BASIC SCIENCES IN HIGHER EDUCATION, AND TEACHING APPROACHES IN THE CONTEXT OF 21ST-CENTURY ADVANCES: TIME FOR A CHANGE?

G. J. Maarman
Department of Biomedical Sciences
Centre for Cardio-Metabolic Research in Africa
Stellenbosch University,
Stellenbosch, South Africa
https://orcid.org/0000-0003-3336-5594

ABSTRACT

Higher education has become a leading life goal for youth across the world. More specifically, the higher education of basic scientists is key in the creation of new developments in economics, healthcare, science, and technology. However, advances and challenges that came with the 21st century have impacted how basic science research is conducted and how basic scientists function within a rapidly changing world. Without a doubt, the way in which basic scientists are trained at higher education institutions needs to be revisited and adapted where needed. By means of a literature review, this article demonstrates the significant challenges and advances in the 21st century, and how these impact the higher education of basic scientists. To summarise, training programmes must include a digitalisation focus and teach the use of digital technology to disseminate research findings to the lay public. Training must hone the skills that will help scientists to survive job scarcity in academia, skills such as curriculum vitae writing, promoting oneself as employable to industry companies and how to repurpose academic experiences for a different job market. Other aspects that need to be included are raising awareness, among the next generation of basic scientists, of the need to conduct research that has nationally and internationally relevant foci. Training must include mentorship during postgraduate training, the use of hybrid models of teaching, curricular integration and interdisciplinary learning and practices during the early stages of these scientists' careers. Lastly, undergraduate degrees give a general introduction to the basic sciences, but leave graduates with insufficient laboratory experience, and thus they struggle to enter the job market after their undergraduate degree is completed. In other fields, a B. in Accounting makes a graduate an accountant, B. Eng makes them an engineer, but BSc. equates to nothing besides several introductions to various fields. More must be done.

Keywords: higher education, teaching, basic sciences, undergraduate, postgraduate, pedagogy, South Africa

INTRODUCTION

Basic science, albeit known to the medical fraternity and scientific community, has shot to fame with the COVID-19 pandemic (Evans et al. 2020). Its importance in combating the global disease burden (Bedford et al. 2019) and strengthening the healthcare sector (Sheikh, George, and Gilson 2014) cannot be denied. The higher education of basic scientists is vitally important as it leads to the training and development of the next generation of scientists in the basic sciences (Arias 1989) or biomedical researchers in a clinical setting (Burman et al. 2019). The profound impact of the higher education of basic scientists has been demonstrated for as long as one can remember, with discoveries such as the eradication of smallpox in 1757 (Riedel 2005) and penicillin in 1928 (Foletti and Fais 2019).

The 21^{st} century came with several challenges and advances in economics, healthcare, science and technology (Northam 2015). These have made a significant impact on the way basic scientists are trained at higher education institutions (Tang Wee, Tan, and Yann 2020). In brief, the 21^{st}-century world has new needs to which basic science education and research must adapt to remain relevant and to fulfil more prominent leadership roles. There is a need to address several challenges that basic sciences have encountered in the last few decades, including job scarcity, graduate unemployment, a trend to shift from academia to industry etc. In order to draw meaningful inferences about how the higher education of basic scientists can be improved, this article reviews higher education globally and reviews higher education approaches in basic sciences with a strong African perspective. Subsequently, recommendations are made based on the reviewed literature. To achieve these aims, the relevant literature was perused and reviewed via the search engines PubMed, LISTA (EBSCO), Web of Science Core, Google, and Google Scholar.

THE MEDICAL SCIENCES

In the medical arena, several branches are commonly referred to as "basic sciences" (Yograj et al. 2019). These include disciplines such as human genetics, medical immunology, medical microbiology, medical biochemistry and medical physiology (Joyner 2011). They are called basic sciences largely because of their fundamentality in medicine (Dominguez and Zumwalt 2020) and research (La Caze 2011). Basic sciences are instrumental in research in which studies are conducted on cell lines and laboratory animals (Bhatt 2010). Inferences drawn from these studies are translated to the first four phases of clinical trials (Friedman 2016), and the latter should usually not be attempted without being substantiated by good basic science research (Mohs and Greig 2017). The COVID-19 pandemic has shone more light on the roles of basic science (Dobson 2020) and has reiterated its importance in the clinical management of patients (Biochemistry 2020). To people who are unfamiliar with research, COVID-19 and especially the development of a vaccine have provided insight into the important role that basic science research play in the development of vaccines and new medications. COVID-19 vaccines are grounded on years of basic science research, which has led to a better understanding of coronaviruses (Marian 2021). Moreover, vaccine concepts were first tested on cell lines and laboratory animals before vaccine candidates reached the clinical trial phases. It is safe to say that without basic science, COVID-19 vaccines would not have been possible (Bok et al. 2021). Basic science has also played an important role in the development of vaccines for diseases such as tuberculosis (Kaufmann 2020) and smallpox (Bidgood 2019). In line with this, the World Heart Federation contends that in order to combat cardiovascular disease, more should be done to ensure translation from basic science research to the clinical arena, for example, support structures that promote translation of experimental research to clinical trials (Maarman, Chakafana, and Sliwa 2020).

Basic sciences are also key to the management of many diseases (Filewod et al. 2018) because they deal with gaining a better understanding of how and why diseases occur, and how medication and therapies alter diseases to promote health. The life-changing impact of basic sciences was further shown when basic science research led to the development of better medication for heart (Dzau and Balatbat 2017; Lim and Hausenloy 2012) and lung (Maarman 2019; Maarman 2020; Maarman and Lecour 2021) diseases.

Furthermore, every physician should have a good understanding of the basic sciences (especially medical physiology) when practising medicine in a clinical setting. Medical physiology is crucial to the understanding of clinical tests such as those for electrolytes and plasma creatinine, the basics of an electrocardiogram, the use of a sphygmomanometer or the application of lung function tests (Joyner 2011) when managing patient diseases. Albeit common sense to the experienced eye, there is a difference between beta-adrenergic receptor blockers, calcium channel blockers, alpha-2 receptor agonists and angiotensin II receptor blockers, even if they all influence blood pressure (Opie 1980; 1997). Doctors should know this and can only do so with a good command of the basic concepts of medical physiology. Basic sciences certainly form the cornerstone of the first phases of the training and education of health professionals (DeFranco and Sowa 2014).

Higher education is defined as tertiary education that leads to the award of an academic degree (Bartik and Erickcek 2007). At university level, higher education is further divided into undergraduate and postgraduate degree programmes, and in this context, basic science students usually enrol in BSc programmes that are followed by BSc honours, MSc, and PhD programmes. Higher education in the basic sciences aid in the moulding of the next generation of scientists and biomedical researchers, who are the future of the field (Campbell 2003).

