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OPINIONS

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THE URGENT AND YET FORGOTTEN PROBLEMS OF CURRENT SCIENTIFIC AND ACADEMIC PRACTICE

Os problemas urgentes e ainda esquecidos da prática científica e acadêmica atual

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ABSTRACT

Science has an immense potential to change society such as by improving global public health or tackling climate change. This is especially important in the next 10 years (2021-2030) which are decisive for many countries around the globe to achieve the Sustainable Development Goals set by the United Nations. For this, the development of more science-based policies is crucial. However, a number of problems affect science nowadays. These problems are all well known, but little is being currently done to solve them. Here, we discuss the past and rising problems in the scientific and academic practice that need our urgent attention, namely the crises of accessibility, equity, reproducibility, credibility, deficiency in job opportunities and the vicious publication system. Additionally, we discuss current political and cultural problems such as the rise of fake news, clickbait videos, science denialism and misinformation that pose a threat not only to science practitioners, but also to the society at large. By acknowledging these crises, we propose that science can be improved for the benefit of the population in general (e.g., stakeholders, companies, governments, non-governmental organizations and traditional communities) and also for the very actors of science; the scientists and the new generations of academics.

Keywords: ethics, fair science, open access, public policies, scientific production.

RESUMO

A ciência tem um imenso potencial para mudar a sociedade, por exemplo, melhorando a saúde pública global ou combatendo a mudança climática. Isso é especialmente importante nos próximos 10 anos (2021-2030), os quais são decisivos para que muitos países ao redor do mundo atinjam as *metas de desenvolvimento sustentável estabelecidas pelas Nações Unidas. Para isso, o desenvolvimento de políticas públicas baseadas na ciência é crucial. Entretanto, uma série de problemas afeta a ciência hoje em dia. Todos esses problemas são bem conhecidos, mas pouco está sendo feito atualmente para resolvê-los. Aqui, discutimos o passado e os problemas emergentes na prática científica e acadêmica que precisam de nossa atenção urgente, entre as principais destacamos as crises de acessibilidade, equidade, reprodutibilidade, credibilidade, deficiência nas oportunidades de emprego e o sistema de publicação vicioso. Além disso, discutimos problemas políticos e culturais atuais, como o surgimento de notícias falsas (*fake news*), vídeos de* clickbait*, negacionismo crescente e desinformação científica, que representam uma ameaça não apenas para os profissionais da ciência, mas também para a democracia e a sociedade. Ao reconhecer essas crises, propomos que a ciência pode ser melhorada para o benefício da população em geral (por exemplo, as partes interessadas, empresas, governos, organizações não governamentais e comunidades tradicionais) e também para os próprios atores da ciência, os cientistas e as novas gerações de acadêmicos.*

Palavras-chave*: ética, ciência justa, acesso aberto, políticas públicas, produção científica.*

INTRODUCTION

Science helped mankind practice rationality and make great achievements over the course of recent history. Today, we live in a world surrounded by algorithms, gadgets and processed products – to cite a few things – that were only possible given our advancement in science, technology and innovation. By the end of 2030, several countries have collectively agreed to achieve 17 Sustainable Development Goals (SDGs, United Nations, 2021), including ocean and marine resources protection (SDG 14: life below water). These goals should be heavily supported by science knowledge and evidence-based policies, and closely in line with our current assessment of climate change (The Intergovernmental Panel on Climate Change, IPCC). Consequently, two important milestones will take place in this decade (2021-2030): the Decade of Ocean Science for Sustainable Development and the United Nations Decade on Ecosystem Restoration; these should bring together more than 150 countries for the 2030 global agenda. In summary, basic and applied scientific research is on our side, having the potential to solve many of our fundamental problems, from poverty and social inequality to biodiversity loss and climate change.

However, science also has a dark facet. As scientists ourselves, it is personally shocking to know that many commonly untold aspects of science practice are quite daunting or even oppressing. Here we focus on these hidden or forgotten aspects of science, because they not only may affect those who directly work on science, but also the population in general and particularly evidence-based policy makers.

