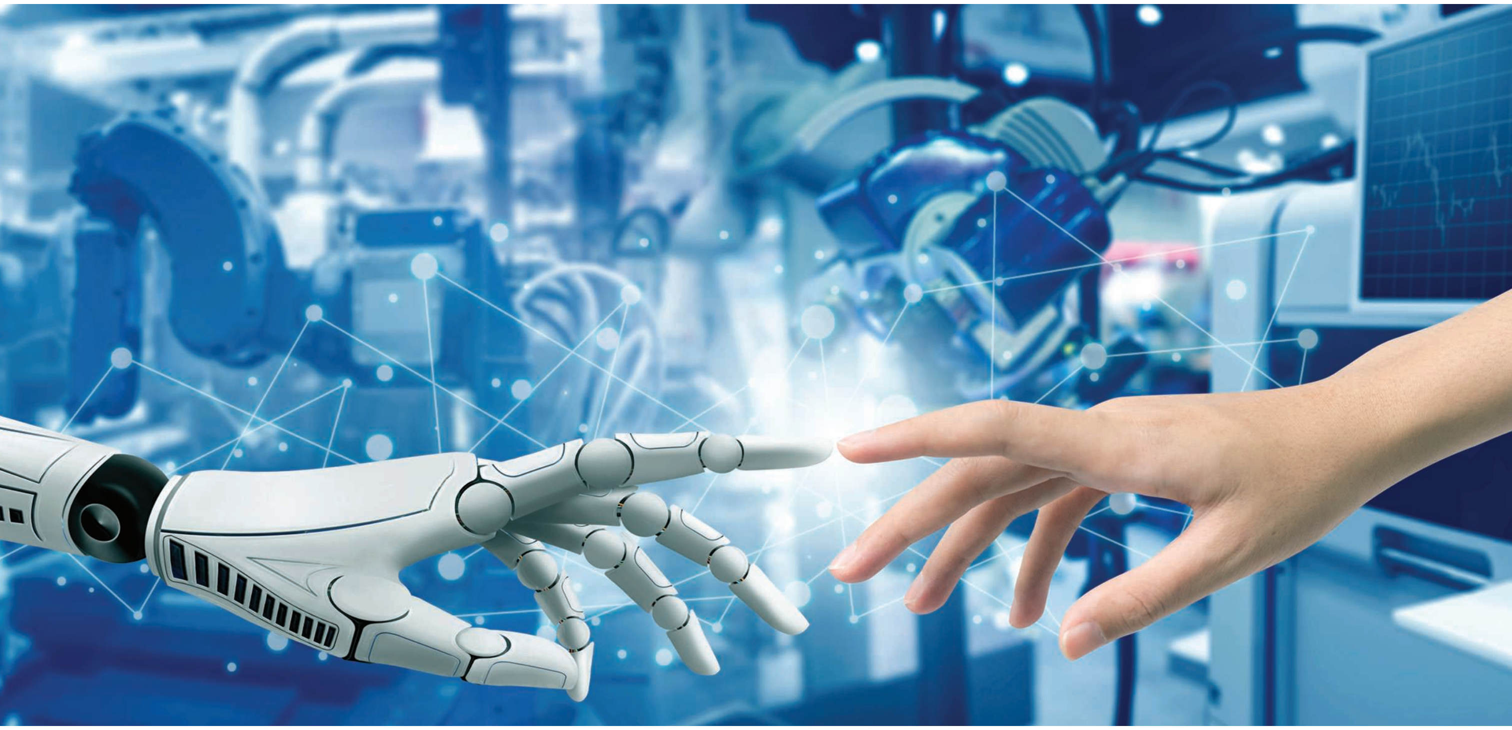
A paradigm shift in higher education in the context of the Fourth Industrial Revolution

Jaco du Preez and Saurabh Sinha



The future of work is upon us and has rapidly and profoundly influenced many professions and industries. Alongside this, we argue that it is essential for the landscape of postschool education and training (PSET), both in South Africa and globally, to adapt to the changing nature of work, and, ideally, lead this evolution.