HIGHER EDUCATION IN FIRST WORLD COUNTRIES: A HISTORIC VIEW

Higher education has become a leading lifegoal for young people 20–24 years old across the world. According to the Higher Education Statistics Agency, there were 165 higher education institutions in the United Kingdom in 2020 (HESA 2020), whereas Statista show that from 2019 to 2020, more than 2.53 million students were enrolled in higher education courses in the United Kingdom (Statista 2020b). The United States of America had 3 764 institutions from 2019 to 2020 (Statista 2020a), and in the same period, close to 17 million students were enrolled in higher education institutions on this continent. According to the National Science Foundation, in 2017, 62 per cent of all international students in graduate programmes at United States of America institutions were enrolled in science-related fields (Foundation, National Science 2018). These are some of the countries that boast with the best education in the world, together with others such as Australia and the Netherlands. They have moved away from an isolated disciplinary model of education that lacks connectedness among different learning experiences (Islam et al. 2016) and have promoted curricular integration and interdisciplinary learning and practices (Irby, Cooke, and O'Brien 2010; Wartman et al. 2001). These countries have managed to achieve great success in higher education, and basic scientists from these countries often move to less fortunate countries to make a global impact through research.

HIGHER EDUCATION IN LOW-TO-MIDDLE-INCOME COUNTRIES: A HISTORIC VIEW

Tracing the origin of higher education in developing countries is a challenging task and perhaps a contentious issue for several reasons outside the scope of this article. However, it has long ago been recognised that developing countries are establishing higher education institutions at a fast pace and in parallel with the rate of developed countries (Zhang 1987). Based on a uniRank database report, there were 1 225 higher-education institutions in Africa in 2020 (database 2021). With 48 countries and a population of over one billion, Sub-Saharan Africa is one of the largest regions in the world, with approximately 600 public universities, 1 000 private universities, and approximately nine million enrolled students (Groups, World Bank Country and Lending 2020).

Basic science undoubtedly has a strong foothold in sub-Saharan Africa (Blom, George, and Adil 2016), and a after successful higher education period, basic scientists make meaningful contributions to global development (Chankseliani, Qoraboyev, and Gimranova 2021). However, many challenges in higher education prevail in this region of the world (Goolam 2011). These include poverty (Machika and Johnson 2015), high tuition fees (Wangenge-Ouma 2012), poor funding support (McKay, Naidoo, and Simpson 2018) and challenges with regard to the implementation of e-learning (Zarei and Mohammadi 2021). UNESCO reported that in 2020, 89 per cent of students in sub-Saharan Africa had no access to household computers and 82 per cent lacked access to the internet (UNESCO 2020). Furthermore, despite Africa having a relatively high graduate output compared to the first world (Dei, Osei-Bonsu, and Amponsah 2019), more development is needed in terms of "under-preparedness" of high school graduates, quality-enhancing investments in facilities and educators, and higher education strategies (Tewari and Ilesanmi 2020).

THE 21ST CENTURY AND ITS IMPACT ON HIGHER EDUCATION

Basic sciences teaching approaches required in the face of 21st-century advances

One must acknowledge that the 21st century came with industrial, social, and technological advances and challenges that have impacted the world in many ways. These include urbanisation and the displacement of animal species, water scarcity, the restriction of energy resources (Gambheera 2016), multidimensional population growth, inconsistency in the policies of various regimes and political instability (Salmi 2020). Furthermore, it came with technological advances such as Bluetooth, social media, self-driving cars, three-dimensional printing, and fibre optics (Yamin 2019). Without a doubt, these advances and challenges have made their impact on the global stage by influencing the global economy, the healthcare sector and higher education (Robertson 2021).

It might be asked, "*How do these advances influence higher education in basic sciences?*" Most certainly this influence takes place by means of revolutionised information and communications technology practices, digitalisation, internationalisation, globalisation, marketisation, commodification and deregulation policies. Scientists function within a local and global context, and, of course, research is influenced by advances or challenges on a local and global scale. For example, information and communications technology has brought about revolutionary changes in the way that people work, communicate, learn, spend time and interact (Jorgenson and Vu 2016). It has further transformed the practices of businesses, governments and higher education institutions with regard to the use of information and communication (Salmi 2020). These 21st-century advances certainly impact how basic scientists communicate their research findings to the scientific community and the general public (Ross-Hellauer et al. 2020).

Digitalisation

Digitalisation in higher education refers to the use of digital technology to teach students through desktop computers and/or mobile devices connected to the internet, using software applications, online teaching portals and other types of digital technology for teaching (Schmidt and Tang 2020). Online portals are instrumental in the teaching of basic science theory. However, basic science is largely laboratory-based, and this is challenging because laboratory skills are not easy, albeit not impossible, to teach digitally. Nonetheless, a basic scientist will have to function in a world where digital technology reigns and must therefore be technologically knowledgeable. Many basic science research instruments and tests use digital technology to generate and analyse data, and technology is used to publish and disseminate research findings. In the basic science sphere, the COVID-19 pandemic has influenced the way in which digital technology is used to train basic scientists. During the pandemic, social media platforms have become useful tools for governments and pharmaceutical companies to put the public's mind at ease regarding vaccines (Abbas et al. 2021). This technology was also utilised by scientists to communicate their research to the public (Song and Karako 2020). Thus, as opposed to previous decades, it has become a requirement to include digitalisation as a key focus in the higher education of basic scientists.

Internationalisation

Internationalisation of higher education is the process of integrating an international, intercultural or global dimension into the purpose, functions or delivery of postsecondary education (De Wit and Altbach 2021). This shapes the missions and goals of higher education institutions (Zha 2003), and, moreover, the current labour market requires graduates to have international, foreign language and intercultural skills to be able to interact in a global setting (Hénard, Diamond, and Roseveare 2012). Therefore, higher education institutions are placing increasing importance on internationalisation (Hénard et al. 2012). In the teaching and learning of basic scientists in the higher education sphere, internationalisation has become important because basic science research is generally conducted with a country-level focus, for example, tuberculosis research in South Africa, where the disease is rife. However, this research has global relevance as infectious diseases can spread to other parts of the world or infected individuals may create a less effective workforce, which has a global economic impact. Basic scientists must, therefore, perceive themselves and their work through the lens of internationalisation and conduct research with an international focus. Young budding scientists must be made aware, quite early in their postgraduate careers, of the need to conduct research that has a broader global focus. For example, basic science research in the medical field, such as medical physiology research, should not only focus on in vitro research but should also aim to translate research from bench to bedside (Iyngkaran and Thomas 2015; Martinez and

Kornfeld 2019). This is also relevant to basic science research on, for example, pulmonary hypertension, which is rife in Sub-Saharan Africa but also highly prevalent in developed countries (Maarman, Shaw, and Allwood 2020; Wijeratne et al. 2018). In such a case, conducting basic science research and only focusing on in-country populations or in vitro models is a loss for other countries that could also benefit from research with a broader focus.