The aim of this perspective article is thus to raise awareness of the (both past and rising) obstacles to equity, fairness, quality and sustainability of science. Moreover, science requires the trust of the public more than ever, given the recent spread of fake news, clickbait videos and misinformation on digital platforms, and even over large communication channels (Lazer *et al.*, 2018; Allen *et al.*, 2020). Finally, we need to motivate and protect the new generations of scientists and academics that will promote and build upon our knowledge.

THE MULTIPLE CRISES IN SCIENCE

Accessibility crisis

Scientific research has been traditionally published in specialized journals that charge for their services. Through paywalls, scientific literature has been shielded from open and unlimited access for decades. In fact, scientific literature is commonly accessible only to a limited group of individuals who can directly pay for accessing single papers or who are employed by institutions (generally public) that can afford paying large sums of money to close bundle subscriptions with multinational publication groups. This rather odd pattern in science that transfers public-funded knowledge to private companies seems to have roots in the early 1950s (Buranyi, 2017). Although information is scarce on how much money is spent on private or institutional subscriptions made by the largest commercial publishers (but see Bergstrom *et al.*, 2014), figures show that this is a billionaire business on the rise; some information can be accessed for North America (see the USA Library Statistics Program) and Europe (see Lawson; Meghreblian & Brook, 2015).

Within the publishing – profit-oriented – industry, collusion is a common practice that brings publication prices up. This has been observed over many years now (Madras, 2008), despite constant advancements in technology, communications and digitalization that could actually dramatically reduce publication costs. It is important to mention that publication costs and statistics on that topic are far from transparent overall across the globe.

Moreover, reviewers who work for major journals or referees who work in scientific institutions are commonly not paid for their peer-revisions, despite dedicating part of their work time for that purpose. It would be important to give them more recognition. In fact, not even the original authors of publications are directly paid or receive incentives from their publications, because there is usually a transfer of copyrights from science producers to journals (except in the case of open-access). Open-access journals in which authors pay for publication costs have seen a significant increase in the last few decades (Science, 2013; The Royal Society, 2017). However, this has generated two issues: (1) increase of predatory journals with poor quality that accept articles in exchange for payment and (2) abusive pricing for publication in high-impact journals which are especially damaging for developing countries.

It is evident that predatory paywalls and high publication costs drive segregation in access to scientific literature. This accessibility crisis is bad for science, in a sense that scholars based in regions with low income (e.g., Latin America and Africa) will obviously have less access to up-to-date knowledge. This can at least in part explain lower performances of scientists compared to their peers from high income regions (e.g., Europe and USA). Although an increasing number of publications are being provided digitally and mostly publicly, high-impact journals are still stubborn in charging for publication costs, which hinders a solution to this pervasive and persistent problem. It is common for large institutions in high income countries to assign budgets to cover publication costs for its researchers, but it does not tackle the problem at its root.

Recently, there has been an increasing number of journals publishing open-access (OA) articles or shifting towards this approach. To this date, for example, the Directory of Open Access Journals (DOAJ) has a record of 16,566 journals and 6,285,188 OA articles. More information can also be found in the Open Access Directory (OAD) compendium.

Therefore, making the product of science (i.e., publications mostly) available to the public should have a major impact on the progress of science, by allowing scientific knowledge to democratically spread across the world and reach different *publica* irrespective of their economical, educational or geographical condition.

Solutions to this problem may already be on the way in some universities and public institutions around the world, which plan to foster the publication of high-quality, open-access and free-of-charge research in alternative e-journals. In these cases, copyright remains with the authors that do not need to pay APC (Article Processing Charges). This new model benefits the scientific community and has been carried out by journals Scientia Marina in Europe and Ocean and Coastal Research in Brazil, for example. Therefore, free accessible research is getting more widespread, suggesting that this will be an important topic of discussion in the future.