Digital Object Identifier 10.1109/MPOT.2020.3044279
Date of current version: 10 March 2021

In this article, we summarize learning—the nexus among teaching, research, and innovation—as a service in the context of the Fourth Industrial Revolution (4IR), given the innovative technologies that are increasingly penetrating the mainstream. We discuss the transition toward an augmented approach, University 4.0, and the associated challenges, both technological and societal, that accompany the shift.

Changing PSET models

On the eve of the ongoing Cricket Test Series between South Africa

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and England, intertwined with our regular discussion of which team would emerge victorious, we also debated whether computational algorithms could predict the outcome of this match. It was something we also debated during the Rugby World Cup Final between the two nations. Perhaps we could predict—if we had access to higher-quality data about the players, weather conditions, crowd, cheerleading, computational resources, and so on. Some argue that self-learning algorithms can use abundant data and correlation techniques as a possible alternative to high-quality data. In any case, abundant data of various scenarios is, perhaps, also a tall order.

Vast amounts of variability necessitate tremendous computing power. How exactly does one address "infinite" computing or processing of data in 4IR? We really do not yet have an answer to this question, but an asymptomatic response lies in cloud computing. Simply put, cloud computing is a distributed form of computing where computing power connects remotely and, thus, extends over the Internet. Similar to the way that computing power distributes in a virtual way, it is imminent that human power, or the future of work, will also change. It is, therefore, also essential for the PSET landscape in South Africa and elsewhere to analogously change. Ideally, PSET must lead.

Looking back at previous industrial revolutions (starting from the very beginning in the mid-18th century), the limitations of existing higher-education systems were discovered quite abruptly. The necessity for the development of new disciplines was abundantly clear, and we have been experiencing a similar situation with the advent of 4IR. Considering the higher-education system as an industry in and of itself is by no means unheard of, seeing that it generates nearly US$400 billion of economic activity in the United States alone (Penprase, 2018).

Perhaps a suitable metaphor for the methods by which universities navigate and respond to the trends of the time, such as digital disruption and rapidly morphing labor markets, is to denote them as being part of the University 4.0 evolution. Characteristics of the new University 4.0 paradigm have slowly been introducing themselves to an extent, with a unique acceleration occurring during the year that the globe was struck by the COVID-19 pandemic. Aspects of higher education, such as on-demand learning, an increased focus on shorter-term qualifications (condensed learning programs, for example), the prevalence of career management at the undergraduate level, and coordination with industry (fulfilling the role of broker between entrepreneurs and potential supporters), have muscled their way to the forefront of our reimagining of university education.

In 4IR, the pace of change has been quicker than in the past. Traditional PSET (slow to change) is contending with this, and, at the same time, new players and business models are rapidly emerging. PSET providers, particularly staff, have to learn the many changes and be exemplars themselves. This requires both a top-down and bottom-up approach—the change management should be strategically enabled. However, this reworking is done to bring about not only education "efficiencies" but also a way of thought in which disruptions become a new norm.

Emerging technologies leading toward University 4.0

The profound escalation in the performance and availability of connected mobile devices as well as continually down-trending prices for high-speed Internet access, coupled with quality online educational tools (online courses, interactive and remote learning, and so on) has brought about drastic paradigm changes to the delivery of educational services. Alongside this, the COVID-19 pandemic has, perhaps, forced many institutions to ramp up their adoption of this new type of educational service delivery, given the necessity for online distance learning. With COVID-19, in a way, the online approach was forced upon them.

Geographical borders became more virtual than before, and new education business models have emerged. This brings about a prominent change in the engagement of international students—the landscape has been altered. Institutions with significant brand leverage, often well resourced, are elevating the competition. At the same time, technology companies with the ability to disrupt are also coming to the fore.