Globalisation

Globalisation refers to the interconnectedness of people and institutions globally, which may lead to global cultural, political and economic integration (Dzvimbo and Moloi 2013). Many role players in civil society and industry are focusing their attention on globalising their efforts, and companies are beginning to require job professionals to be aware of and function with a globalised mindset. Global competencies and multicultural skills are needed for a future basic scientist to succeed in such a globalised world (Nayyar 2007; Woodard et al. 2011). These skills include cross-cultural communication skills, excellent networking abilities, the ability to foster cross-disciplinary networks, a strong sense of collaboration across racial and economic divides, and awareness of and the ability to overcome language, communication and cultural differences (Nayyar 2007; Woodard et al. 2011). Therefore, 21st-century advances and challenges necessitate corresponding changes in the higher education of basic scientists so that globalisation is incorporated into the training and learning of basic scientists at universities from an early stage (Kromydas 2017).

Africanisation

The impact of colonialism on African higher education has been reviewed extensively (Abrokwaa 2017). This has led to a deeper academic discourse on the need for, validity and potential outcomes of Africanisation in higher education (Botha 2010). Africanisation aims to affirm African cultures and identities in a global community (Crossman 2004). It further implies that education and training, as well as praxis, be informed by the reality of the African context (Van der Westhuizen, Greuel, and Beukes 2017). Thus, it is important to inspire a consciousness of issues or challenges that are unique to the African continent (Kamwendo 2016), and to do this during the early development of future basic scientists. Questions that are key during the training of next-generation basic scientists include the following, *what does the job market lack in Africa? What are the challenges in Africa that basic science can help overcome? To achieve this, how should basic science curricula be adjusted, if need be?*

For example, a few decades ago, the use of traditional herbs and medicinal plants was frowned upon by the global medical fraternity (Miranda 2021), as Western medicine was considered the be-all and end-all of the medical field. It is encouraging to see that in the last few years, Universities on the African continent have incorporated traditional herbs and medicinal plants as possible therapies against diseases in their (basic science) research programs (Street and Prinsloo 2013). This approach has also been adopted by the World Health Organization (Lezotre 2014; WHO. Programme on Traditional Medicine 2000) and research funding bodies in Africa who now fund basic science research that focuses on creating medicine from Africa, for Africa. It is important to realise that training future basic scientists who reside in Africa, should provide the opportunity for them to use their skills to create solutions for the context in which they live and practice. This will advance Africanisation in the higher education of basic scientists, leading not only to a change in their training but also in the impact they make in Africa and the world.

Personalised medicine

Extraordinary molecular advances have changed the way that doctors treat patients (Hutchinson and DeVita 2008) and have given rise to precision medicine that is used for targeted treatments based on individual patient characteristics (Sigman 2018). Personalised medicine may incorporate biomarkers but also patient preferences and social and economic factors (Fröhlich et al. 2018). Personalised medicine comprises medical decisions, practices, interventions and/or products that are tailored to the individual patient based on his/her predicted response or risk of disease (Fröhlich et al. 2018). This raises the question, "*Is basic science still relevant in the era of personalised medicine?*" Of course, it is, but it is important to train undergraduate and postgraduate basic science students on how to adapt their research approaches in this context. The training programmes of next-generation basic scientists could include dedicated time spent on clinical research studies to gain more experience and develop a better sense of personalised medicine in real-time.

Job security

Making the transition from an undergraduate or postgraduate student to an employee at a university is challenging (Talgar and Goodey 2015). In the same vein, academia has historically displayed gender disparity (Casad et al. 2020) and racial inequality in many parts of the world (Moore et al. 2018). These challenges have been reviewed and discussed endlessly, and it is time that universities address them early on in undergraduate and postgraduate programmes (Bhopal 2017; Malisch et al. 2020). It is unacceptable that some tertiary institutions still have, for example, senior positions that are largely occupied by white individuals (Arday 2018; Mabokela 2000). It cannot be that academics can conduct highly intelligent research projects and create solutions for the world's biggest medical and technological conundrums but cannot find a solution to racial and gender inequality in higher education.

Making the transition from student to an academic employee requires a particular set of skills (Talgar and Goodey 2015). These include grant writing, academic writing, forming professional networks, establishing research collaborations (nationally and internationally) and creating a footprint in research by becoming an internationally recognised researcher. However, although these skills are learnt through a journey of training and practice, more must be done to help the next generation to acquire them earlier (Turner et al. 2012). One of the most effective ways to achieve this is through mentorship (Bäker, Muschallik, and Pull 2020), which is a way to facilitate academic and research development (Kunselman, Hensley, and Tewksbury 2003). An effective mentorship programme during the training of basic scientists can promote the recruitment and retention of promising students and early-career researchers (Marino 2021). Universities should begin to include more formal/structured mentorship programmes for developing basic scientists at the postgraduate level, if not earlier. It may help the next generation of basic scientists and academics to learn early on how to navigate challenges in a work environment (i.e., grant writing, establishing one's own research group, academic writing, prolific publishing, etc.).

Academia is a tough career, often fraught with years of unsuccessful grant applications, more than 80-hour weeks and the psychological atrocities of the tenure system (Van Maanen 2015). The pinnacle of an academic career, desired by many, is a full-time position as a lecturer, associate professor, or full professor. Upon successful completion of postgraduate training, most basic scientists dream of a job in academia (Kenner and Pressler 2006). However, the journey is challenging, especially with a lack of permanent employment, high-performance requirements, strong competition and fixed-term employment contracts (Ortlieb and Weiss 2018). According to a 2021 Statista report, the number of unemployed people rose to 220.5 million globally (Statista 2021). In the last two decades, job scarcity has not only troubled the economic and technology sectors but also higher education and academia (Ortlieb and Weiss 2018). Job loss has become more evident during the COVID-19 pandemic (Blustein et al. 2020). In many countries around the world, graduate unemployment has become a concern (Mgaiwa 2021). It has become more difficult to secure a job in academia, more so if the applicant is a basic scientist because their training is designed to prepare basic scientists for a career in an academic research environment and not an industry (Woolston 2021). It is perhaps time that we rethink the teaching approaches followed during the higher education of basic scientists. Job scarcity is forcing basic scientists to apply their skills outside of academia, and to assist the next generation in this, we need to include the honing of new skills during undergraduate and postgraduate training. These could include curriculum vitae-writing skills, skills for selling oneself for job opportunities in the industry (outside one's field of expertise) and making a few weeks during laboratory training available for job shadowing at, for example, pharmaceutical companies. A similar approach is followed for MBChB programmes in certain countries, where students take time off to gain experience in other fields such as research and service delivery. Alternatively, universities can provide support and advisory services to students in terms of their careers and making the transition from education to employment during training.