Equity crisis

Developed countries such as Switzerland have at least two-fold more PhD holders in total numbers than developing countries such as Indonesia, Mexico or Brazil which are comparatively more populated (OECD, 2019). Geographic inequities in science are common between and even within countries. For example, in Brazil richer regions (e.g., São Paulo) concentrate more resources and attract professionals with more years of education, compared to poorer or less-populated regions such as the Brazilian Northeast and the Amazon regions (Inep, 2020; https://geocapes.capes.gov.br/geocapes). These disparities are not only a reflection of differences in resources available for graduation and post-graduation study programs, but also deeper gaps for example in infrastructure, number of institutions and access to digital technologies. The UNESCO science report (2015) and the USA Science & Engineering Indicators (2018) show further examples worldwide. This inequity hinders sustainable regional development in areas such as Bioeconomy, Biotechnology, Creative Industry, and Information and Communication Technologies. Moreover, with economic differences among countries, regions and groups, there is also the risk of a so-called "scientific colonization", where research is conducted overseas by rich parties in poor regions of the planet which hold high biodiversity. Thus, major economic differences are indicators for inequity in science, development and innovation.

Another level of inequity in science regards gender, ethnicity and people with disabilities (Kosanic *et al.*, 2019). Rather consciously or unconsciously, science is unfortunately a white- and male-dominated field up to now. For example, evidence shows that women are paid less and usually have secondary positions (Fleming, 2018) or that individuals of color receive on average fewer grants then their white male counterparts (Woolston, 2021). Besides, only recently people with disabilities have been more actively considered for job openings or to foster research group diversity. Initiatives in Brazil and the USA have tried to incorporate admission to the university for marginalized groups, such as for applicants of indigenous origins or low-income families. However, more is needed to fundamentally change current inequities within science, particularly focusing on reaching advanced researchers and lab leaders. Of course, the equity crisis in science reflects a deeper in-grained problem in our society. Although it might be daunting, we need to find a long-term solution for this issue.

Publication crisis

As the old saying goes, "publish or perish", the scientific community is built in a very competitive environment. Scientists are constantly under pressure to produce several publications. Preferably, these publications are aimed at high-impact journals, because it helps scientists obtain funding for further projects and secure temporary or long-term job positions. The drawback, however, is that a race for publication may negatively impact the quality of research, and encourage bias or misconduct. Moreover, this pressure for publication may inhibit research on risky projects that are less likely to reach conclusive results, forcing researchers to recycle their studies by applying minimal changes to their study "recipes" which hinders creativity and progress. Indeed, various examples of fraud within the scientific community have been reported so far (see this Wikipedia list). These examples could well be explained – at least partially – by the pervasive need to publish. Finally, the "publish or perish" way of life is especially true for young scientists at the beginning of their careers, because a large record of publications usually reflects in real chances of success in science.

One could reasonably argue that publications are the most important assets in science and as such that they need to be demanded from scientists. Alternatively, enforcing the quality over the number of publications might as well benefit the scientific community, by reducing the massive amounts of (bad) papers published each year and facilitating the retrieval of important information from public archives. The slow science movement (http://slow-science.org/) is one initiative that goes into that second argumentation, but it was not really successful to date. Slow science borrows its concept from slow food, a movement that started particularly as a protest against exaggerated food consumption in the late 80's (Adams; Burke & Whitmarsh, 2014). The slow movement now covers different human activities, such as tourism, culture, money and even religion, around the globe.

To solve the publication crisis, major changes are needed. For example, states and governments could set up well-structured budgets for science, which included more job positions for young scholars. This could help reduce the demand for publication quantity and improve science quality in the long run. Additionally, regulations for science ethics and practice should be defined internationally. This high-level type of action could benefit the scientific community and limit the power of predatory companies that hinder progress and sharing of science. Another type of action is at the local and individual levels. Departments or group leaders should take the initiative to establish more consortiums and interdisciplinary collaborations, also internationally. Consequently, costs but also credits for discoveries should be shared among distinct groups, reducing overall competition. These two types of actions might together be an efficient tool to improve the current (competitive/selfish) scenario to a new (solidary) scenario that promotes sharing without overloading scientists.

Reproducibility crisis

Reproducibility is a fundamental element in scientific practice, because it helps scholars distinguish the good from the bad science, test early studies, and find weak points in studies from other peers. However, poor experimental design, incomplete documentation, lack of transparency, unavailability of data, together with p-hacking, dubious analyses or even fraudulent results are examples of known issues in the scientific community that bring us to a crisis of reproducibility. Examples of research studies that cannot be widely replicated populate even traditional and renowned journals. In addition, highly cited or seminal articles that are protected by paywalls amplify this issue even further, because data is not always readily available for replication by anyone interested.

