany.com/3015844/the-10000-business-degree.

Kerawalla, Lucinda, Sonal Minocha, Gill Kirkup, and Grainne Conole. "An empirically grounded framework to guide blogging in higher education." *Journal of Computer Assisted Learning* 25, no. 1 (2009): 31–42.

Kukulska-Hulme, Agnes. "How should the higher education workforce adapt to advancements in technology for teaching and learning?" *Internet and Higher Education* 15, no. 4 (2012): 247–254.

Lee, Molly N. N. "Higher education in Malaysia: national strategies and innovative practices." In *Mass Higher Education Development in East Asia: Strategy, Quality, and Challenges*. Edited by Jung C. Shin, Gerard A. Postiglione, and Futao Huang, 105–118. New York: Springer International Publishing, 2015.

Lewis, Harvey, Jim Guszcza, John Lucker, Vivekanand Gopalkrishnan, and David Steier. "Big data 2.0: new business strategies from big data." *Deloitte Review* 12, (2013): 1–17.

"Lifelong learning: continuous training and development is the key to business success." *Development and Learning in Organizations* 27, no. 2 (2013): 23–25.

Manyika, James, Michael Chui, Brad Brown, Jacques Bughin, Richard Dobbs, Charles Roxburgh, and Angela H. Byers. *Big data: the next frontier for innovation, competition, and productivity*. New York: McKinsey Global Institute, 2011.

Mara, Daniel. "Higher education for people with disabilities – Romanian education experience." *Procedia – Social and Behavioral Sciences* 142, (2014): 78–82.

Marwala, Tshilidzi. *Computational intelligence for missing data imputation, estimation and management: knowledge optimization techniques*. New York: IGI Global, 2009.

———. *Finite-element-model updating using computational intelligence techniques: applications to structural dynamics*. London: Springer-Verlag, 2010.

———. *Condition monitoring using computational intelligence methods: applications in mechanical and electrical systems*. London: Springer-Verlag, 2012.

———. *Economic modeling using artificial intelligence methods*. London: Springer-Verlag, 2013.

———. *Artificial intelligence techniques for rational decision making*. London: Springer International Publishing, 2014.

———. *Causality, correlation and artificial intelligence for rational decision making*. Singapore: World Scientific Publishing, 2015.

Marwala, Tshilidzi, and Evan Hurwitz. *Artificial intelligence and economic theory: skynet in the market*. Cham: Springer International Publishing, 2017.

Marwala, Tshilidzi, Ilyes Boulkaibet, and Sondipon Adhikari. *Probabilistic finite element model updating using Bayesian statistics: applications to aeronautical and mechanical engineering*. Chichester: John Wiley & Sons, 2017.

Marwala, Tshilidzi, and Monica Lagazio. *Militarized conflict modeling using computational intelligence*. London: Springer-Verlag, 2011.

Msindisi, Fengu. "Forging a new academic path." July 2, 2017. http://www.news24.com/SouthAfrica/News/newsmaker-forging-a-new-academic-path-20170702-2.

National Academies of Sciences Engineering and Medicine. *A new vision for center-based engineering research*. Washington, D.C.: The National Academies Press, 2017.

Olivier, Abrie, and Trevor Page. *Rewriting the rules for the digital age: 2017 human capital trends report for South Africa*. New York: Deloitte Touche Tohmatsu, 2017.

O'Sullivan, Arthur, Steven M. Sheffrin, and Stephen Perez. *Macroeconomics: principles, applications, and tools*. New Jersey: Pearson Education, 2014.

Oguro, Kazumasa. "Big data – key to the 4th industrial revolution." *Japan SPOTLIGHT*, (2016): 24–27.

Phillips, Jack, and Patricia P. Phillips. *High-impact: human capital strategy: addressing the 12 major challenges today's organizations face*. New York: American Management Association, 2015.

Pucciarelli, Francesca, and Andreas Kaplan. "Competition and strategy in higher education: managing complexity and uncertainty." *Business Horizons* 59, no. 3 (2016): 311–320.

Rider, Sharon, Ylva Hasselberg, and Alexandra Waluszewski. *Transformations in research, higher Education and the academic market: the breakdown of scientific thought*. Dordrecht: Springer Science+Business Media, 2013.

Roberts, Keith J. "Community engagement in Indian higher education: financial and partnership trends." *International Journal of Educational Development,* (forthcoming). https://doi.org/10.1016/j.ijedudev.2017.03.005.