The 21st century demands radical advances in training and teaching, new forms of competition, and new configurations and modes of operation for higher education institutions (Salmi 2000). Thus, teaching approaches in the higher education of basic scientists must be adjusted accordingly, and new teaching/learning approaches that enable the development of critical and creative thinking should be integrated. Having established the need for change in higher education of the basic sciences in proportion to global advances in the 21st century, this change must be well-guided (Kang et al. 2020). A recent publication has demarcated four models of higher education that will be crucial: the Tamagotchi, Jenga, Lego Set and Transformer models (Orr et al. 2020). In brief, the Tamagotchi model is the approach of entering higher education directly after secondary school, whereas the Jenga model comprises later phases of self-learning and organisation. The Lego Set model combines modules of different sizes, making for a self-reliant and non-standardised learning path rather than one compact unit (Orr et al. 2020). Lastly, the Transformer model represents learners who return to higher education later in life to acquire new basic knowledge or upskill their formal education [38]. These are only some of the reported models of higher education, and whichever one is implemented depends on the needs of the specific country, based on global changes.

To ensure that humanity is prepared for the next pandemic, we need to produce more next-generation scientists who conduct good-quality research to the benefit of the world. Needless to say, their training has to be improved in parallel with the changing world in which they function.

STRATEGIES IN THE HIGHER EDUCATION OF BASIC SCIENTISTS IN THE 21ST CENTURY

The following has become important in the training of next-generation scientists:

- Include digitalisation and the use of digital technology in research and the dissemination of research findings during training.
- Hone the skill of communicating research to the general public by utilising the latest

technological advances (Martinez 2018) as part of formal training (Brownell, Price, and Steinman 2013).

- Have a strong focus on Africanisation in the training of basic scientists.
- Incorporate internationalisation as a key focus in training.
- Create awareness of the need to conduct research that has a national and an international focus.
- Hone skills such as curriculum vitae writing, promoting oneself as employable and repurposing academic experiences for the job market (Hanlon 2019).
- Make mentorship more prominent and structured during postgraduate training to assist basic scientists (especially postgraduate students) in overcoming challenges in grant writing, establishing a research group, achieving professorships and so forth (Zimmerman 2018).
- Improve and employ hybrid models of teaching, curricular integration and interdisciplinary learning and practices during the early stages of university training.
- Rethink the way in which BSc degrees are designed, as the current format leaves many graduates with a 3-year degree, but they struggle to find jobs. This compares poorly to other undergraduate degrees in other fields, and although a broad introduction to several fields of science has a role, more need to be done to leave graduates skilled and ready for a job, not just in academia or research but industry.

CONCLUSION

This article demonstrates the significant challenges and advances of the 21st Century and how these impact the higher education of basic scientists. Training programmes must include a digitalisation focus and educate basic scientists on the use of digital technology to disseminate research findings to the lay public. Training must hone the skills that will help scientists to survive job scarcity in academia, skills such as curriculum vitae writing, promoting oneself as employable to industry companies and how to repurpose academic experiences for the job market. Other aspects that need to be included are creating awareness among next-generation basic scientists of the need to conduct research that has nationally and internationally relevant foci. Training must include mentorship during postgraduate training, the use of hybrid models of teaching, and curricular integration and interdisciplinary learning and practices during the early stages of their careers. Undergraduate degrees give a general introduction to the basic sciences but leave graduates with insufficient laboratory experience, and thus they struggle to enter the job market after their undergraduate degree is completed. In other fields, a B. in

Accounting makes a graduate an accountant, B. Eng makes them an engineer, but BSc. equates to nothing besides several introductions to various fields. More must be done.

CONFLICT OF INTEREST

None to declare.

REFERENCES

Abbas, J., D. Wang, Z. Su, and A. Ziapour. 2021. "The Role of Social Media in the Advent of COVID-19 Pandemic: Crisis Management, Mental Health Challenges and Implications." *Risk Manag Health Policy* 14: 1917–1932. https://doi.org/10.2147/rmhp.S284313.

Abrokwaa, Clemente. 2017. "Colonialism and the Development of Higher Education." In *Re-thinking Postcolonial Education in Sub-Saharan Africa in the 21st Century: Post-Millennium Development Goals*, ed. Edward Shizha and Ngoni Makuvaza, 203–220. Rotterdam: SensePublishers.

Arday, Jason. 2018. "Understanding race and educational leadership in higher education: Exploring the Black and ethnic minority (BME) experience." *Management in Education* 32(4): 192–200. https://doi.org/10.1177/0892020618791002. https://journals.sagepub.com/doi/abs/10.1177/0892020618791002.

Arias, I. M. 1989. "Training basic scientists to bridge the gap between basic science and its application to human disease." The *New England Journal of Medicine* 321(14): 972–974. https://doi.org/10.1056/nejm198910053211412.

Bäker, Agnes, Julia Muschallik, and Kerstin Pull. 2020. "Successful mentors in academia: Are they teachers, sponsors and/or collaborators?" *Studies in Higher Education* 45(4): 723–735. https://doi.org/10.1080/03075079.2018.1544235.

Bartik, Timothy and George Erickcek. 2007. "Higher Education, the Health Care Industry, and Metropolitan Regional Economic Development: What Can 'Eds & Meds' Do for the Economic Fortunes of a Metro Area's Residents?" Upjohn Institute Staff Working Paper No. 08-140.

Bedford, Juliet, Jeremy Farrar, Chikwe Ihekweazu, Gagandeep Kang, Marion Koopmans, and John Nkengasong. 2019. "A new twenty-first century science for effective epidemic response." *Nature* 575(7781): 130–136. https://doi.org/10.1038/s41586-019-1717-y.

Bhatt, A. 2010. "Evolution of clinical research: A history before and beyond james lind." *Perspect Clin Res* 1(1): 6–10.

Bhopal, Kalwant. 2017. "Addressing racial inequalities in higher education: Equity, inclusion and social justice." *Ethnic and Racial Studies* 40(13): 2293–2299. https://doi.org/10.1080/01419870.2017.1344267.

Bidgood, Susanna R. 2019. "Continued poxvirus research: From foe to friend." *PLOS Biology* 17(1): e3000124. https://doi.org/10.1371/journal.pbio.3000124.

Biochemistry, Governing Council of the Italian Society of Biochemistry Molecular Biology Board of the Italian Professors of. 2020. "Basic and applied science at the time of COVID-19." *FEBS Letters* 594(18): 2933–2934. https://doi.org/https://doi.org/10.1002/1873-3468.13927. https://febs.onlinelibrary.wiley.com/doi/abs/10.1002/1873-3468.13927.

Blom, A., L. George, M. Adil. 2016. *Sub-Saharan African Science, Technology, Engineering, and Mathematics Research: A Decade of Development*. Washington, DC.: World Bank Study.

Blustein, David L., Ryan Duffy, Joaquim A. Ferreira, Valerie Cohen-Scali, Rachel Gali Cinamon, and Blake A. Allan. 2020. "Unemployment in the time of COVID-19: A research agenda." *Journal of Vocational Behavior* 119: 103436. https://doi.org/https://doi.org/10.1016/j.jvb.2020.103436. https://www.sciencedirect.com/science/article/pii/S0001879120300610.