In our daily scientific practice, we are commonly on a quest to find patterns and establish differences between our study units, groups, treatments, or populations. Scientists are fascinated by finding positive results, which means – in frequentist statistics – looking for *significance* (i.e., commonly a p-value of < 0.05). When we do not find significant results, we invariably assume that chances for publication are inexistent, and this is perhaps the trap we usually fall into. Perhaps, the absence of significance could also be an indication that our initial hypothesis was actually wrong. In science, we usually base our studies on hypothesis testing, but positive results massively outweigh negative results in science publications, due to publication bias. Journals that offer the explicit publication of negative results are very few (for example, JASNH, JNR, PLOS ONE).

Some experts argue that a major part of published research findings are false, given the search for significant results (Ioannidis, 2005). In fact, this fixation on p-values might hinder us from actually tackling meaningful scientific questions, if analyses are not conducted carefully. Reviews and meta-analytical studies regularly compile and test previous reports, helping science move forward. However, the issue of reproducibility should still be acknowledged more incisively from the very start.

Fortunately, there have been recent developments around the world that could solve this issue. The evolution of new software, algorithms, and programming languages has produced a large portfolio of tools (e.g., R software or the PRISMA method) that can help scientists in all steps of their practice. These efficient tools can in turn promote the adoption of standard methods to build workflows or pipelines that support reproducibility. In addition, best practice is being increasingly praised and online platforms are being developed with open-source code that allows interoperability and flexible improvement or data sharing. Journals commonly offer the option for authors to append supplementary materials that help describing methods and complementing results. Finally, sharing raw and processed data over public repositories is being supported by journals, which increases transparency in science.

Credibility crisis

The spread of disinformation, such as fake news and clickbaits has been a major concern in our recent digital times. For example, some political leaders and powerful personalities – helped by social media – have been supportive of science denial, strongly influencing the public opinion to move away from evidence-based science to rumors, conspiracies and alike. Unfortunately, this current trend might produce tremendous consequences to society, such as in political elections, flawed policies, and public important decisions. The general public and even policy makers seem to be taking science less seriously nowadays (but see Yin *et al.*, 2021). For example, think tanks which are entities supposed to bridge the gap between science and policy making (Weaver, 1989) may actually constitute obstacles for progress when basing their work on pre-formed points of view rather than on neutral or rational analyses (Rich, 2005). This not only depreciates the work conducted by scientists but also may lead to catastrophic outcomes, as we have recently observed during the covid-19 pandemic where countries that used denialist approaches had higher infection and death rates, such as Brazil (Lancet, 2020; Castro *et al*., 2021).

Stronger ties between the scientific community and the society should be beneficial for all of us, allowing a better flow of information, awareness, and reciprocal feedback. The general public should be keen on receiving the benefits of science outreach, while the scientific community should be more sensitized to the needs of society and science-based policies. As scientists, we should make efforts to reach the common public and create awareness, for example in nature conservancy (Bearzi, 2020). Finally, content creators that spread unreliable or grey science should be avoided, and liability should be the norm to reduce the spread of disinformation.

Cultural and political crisis

So far, we have described science through the lens of individuals who live in the West, in the global North or in South America. Of course, numerous other traditions across the globe defend very different views on how politics, society and ultimately science should be conducted, compared to our own point of reference. Different world viewpoints may also be heavily influenced by philosophical conceptions deeply rooted in societies and long determined by history (Baggini, 2018). Therefore, one should necessarily expect that there is a major variation in science practice when accounting for cultural differences. Hereby, we do not want to defend that a particular worldview is the most important. Instead, we want to point out that the diversity of cultural world conceptions influences our understanding about society and nature, further determining how we set questions, design studies and conduct science in general.