The aspect of learning can be seen as the nexus among teaching, research, innovation, and community service. Learning is evolving in the form of "University 4.0"—the university as a "platform"; thus, in cloud computing terminology, one could think of "University 4.0" as a service.

When thinking of "X" software or software platform as a service over the Internet, one must keep in mind the dangerous corollary that inevitably follows—the services of the dark or deep web. Hidden in the layers of this dimension of the web is the aspect, for example, of ransomware as a service (Zimba et al., 2018). Analogous to the online "rise," cybersecurity challenges have simultaneously grown during the COVID-19 period. The technique to deal with cybersecurity requires an augmented approach—data collected and deep learning algorithms coupled with human intervention (Baygin et al., 2016). In other words, like the methods for managing spam, deep learning technologies are a key contributor in dealing with cybersecurity and the associated challenges.

Perhaps the most widely recognized application of the digital revolution to education is massively open online courses.

Emerging technologies have always been around, and drove the Third Industrial Revolution. For 4IR, our thinking is shaped primarily by artificial intelligence (AI) and the aspect of deep learning. What is amazing here is that the world, like the ocean, has data. We often use the ocean analogy—there's an expression that, in the ocean, there's so much water yet not a single drop to drink. Likewise, the digital economy contains astronomical amounts of data, but we contend with many limitations that prevent us from utilizing all of these data in any meaningful way.

Through the Third Industrial Revolution, we now access (say) 25% of the data that we have; this could be because the available technologies for computing and communication have not yet converged in a manner that is sufficiently sophisticated. We have the opportunity to harness, through 4IR technologies (machine learning and, increasingly, deep learning), the other aspects of available and emerging data. We have to do this carefully and through "appropriate" technologies and an ethical approach.

For example, we were enthused by smart-metering data provided recently. A side-by-side comparison of the metering data with traffic data, however, revealed that we're getting information about what people are doing, where they are at what time, and so on. Such traffic systems also face probable security breaches, compromising data privacy and trust. There is an unintended "collusion" of computing algorithms and potential for "algorithm colonization," and we have to ensure that our take is in a multidimensional way.

This approach will help us evaluate and utilize technology for the ecosystem of learning. This problem is, in part, being addressed by a strong push for open access software with less-restrictive licensing, which effectively decentralizes a large portion of the digital marketplace.

Blockchain technology burst into the public eye with the rapid increase in U.S. dollar value experienced by Bitcoin, the most widely known cryptocurrency, near the end of 2017. Setting aside the cryptocurrency space, the underlying blockchain technology could prove invaluable for data security and integrity and solves many of the problems experienced with centralized networks.

IMAGE LICENSED BY INGRAM PUBLISHING

The history of a digital asset stored in a blockchain is both transparent and unalterable through its decentralized nature and strong encryption. Trusting a central authority is removed from the equation, seeing that it is, rather, established through network consensus—essentially, a marriage of public information with a system of counterbalances that maintains block integrity and creates trust among users.

Blockchain technology could, however, also play a role in the way course credits compile toward a qualification. Accompanying certification could also be verifiable. One example is the utilization of blockchain technology for education credit and grading systems, available on the EduCTX platform (Turkanović et al., 2018). Within the broader physical infrastructure, blockchain technology has wide-ranging applications, including the asset-value chain, library access, and copyright as well as student records and profiles (Al Harthy et al., 2019).

Applications of 4IR in higher education

Perhaps the most widely recognized application of the digital revolution to education is massively open online courses (MOOCs). Removed from the classical model of students gathering in a lecture hall, the MOOC paradigm eliminates the requirement for physical proximity to deliver lectures. Moreover, classes that are much larger than a typical university classroom can be accommodated and expanded with little to no infrastructure-related obstacles. The demand of such services is self-evident, with the exponential increase in the availability and utilization of services; providers include Coursera, edX, Udemy, and Skillshare, to name but a handful.