Bok, Karin, Sandra Sitar, Barney S. Graham, and John R. Mascola. 2021. "Accelerated COVID-19 vaccine development: Milestones, lessons, and prospects.” *Immunity* 54(8): 1636–1651. https://doi.org/https://doi.org/10.1016/j.immuni.2021.07.017. https://www.sciencedirect.com/science/article/pii/S1074761321003034.

Botha, Maria Magdalena. 2010. “Compatibility Between Internationalizing and Africanizing Higher Education in South Africa.” *Journal of Studies in International Education* 14(2): 200–213. https://doi.org/10.1177/1028315309357943. https://journals.sagepub.com/doi/abs/10.1177/1028315309357943.

Brownell, Sara, Jordan Price, and Lawrence Steinman. 2013. “Science Communication to the General Public: Why We Need to Teach Undergraduate and Graduate Students this Skill as Part of Their Formal Scientific Training.” *Journal of Undergraduate Neuroscience Education: A publication of FUN, Faculty for Undergraduate Neuroscience* 12: E6–E10.

Burman, R. J., T. J. de Wet, M. Amoni, K. M. Düsterwald, D. M. Favara, M. Setshedi, C. L. Rametse, and A. A. Katz. 2019. “Training South African clinician-scientists: Lessons from the University of Cape Town’s intercalated programme.” *SAMJ* 109: 914–918. http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0256-95742019001200007&nrm=iso.

Campbell, Robert A. 2003. “Preparing the Next Generation of Scientists: The Social Process of Managing Students.” *Social Studies of Science* 33(6): 897–927. https://doi.org/10.1177/0306312703336004. https://journals.sagepub.com/doi/abs/10.1177/0306312703336004.

Casad, Bettina, Jillian Franks, Christina Garasky, Melinda Kittleman, Alanna Roesler, Deidre Hall, and Zachary Petzel. 2020. “Gender inequality in academia: Problems and solutions for women faculty in STEM.” *Journal of Neuroscience Research* 99. https://doi.org/10.1002/jnr.24631.

Chankseliani, Maia, Ikboljon Qoraboyev, and Dilbar Gimranova. 2021. “Higher education contributing to local, national, and global development: New empirical and conceptual insights.” *Higher Education* 81(1): 109–127. https://doi.org/10.1007/s10734-020-00565-8.

Crossman, P. 2004. *Perceptions of ‘Africanisation’ Or ‘endogenisation’ at African Universities: Issues and Recommendations*.

database, uniRank. 2021. *African Universities World Representation.* (Sydney New South Wales, Australia.: uniRank). https://www.4icu.org/Africa/#:~:text=How%20many%20Universities%20are%20there,higher%2Deducation%20institutions%20in%20Africa.

De Wit, Hans and Philip G. Altbach. 2021. “Internationalization in higher education: Global trends and recommendations for its future.” *Policy Reviews in Higher Education* 5(1): 28–46. https://doi.org/10.1080/23322969.2020.1820898.

DeFranco, D. B. and G. Sowa. 2014. “The importance of basic science and research training for the next generation of physicians and physician scientists.” *Mol Endocrinol* 28(12): 1919–1921. https://doi.org/10.1210/me.2014-1343.

Dei, Daniel, Robert Osei-Bonsu, and Samuel Amponsah. 2020. "A Philosophical Outlook on Africa's Higher Education in the Twenty-First Century: Challenges and Prospects." *In Pedagogy in Basic and Higher Education - Current Developments and Challenges*, ed. Kirsi Tirri and Auli Toom. IntechOpen.

Dobson, Geoffrey P. 2020. “Science and the War on Truth and Coronavirus.” *Frontiers in Medicine* 7(563). https://doi.org/10.3389/fmed.2020.00563. https://www.frontiersin.org/article/10.3389/fmed.2020.00563.

Dominguez, Isabel and Ann C. Zumwalt. 2020. “Integrating the basic sciences in medical curricula: Focus on the basic scientists.” *Advances in Physiology Education* 44(2): 119–123. https://doi.org/10.1152/advan.00172.2019. https://journals.physiology.org/doi/abs/10.1152/advan.00172.2019.

Dzau, Victor J. and Celynne A. Balatbat. 2017. “Cardiovascular Research and the National Academy of Medicine: Advancing Progress in Science and Medicine.” *Circulation Research* 120(1): 23–26. https://doi.org/doi:10.1161/CIRCRESAHA.116.310358. https://www.ahajournals.org/doi/abs/10.1161/CIRCRESAHA.116.310358.

Dzvimbo, Kuzvinetsa Peter and Kholeka Constance Moloi. 2013. "Globalisation and the internationalisation of higher education in sub-Saharan Africa." *South African Journal of Education* 33: 00–00. http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0256-01002013000300015&nrm=iso.

Evans, P. C., G. E. Rainger, J. C. Mason, T. J. Guzik, E. Osto, Z. Stamataki, D. Neil, et al. 2020. "Endothelial dysfunction in COVID-19: A position paper of the ESC Working Group for Atherosclerosis and Vascular Biology, and the ESC Council of Basic Cardiovascular Science." *Cardiovasc Res* 116(14): 2177–2184. https://doi.org/10.1093/cvr/cvaa230.

Filewod, Niall C., Jane Batt, Andras Kapus, Katalin Szaszi, Gregory D. Fairn, Arthur S. Slutsky, and Warren L. Lee. 2018. "Should basic science matter to clinicians?" *The Lancet* 391(10119): 410–412. https://doi.org/10.1016/S0140-6736(18)30199-5.

Foletti, A. and S. Fais. 2019. "Unexpected Discoveries Should Be Reconsidered in Science – A Look to the Past?" *Int J Mol Sci* 20(16). https://doi.org/10.3390/ijms20163973.

Foundation, National Science. 2018 2018. *Higher Education in Science and Engineering.* (USA). https://nsf.gov/statistics/2018/nsb20181/report/sections/higher-education-in-science-and-engineering/graduate-education-enrollment-and-degrees-in-the-united-states.

Friedman, L. M., C. D. Furberg, D. L. DeMets, D. M. Reboussin, and C. B. Granger. 2016. "Fundamentals of Clinical Trials. Fifth Edition." *Anticancer Research* 36(1): 480–480. https://ar.iiarjournals.org/content/anticanres/36/1/480.1.full.pdf.

Fröhlich, Holger, Rudi Balling, Niko Beerenwinkel, Oliver Kohlbacher, Santosh Kumar, Thomas Lengauer, Marloes H. Maathuis, et al. 2018. "From hype to reality: Data science enabling personalized medicine." *BMC Medicine* 16(1): 150. https://doi.org/10.1186/s12916-018-1122-7.