Political polarization over science is a fact (Rekker, 2021). One danger that may arise from our cultural differences is the belief that there is a "correct vs. wrong" battle in science. This can be even aggravated when science is granted as an instrument of status or power by companies or national states. In our opinion, science should be the democratic result of collaboration and exchange of ideas, backed by the analytical method, data, and expertise. In contrast to a "wrong science" concept, the scientific community should join efforts to promote rigorous and reliable scientific practice, replacing the "bad science" for the "good science" instead. Therefore, the diversity of cultural and political views in science can be channeled to help us understand as much as possible the natural world around us and to move the field of science forward. Scientists and society must acknowledge the complexity of human behavior in order to overcome misunderstandings, prejudices and segregation globally. Again, the solution to this issue could lie in solidarity, collaboration and open-mindedness. For that and especially in this decade, much discussion is needed, nevertheless.

Reality crisis

In its early years, modern science was done by a very limited number of individuals. Today, science is not that elitist, because it has been institutionalized and disseminated over the globe. Science has now a considerable importance in many economies, with high sums of money being annually invested in innovation, research and education (e.g., Horizon 2020 iniciative (European Commission, 2022)). The massification of science has increased the number of discoveries and helped the development of new technologies at an implicit human cost, nevertheless.

The formation of new scientists requires long and expensive educational support backed by study programs, specialized infrastructure and trained personnel. Unfortunately, many students and young scientists are severely overwhelmed by their studies or work, and worried about their future. A clear sign of that issue may be seen in the dropout rates that exist in higher education (Ulriksen; Madsen & Holmegaard, 2010). Dropouts may originate from several reasons (Spady, 1970), such as the lack of comprehensive support; little importance is given to communicating career paths, job opportunities and market developments to young professionals at very early stages. Moreover, it is usually difficult to combine professional and personal lives in science, when jobs do not offer attractive conditions, such as child-care and good work-balance opportunities. Motivation and happiness of individual scientists also constitute a fundamental part of science. However, it is not uncommon that scientists develop mental health problems due to their stressful and demanding work. Disorders, such as anxiety or burnout are very common indeed (Gewin, 2021) and they need to be treated individually, but also at the community (see Dragonfly initiative) and institutional level (psychological support for employees at specific institutions). Therefore, individual support and attention to mental health needs to be urgently emphasized in science.

Positive developments should thus be (1) more careful support of students and scientists, (2) better planning and structuring of study programs, (3) clear communication and transparency of professional careers, (4) fostering fair jobs with adequate working conditions, and (5) psychological support for scientists. Science should not only be made out of passion. High-level support should also help individual scientists overcome difficulties of everyday practice and insecurities of the professional career.

CONCLUSION AND FINAL PERSPECTIVES

In conclusion, the issues listed above produce an impediment to a democratic and fair development of science. By acknowledging and discussing these untold truths, we as a scientific community should find ways to engage in responsible and trustworthy science practice. This effort should not only benefit us, but also the society at large, if science-based solutions and policies should originate from a healthy scientific community.

Moreover, science has dramatically changed over the course of human history. Problems and flaws have been present, but also solutions and improvements have then been found. Scientific knowledge is gathered in an open-ended process and perhaps we find ourselves at the ideal moment to shift science and technologies to a new paradigm, more adapted to our current time.

Science has been a very dynamic field of human knowledge, particularly now in times of big data and digitalization. The issues mentioned here should not be new to scientists or science practitioners. Yet, measures to improve science in that respect are in our view momentarily insufficient and isolated, for example the first draft of the Unesco recommendation on open-science, the slow science movement or the dragonfly initiative.

There are many open questions and doubts on how to comprehensively tackle the entire list of crises that science faces nowadays. Who should pay for costs of publication, if not through predatory companies? How to overcome cultural barriers and promote union among research groups worldwide, if not only depending on personal motivation? How are patents and other special cases accommodated in the context of scientific research, if we are to foster fairness and sustainability? Perhaps, an effective change should come at a higher institutional level (Smaldino & McElreath, 2016). Still, the issues raised here are probably going to accompany us in many years to come. The issues in science are urgent and deserve to be discussed and thought about by all of us, as Albert Einstein said: "One thing I have learned in a long life: that all our science, measured against reality, is primitive and childlike – and yet it is the most precious thing we have."

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