However, one should be careful with evaluating MOOCs on the same terms as conventional university classroom-based instruction, as these two pathways serve different roles. Coupled with distance learning programs (albeit not unique to such programs) are active discussion boards, where students can interact with each other and instructors and tutors. An evolution of classroom instruction could just as easily be virtual and live action, as opposed to prerecorded and available on demand.

MOOCs, in this sense, are much more useful to augment the fundamental education experience, with

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credit transfer in some instances, rather than replace it entirely. In programs where a laboratory component is required, innovative alternatives may be possible. For example, a project-based learning experience could enable "learning by doing" and, simultaneously, a multidisciplinary approach to education. A conceptual diagram illustrating these concepts is shown in Fig. 1, highlighting the interactive nature of remote learning applied to the traditional classroom.

Another application that rapidly gained traction is the automation of administrative tasks. Gradescope, a tool that automates the grading process of almost any subject area, is utilized by more than a thousand universities (Atwood and Singh, 2018). The aim of this service is to provide strong assistance with handwritten or online assignment grading, and it enables detailed reporting on the progress of each student in addition to identifying potential problem areas for early warning.

This allows instructors and tutors to spend their time more valuably elsewhere—feedback captured from users over a four-year period revealed that two thirds of users reported time savings of more than 30%—and other administrative tasks could be tackled through similar means. Larger numbers of students could be reached in this way with roughly the same amount of teaching and administrative resources, and users are generally able to grade with greater consistency and flexibility, seeing that the platform allows back-annotation of rubric modification. Moreover, Gradescope provides students with greater transparency in grading methodology, which efficiently aids in learning from mistakes.

Using AI to improve writing (technical and otherwise) can be accomplished through Grammarly (O'Neill and Russell, 2019), a tool that intelligently plugs into a web browser, document-generation software, and even mobile and desktop operating systems. It utilizes a natural language processing engine to improve writing style, enhance clarity and conciseness, and expand vocabulary, and it even provides an estimate of the tone conveyed by a particular message.

Grammarly can, therefore, be useful to improve writing and communication in a variety of settings in addition to academic writing for students and staff alike. In an integrated approach, where the student completes a first evaluation, the workload for the instructor is reduced. The approach of Grammarly to evaluate text for emotions and improve the writing "behavior" illustrates the 4IR future trajectory. On the other hand, one could argue that AI-based tools are paid twice—they earn from software licensing and, simultaneously, as the data enrich their own capabilities.

University education as a service

The modalities for credentialing continue to evolve. The University of Johannesburg (UJ) recently implemented digital certificates, or badges—an aspect of open online courses and collaboration. UJ has implemented a continuing education program, using a cloud computing platform, through the Applied Information Systems Department (part of the College of Business and Economics). Here, we are exploring the approach of cloud computing as a service and investigating how scalable high-performance computing could be used by businesses and universities.

The cloud computing platform being used, as an example, is Amazon Web Services (AWS). The approach also couples with AWS certification for additional graduate value. The aspect of learning "as a service" was mentioned earlier, and we will continue this development by placing greater emphasis on research and innovation.

Some further AI-based examples of how learning and innovation couple include the following. We have implemented a tool, Teqmine, that