Gambheera, Harischandra. 2016. "Social changes in the 21st century have differentially affected the mental health scenario in the developing world." *Indian Journal of Social Psychiatry* 32(3): 238–242. https://doi.org/10.4103/0971-9962.193198. https://www.indjsp.org/article.asp?issn=0971-9962;year=2016;volume=32;issue=3;spage=238;epage=242;aulast=Gambheera.

Goolam, Mohamedbhai. 2011. "Higher Education in Africa: Facing the Challenges in the 21st Century." *International Higher Education* 0(63). https://doi.org/10.6017/ihe.2011.63.8534. https://ejournals.bc.edu/index.php/ihe/article/view/8534.

Groups, World Bank Country and Lending. 2020. *Country Classification.* (World Bank Group). https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups.

Hanlon, Shane M. 2019. "Scientists who leave research to pursue other careers in science are still scientists." *Proceedings of the National Academy of Sciences* 116(36): 17624–17624. https://doi.org/10.1073/pnas.1909427116. https://www.pnas.org/content/pnas/116/36/17624.full.pdf.

Hénard, F., L. Diamond, and D. Roseveare. 2012. *Approaches to Internationalisation and Their Implications for Strategic Management and Institutional Practice*. OECD.

HESA. 2020. "Higher education institutions in the UK." HESA provider metadata. https://www.hesa.ac.uk/support/providers. (Accessed 15 October).

https://journals.co.za/doi/abs/10.10520/EJC191482.

Hutchinson, Lisa and Vincent T. DeVita. 2008. "The era of personalized medicine: Back to basics." *Nature Clinical Practice Oncology* 5(11): 623–623. https://doi.org/10.1038/ncponc1253.

Irby, D. M., M. Cooke, and B. C. O'Brien. 2010. "Calls for reform of medical education by the Carnegie Foundation for the Advancement of Teaching: 1910 and 2010." *Acad Med* 85(2): 220–227. https://doi.org/10.1097/ACM.0b013e3181c88449. https://www.ncbi.nlm.nih.gov/pubmed/20107346.

Islam, M. A., R. M. Talukder, R. Taheri, and N. Blanchard. 2016. "Integration of Basic and Clinical Science Courses in US PharmD Programs." *American Journal of Pharmaceutical Education* 80(10): 166. https://doi.org/10.5688/ajpe8010166.

Iyngkaran, P. and M. Thomas. 2015. "Bedside-to-Bench Translational Research for Chronic Heart Failure: Creating an Agenda for Clients Who Do Not Meet Trial Enrollment Criteria." *Clin Med Insights Cardiol* 9(Suppl 1): 121–132. https://doi.org/10.4137/cmc.S18737.

Jorgenson, Dale W. and Khuong M. Vu. 2016. "The ICT revolution, world economic growth, and policy issues." *Telecommunications Policy* 40(5): 383–397. https://doi.org/https://doi.org/10.1016/j.telpol.2016.01.002. https://www.sciencedirect.com/science/article/pii/S0308596116000033.

Joyner, Michael J. 2011. "Why Physiology Matters in Medicine." *Physiology* 26(2): 72–75. https://doi.org/10.1152/physiol.00003.2011. https://journals.physiology.org/doi/abs/10.1152/physiol.00003.2011.

Kamwendo, Gregory H. 2016. "Unpacking Africanisation of higher education curricula." In *Africanising the Curriculum: Indigenous Perspectives and Theories,* ed. Vuyisile Msila, 11–31. AFRICAN SUN MeDIA.

Kang, Sung Pil, Yan Chen, Vanessa Svihla, Amber Gallup, Kristen Ferris, and Abhaya K. Datye. 2020. "Guiding change in higher education: An emergent, iterative application of Kotter's change model." *Studies in Higher Education*: 1–20. https://doi.org/10.1080/03075079.2020.1741540.

Kaufmann, Stefan H. E. 2020. "Vaccination Against Tuberculosis: Revamping BCG by Molecular Genetics Guided by Immunology." *Frontiers in Immunology* 11(316). https://doi.org/10.3389/fimmu.2020.00316. https://www.frontiersin.org/article/10.3389/fimmu.2020.00316.

Kenner, Carole and Jana L. Pressler. 2006. "Successfully Climbing the Academic Leadership Ladder." *Nurse Educator* 31(1): 1–3. https://journals.lww.com/nurseeducatoronline/Fulltext/2006/01000/Successfully_Climbing_the_Academic_Leadership.1.aspx.

Kromydas, Theocharis. 2017. "Rethinking higher education and its relationship with social inequalities: Past knowledge, present state and future potential." *Palgrave Communications* 3(1): 1. https://doi.org/10.1057/s41599-017-0001-8.

Kunselman, Julie, Christopher Hensley, and Richard Tewksbury. 2003. "Mentoring in academe: Models for facilitating academic development." *Journal of Criminal Justice Education* 14(1): 17–35. https://doi.org/10.1080/10511250300085631.

La Caze, Adam. 2011. "The role of basic science in evidence-based medicine." *Biology and Philosophy* 26: 81. https://doi.org/10.1007/s10539-010-9231-5.

Lezotre, Pierre-Louis. 2014. "State of Play and Review of Major Cooperation Initiatives." In *International Cooperation, Convergence and Harmonization of Pharmaceutical Regulations*, 7–170.

Lim, S. Y. and D. J. Hausenloy. 2012. "Remote ischemic conditioning: from bench to bedside." *Front Physiol* 3: 27. https://doi.org/10.3389/fphys.2012.00027. https://www.ncbi.nlm.nih.gov/pubmed/22363297.

Maarman, G. J. 2020. "Making a case for metallothioneins conferring cardioprotection in pulmonary hypertension." *Med Hypotheses* 137: 109572. https://doi.org/10.1016/j.mehy.2020.109572. https://www.ncbi.nlm.nih.gov/pubmed/31986470.

Maarman, G. J., G. Chakafana, and K. Sliwa. 2020. "World Heart Day: A World Heart Federation communique on the future of basic sciences and translational medicine in global cardiovascular research." *Am J Physiol Lung Cell Mol Physiol* 319(3): L545–L546. https://doi.org/10.1152/ajplung.00339.2020. https://www.ncbi.nlm.nih.gov/pubmed/32726129.

Maarman, G. J., J. Shaw, and B. Allwood. 2020. "Pulmonary hypertension in majority countries: Opportunities amidst challenges." *Curr Opin Pulm Med* 26(5): 373–383. https://doi.org/10.1097/MCP.0000000000000702. https://www.ncbi.nlm.nih.gov/pubmed/32701672.

Maarman, Gerald J. 2019. "Cardioprotection conferred by rooibos (Aspalathus linearis): A mini review to highlight a potential mechanism of action." *South African Journal of Science* 115: 1–4. http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0038-

23532019000400015&nrm=iso.