Shin, Jung C., Gerard A. Postiglione, and Futao Huang. *Mass higher education development in East Asia: strategy, quality, and challenges*. New York: Springer International Publishing, 2015.

Sinha, Saurabh, and Hennie Grobler. "UJ-Sibanye engineering "mining leadership"." April 3, 2017. https://goo.gl/OPbzdI.

Tess, Paul A. "The role of social media in higher education classes (real and virtual) – a literature review." *Computers in Human Behavior* 29, no. 5 (2013): A60–A68.

The Economist. "Technology quarterly: ghost ships." *The Economist Technology Quarterly* 410, no. 8877 (2014): 3–4.

———. "Fuel of the future." *The Economist*, May 6–12, 2017.

———. "The world's most valuable resource." *The Economist*, May 6–12, 2017.

Tsvetkov, Pavel. *Nuclear power – control, reliability and human factors*. Rijeka: InTech, 2011.

University of Cape Town. "RARL." 2017. http://www.rarl.uct.ac.za/.

University of Johannesburg. "Institutional transformation plan." 2011. https://www.uj.ac.za/about/Transformation-Unit/Documents/UJ_Institutional_Transformation_Plan.pdf.

———. "Community engagement report." 2014. https://www.uj.ac.za/about/Documents/reports/community%20engagement%20report%202014.pdf.

———. "Annual report 2015." 2015. https://www.uj.ac.za/about/Documents/reports/UJ_AnnualReport2015ONLINE.pdf.

———. "Dismantling data obstacles with intelligent systems for national benefit." November 13, 2017. https://www.uj.ac.za/newandevents/Pages/Dismantling-data-obstacles-with-intelligent-systems-for-national-benefit.aspx.

———. "Gauteng University Vice-Chancellors partner with Government to strengthen research and innovation: The University of Johannesburg." May 25, 2017. https://www.uj.ac.za/newandevents/Pages/gauteng-university-vice-chancellors-partner-with-government-to-strengthen-research-and-innovation.aspx.

"University of Johannesburg Corp Video 2017." Filmed July 2017 at Johannesburg. UJ video, 5:52. https://www.youtube.com/watch?v=QF2hDivUhos.

———. "About Us." Accessed January 10, 2018, https://www.uj.ac.za/about.

———. "Mission, Vision and Values." Access January 10, 2018. https://www.uj.ac.za/about/Pages/vision-mission-and-values.aspx.

University of Pretoria. "CIRG." 2017. http://cirg.cs.up.ac.za/visitPage.php?pageID=1701.

Visser, Jan. "Integrity, completeness and comprehensiveness of the learning environment: meeting the basic learning needs of all throughout life." In *International Handbook of Lifelong Learning*. Edited by David N. Aspin, Judith Chapman, Michael Hatton, and Yukiko Sawano, 447–472. Dordrecht: Kluwer Academic Publishers, 2001.

———. "The role of human learning in the information age: challenges and opportunities for Latin America and the rest of us." Accessed December 28, 2017. http://www.learndev.org/dl/HumanLearnInfoAge.pdf.

von Kotze, Astrid, and Shirley Walters. *Forging solidarity: popular education at work*. Rotterdam: Sense Publishers, 2017.

Wang, Lidong, and Guanghui Wang. "Big data in cyber-physical systems, digital manufacturing and industry 4.0." *International Journal of Engineering and Manufacturing* 4, (2016): 1–8.

Whittemore, Simon. "The JISC business and community engagement programme." In *Trends, Discovery, and People in the Digital* Age. Edited by David Baker and Wendi Evans, 185–203. Witney: Chandos Publishing, 2013.

Xing, Bo, and Wen-Jing Gao. *Innovative computational intelligence: a rough guide to 134 clever algorithms*. London: Springer International Publishing, 2014.

Xing, Bo, and Tshilidzi Marwala. *Smart maintenance for human–robot interaction: an intelligent search algorithmic perspective*. Cham: Springer International Publishing, 2018.

Yaqoob, Ibar, Ibrahim A. T. Hashem, Abdullah Gani, Salimah Mokhtar, Ejaz Ahmed, Nor Badrul Anuar, and Anthasios Vasilakos. "Big data: from beginning to future." *International Journal of Information Management* 36, no. 6 (2016): 1231–1247.