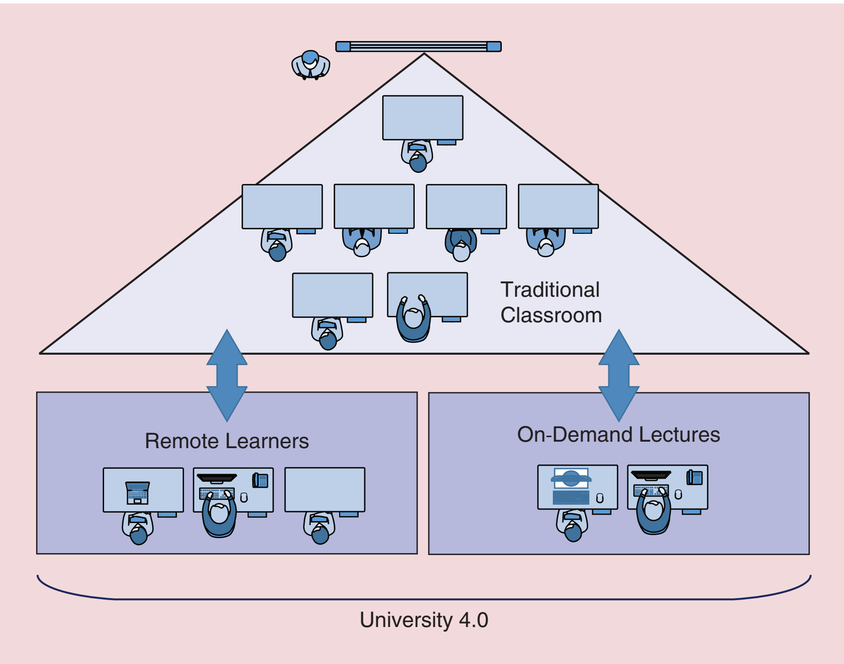

FIG1 The expansion of the university into the online space.

harvests intellectual property (IP) with commercialization potential, as an input into the learning process; this helps identify IP "collaborators" internally and outside of the university. Various initiatives to increase participation in netpreneurship (that is, online businesses without any physical offices) among the youth population are in the works. (The Africa Netpreneur Prize is one of these.)

Youth have a greater uptake for technology, and we expect a rise of netpreneurship through similar avenues. We foresee a blend of innovation to all aspects of teaching and learning: the university "as a service" would enable the bringing together of IP, internal to the institution and also otherwise. We live in exciting times.

Paradigm shifts are hard to implement—the PSET sector can be slow to adapt, and we have to find ways of disrupting the system. At UJ, we implemented a 4IR catalytic set of initiatives over five years as well as pilot initiatives.

First, we are aggressively recruiting from academia and industry, postdoctoral research fellows, master's and doctorate degree students, professors of practice, and so on. Second, we are catalyzing 4IR evangelists in both the academic and professional domains. Our library, often seen as the heart of academia, has implemented a number of 4IR initiatives, from an automated checkout procedure, to advancing search parameters, to wellness programs for students based on their opted-in data, and so on.

Our quest herein is for a way forward to see "impediments" as "opportunities," and this is the course for our change management. The university's library has, in particular, become a hub of 4.0 activities—this allows for cross-disciplinary dialog; it is ultimately about ethically aligned AI. The aspects of both emotional and ethical intelligence emerge through cross-disciplinary conversation, as the approach brings about continuous reflection.

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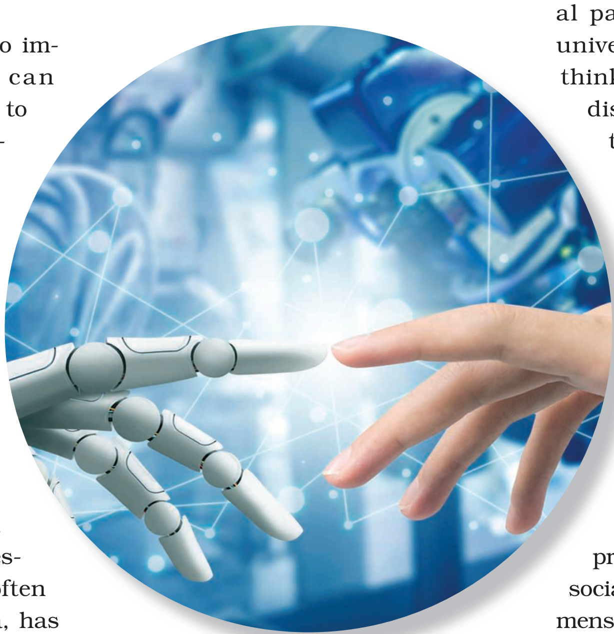
A growing pain of utilizing AI technology is the resource intensity of producing useful results. Complex models reliant on massive amounts of data require processing infrastructure that, in most cases, is simply not available to academics and graduate students. For academia to continue its contribution, collaborative industry and cloud computing initiatives are necessary (Morrisett et al., 2019).