Maarman, Gerald J. and Sandrine Lecour. 2021. "Melatonin against pulmonary arterial hypertension: is it ready for testing in patients?" *Cardiovascular Journal of Africa* 32(2): 111–112. https://doi.org/doi:10.5830/CVJA-2021-008. https://journals.co.za/doi/abs/10.5830/CVJA-2021-008.

Mabokela, Reitumetse Obakeng. 2000. "'We Cannot Find Qualified Blacks': Faculty Diversification Programmes at South African Universities." *Comparative Education* 36(1): 95–112. http://www.jstor.org/stable/3099853.

Machika, P. and B. Johnson. 2015. "Postgraduate students' experience of poverty and academic success at a university of technology in South Africa." *South African Journal of Higher Education* 29(6): 167–181. https://doi.org/doi:10.10520/EJC191482.

Malisch, Jessica L., Breanna N. Harris, Shanen M. Sherrer, Kristy A. Lewis, Stephanie L. Shepherd, Pumtiwitt C. McCarthy, Jessica L. Spott, et al. 2020. "Opinion: In the wake of COVID-19, academia needs new solutions to ensure gender equity." *Proceedings of the National Academy of Sciences* 117(27): 15378–15381. https://doi.org/10.1073/pnas.2010636117. https://www.pnas.org/content/pnas/117/27/15378.full.pdf.

Marian, A. J. 2021. "Current state of vaccine development and targeted therapies for COVID-19: Impact of basic science discoveries." *Cardiovasc Pathol* 50: 107278. https://doi.org/10.1016/j.carpath.2020.107278.

Marino, Francesco E. 2021. "Mentoring gone wrong: What is happening to mentorship in academia?" *Policy Futures in Education* 19(7): 747–751. https://doi.org/10.1177/1478210320972199. https://journals.sagepub.com/doi/abs/10.1177/1478210320972199.

Martinez, N. and H. Kornfeld. 2019. "Tuberculosis and diabetes: From bench to bedside and back." *Int J Tuberc Lung Dis* 23(6): 669–677. https://doi.org/10.5588/ijtld.18.0805.

Martinez, Wendy. 2018. "How science and technology developments impact employment and education." *Proceedings of the National Academy of Sciences* 115(50): 12624–12629. https://doi.org/10.1073/pnas.1803216115. https://www.pnas.org/content/pnas/115/50/12624.full.pdf.

McKay, Tracey, Anban Naidoo, and Zach Simpson. 2018. "Exploring the Challenges of First-Year Student Funding: An Intra-Institutional Case Study." *Journal of Student Affairs in Africa* 6. https://doi.org/10.24085/jsaa.v6i1.3063.

Mgaiwa, Samson John. 2021. "Fostering Graduate Employability: Rethinking Tanzania's University Practices." *SAGE Open* 11(2): 21582440211006709. https://doi.org/10.1177/21582440211006709. https://journals.sagepub.com/doi/abs/10.1177/21582440211006709.

Miranda, Juan. 2021. "Chapter 4: Medicinal plants and their traditional uses in different locations." In *Phytomedicine*, ed. Rouf Ahmad Bhat, Khalid Rehman Hakeem, Moonisa Aslam Dervash, 207–223. Academic Press.

Mohs, Richard and Nigel Greig. 2017. "Drug discovery and development: Role of basic biological research." *Alzheimer's & Dementia: Translational Research & Clinical Interventions* 3(4): 651–657. https://doi.org/10.1016/j.trci.2017.10.005.

Moore, Kyle K., Ismael Cid-Martinez, Jermaine Toney, Jason A. Smith, Amber C. Kalb, Jean H. Shin, and Roberta M. Spalter-Roth. 2018. "Who Climbs the Academic Ladder? Race and Gender Stratification in a World of Whiteness." *The Review of Black Political Economy* 45(3): 216–244. https://doi.org/10.1177/0034644618813667. https://journals.sagepub.com/doi/abs/10.1177/0034644618813667.

Nayyar, Deepak. 2007. "Globalisation: What Does It Mean for Higher Education?" *Economic and Political Weekly* 42(50): 30–35. http://www.jstor.org/stable/40277048.

Northam, Sarah H. 2015. "Braving 21st-century challenges." ACRL 2000–09**.** *College & Research Libraries News* 76(8): 454–456. https://doi.org/10.5860/crln.76.8.9369. https://crln.acrl.org/index.php/crlnews/article/view/9369/10526.

Opie, L. H. 1980. "Drugs and the heart. VII. Which drug for which disease?" *Lancet* 1(8176): 1011–1017. https://doi.org/10.1016/s0140-6736(80)91448-8. https://www.ncbi.nlm.nih.gov/pubmed/6103335.

Opie, L. H. 1997. "New developments in cardiovascular drugs: Heart failure – an informal and personal viewpoint." *Cardiovasc Drugs Ther* 11(4): 519–20. https://doi.org/10.1023/a:1007798613232. https://www.ncbi.nlm.nih.gov/pubmed/9358955.

Orr, Dominic, Maren Luebcke, J. Philipp Schmidt, Markus Ebner, Klaus Wannemacher, Martin Ebner, and Dieter Dohmen. 2020. "Four Models of Higher Education in 2030." In *Higher Education Landscape 2030: A Trend Analysis Based on the AHEAD International Horizon Scanning*, ed. Dominic Orr, Maren Luebcke, J. Philipp Schmidt, Markus Ebner, Klaus Wannemacher, Martin Ebner and Dieter Dohmen, 25–42. Cham: Springer International Publishing.

Ortlieb, Renate and Silvana Weiss. 2018. "What makes academic careers less insecure? The role of individual-level antecedents." *Higher Education* 76(4): 571–587. https://doi.org/10.1007/s10734-017-0226-x.

Riedel, Stefan. 2005. "Edward Jenner and the History of Smallpox and Vaccination." *Baylor University Medical Center Proceedings* 18(1): 21–25. https://doi.org/10.1080/08998280.2005.11928028.

Robertson, Susan L. 2021. "Global competences and 21st century higher education – And why they matter." *International Journal of Chinese Education* 10(1): 22125868211010345. https://doi.org/10.1177/22125868211010345. https://journals.sagepub.com/doi/abs/10.1177/22125868211010345.

Ross-Hellauer, Tony, Jonathan P. Tennant, Viltė Banelytė, Edit Gorogh, Daniela Luzi, Peter Kraker, Lucio Pisacane, et al. 2020. "Ten simple rules for innovative dissemination of research." *PLOS Computational Biology* 16(4): e1007704. https://doi.org/10.1371/journal.pcbi.1007704.

Salmi, Jamil. 2000. "Tertiary Education in the Twenty-First Century Challenges and Opportunities." Human Development Department, LCSHD Paper Series No. 62.

Salmi, Jamil. 2020. "New Challenges for Tertiary Education in the Twenty-First Century." In *Higher Education in Latin America and the Challenges of the 21st Century*, ed. Simon Schwartzman, 19–30. Cham: Springer International Publishing.

Schmidt, Joel T. and Min Tang. 2020. "Digitalization in Education: Challenges, Trends and Transformative Potential." In *Führen und Managen in der digitalen Transformation: Trends, Best Practices und Herausforderungen*, ed. Mark Harwardt, Peter F. J. Niermann, Andre M. Schmutte and Axel Steuernagel, 287–312. Wiesbaden: Springer Fachmedien Wiesbaden.

Sheikh, Kabir, Asha George, and Lucy Gilson. 2014. "People-centred science: Strengthening the practice of health policy and systems research." *Health Research Policy and Systems* 12(1): 19. https://doi.org/10.1186/1478-4505-12-19.

Sigman, Mark. 2018. "Introduction: Personalized medicine: what is it and what are the challenges?" *Fertility and Sterility* 109(6): 944–945. https://doi.org/10.1016/j.fertnstert.2018.04.027.

Song, P. and T. Karako. 2020. "COVID-19: Real-time dissemination of scientific information to fight a public health emergency of international concern." *Biosci Trends* 14(1): 1–2. https://doi.org/10.5582/bst.2020.01056.

Statista. 2020a. *Number of higher education institutions in the United States.* (United States). https://www.statista.com/statistics/306880/us-higher-education-institutions-by-state/.

Statista. 2020b. *Number of students enrolled in higher education in the United Kingdom from 2009/10 to 2019/20.* (United Kingdom). https://www.statista.com/statistics/875015/students-enrolled-in-higher-education-in-the-uk/.

Statista. 2021. *Global unemployment figures.* (World wide). https://www.statista.com/statistics/266414/unemployed-persons-worldwide/.

Street, R. A. and G. Prinsloo. 2013. "Commercially Important Medicinal Plants of South Africa: A Review." *Journal of Chemistry* 2013: 205048. https://doi.org/10.1155/2013/205048.

Talgar, C. P. and N. M. Goodey. 2015. "Views from academia and industry on skills needed for the modern research environment." *Biochem Mol Biol Educ* 43(5): 324–332. https://doi.org/10.1002/bmb.20883.

Tang Wee, T., A. Tan, O. Yann Shiou. 2020. *Science Education in the 21st Century*. Switzerland AG.: Springer.

Tewari, Devi Datt, and Kehinde Damilola Ilesanmi. 2020. "Teaching and learning interaction in South Africa's higher education: Some weak links." *Cogent Social Sciences* 6(1): 1740519. https://doi.org/10.1080/23311886.2020.1740519.

Turner, Caroline Sotello Viernes, Jonathan Luke Wood, Yvonne J. Montoya, Idara R. Essien-Wood, Rebecca A. Neal, Gabriel Escontrías, and Aaron D. Coe. 2012. "Advancing the Next Generation of Higher Education Scholars: An Examination of One Doctoral Classroom." *The International Journal of Teaching and Learning in Higher Education* 24: 103–112.

UNESCO. 2020. *Startling digital divides in distance learning emerge.* (Paris, France). https://en.unesco.org/news/startling-digital-divides-distance-learning-emerge.

Van der Westhuizen, Marichen, Thomas Greuel, and Jacques W. Beukes. 2017. "Are we hearing the voices? Africanisation as part of community development." *HTS Theological Studies* 73: 1–9. http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0259-94222017000300041&nrm=iso.

Van Maanen, John. 2015. "The present of things past: Ethnography and career studies." *Human Relations* 68(1): 35–53. https://doi.org/10.1177/0018726714552287. https://journals.sagepub.com/doi/abs/10.1177/0018726714552287.

Wangenge-Ouma, Gerald. 2012. "Tuition fees and the challenge of making higher education a popular commodity in South Africa." *Higher Education* 64(6): 831–844. https://doi.org/10.1007/s10734-012-9531-6. https://doi.org/10.1007/s10734-012-9531-6.

Wartman, S., A. Davis, M. Wilson, N. Kahn, R. Sherwood, and A. Nowalk. 2001. "Curricular change: Recommendations from a national perspective." *Acad Med* 76(4 Suppl): S140–5. https://doi.org/10.1097/00001888-200104001-00028. https://www.ncbi.nlm.nih.gov/pubmed/11299188.

WHO. Programme on Traditional, Medicine. 2000. General guidelines for methodologies on research and evaluation of traditional medicine. Geneva: World Health Organization.

Wijeratne, D. Thiwanka, Katherine Lajkosz, Susan B. Brogly, M. Diane Lougheed, Li Jiang, Ahmad Housin, David Barber, et al. 2018. "Increasing Incidence and Prevalence of World Health Organization Groups 1 to 4 Pulmonary Hypertension." *Circulation: Cardiovascular Quality and Outcomes* 11(2): e003973. https://doi.org/doi:10.1161/CIRCOUTCOMES.117.003973. https://www.ahajournals.org/doi/abs/10.1161/CIRCOUTCOMES.117.003973.

Woodard, Howard C., Sonya S. Shepherd, Mindy Crain-Dorough, and Michael D. Richardson. 2011. "The Globalization of Higher Education through the Lens of Technology and Accountability." *Journal on Educational Technology* 8: 16–24.

Woolston, C. 2021. "Researchers' career insecurity needs attention and reform now, says international coalition." *Career News*, 8 June 2021. https://www.nature.com/articles/d41586-021-01548-0.

Yamin, Mohammad. 2019. "Information technologies of 21st century and their impact on the society." *International Journal of Information Technology* 11(4): 759–766. https://doi.org/10.1007/s41870-019-00355-1.

Yograj, Sabita, Anjali Bhat, Rajiv Gupta, Geetika Gupta, and Leela Kalsotra. 2019. "Role of basic sciences in making of a clinician: Perspectives of medical students from North India." *Journal of Education and Health Promotion* 8(1): 171–171. https://doi.org/10.4103/jehp.jehp_66_19. https://www.jehp.net/article.asp?issn=2277-9531;year=2019;volume=8;issue=1;spage=171;epage=171;aulast=Yograj.

Zarei, S. and S. Mohammadi. 2021. "Challenges of higher education related to e-learning in developing countries during COVID-19 spread: A review of the perspectives of students, instructors, policymakers, and ICT experts." *Environ Sci Pollut Res Int*: 1–7. https://doi.org/10.1007/s11356-

021-14647-2.

Zha, Qiang. 2003. "Internationalization of Higher Education: Towards a Conceptual Framework." *Policy Futures in Education* 1: 248–270. https://doi.org/10.2304/pfie.2003.1.2.5.

Zhang, X. H. 1987. "The development of industry and higher education in developing countries." *Industry and Higher Education* 1(1): 52–54. https://doi.org/10.1177/095042228700100111. https://journals.sagepub.com/doi/abs/10.1177/095042228700100111.

Zimmerman, Andrea M. 2018. "Navigating the path to a biomedical science career." *PLOS ONE* 13(9): e0203783. https://doi.org/10.1371/journal.pone.0203783.