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This has been a growing problem for researchers and the institutions within which they function, and enumerating the enablers and barriers for the adoption of cloud computing services in academia has become a key challenge. Software as a service comes into play, which has gained traction as a model for many business applications and entails a thin client (through, e.g., a web browser) that provides access to centrally hosted software. This is fairly similar to the operation of a traditional gateway. A similar interface to computational infrastructure for university students and researchers could be explored, with the potential of commercial monetization of such resources providing a sustainable financial model to provide such services to students.

We can, but should we?

The "Applications of 4IR in Higher Education" section alluded to an important aspect of the increasingly remote learning constraints that higher education is being forced to operate in, given the global pandemic. The foundations of universities are laid upon critical thinking. The example of MOOCs discussed earlier is representative of the bigger questions surrounding the integration of University 4.0 and the extent to which that augments the campus experience and, by extension, the role and identity of the university as an institution.

The university serves a crucial role in society and is much more than an institution through which a qualification can be earned. It also provides tremendously important social experiences that are often immensely impactful on the remainder of students' lives.

One of the basic human psychological requirements—the need for contact with other people—has been accentuated during the COVID-19 pandemic, perhaps more than ever. The complexities of the interactions among individuals do not permit remote contact to satisfy our basic need for face-to-face relationships (Kwon et al., 2020). This is self-evident for our case of higher education, including psychosocial implications. Regardless of the ever-increasing costs, students flock to attain the campus experience, of which the

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degree awarded at the end of their tenure is but a small part.

Conclusion

South Africa's higher-education systems have developed inclusiveness and excellence and are undergoing transformation. Going forward, we are interested in better and appropriate utilization of student data—to see how we can provide student support in various ways.

For example, utilizing Blackboard Predict, we can attain early warnings of a student who is struggling and determine the appropriate support interventions. We have embedded chatbots into our law programs that smarten based on questions asked and responses seen as favorable by a qualified professional. (In the approach, the online agent self-learns and improves.) For cross-disciplinary education, we are looking to infuse a "1 + 1" model for innovation—an approach that helps our students think inside, outside, and without the box as well as toward the Internet of Things.

We are therefore seeing technologies as a way to further our approach for education that transforms society, simultaneously developing inclusiveness and deepening excellence. However, we need to ensure that we accelerate an augmented approach for cybersecurity—we see that, with growth in the Internet of Things and other areas of connectivity, security loopholes will grow, perhaps even faster, and much awareness is necessary regarding this. An equally driven effort toward data security is contending with the dark web and ensuring that user privacy is maintained. Alongside the technological challenges, societal impact must also be incorporated in the transition to a more connected higher-education experience.

On balance, we expect higher education will be more hybrid than ever before. A greater online approach will enhance student-centered customization, access, and excellence, augmented with in-person, transdisciplinary interactions. Ultimately, however, it must be borne in mind that the purpose of education is beyond merely acquiring skills and develops preparedness for lifelong learning—this is how graduates adapt to the ever-changing world of work.

Read more about it

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About the authors

Jaco du Preez (jaco.dupreez7@gmail.com) is currently pursuing his master's degree at the University of Johannesburg. He is a research associate at the University of Johannesburg, Auckland Park Campus, Johannesburg, South Africa. His research focus is in millimeter-wave power combining amplifiers.

Saurabh Sinha (ssinha@uj.ac.za) is a professor and deputy vice-chancellor of research and internationalization at the University of Johannesburg, Johannesburg, South Africa. He is a Fellow of IEEE.

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