This is an open access article under the
Creative Commons Attribution 4.0 International License

A HISTORICAL UNDERSTANDING OF HOW SCIENCE WORKS

Boris Aberšek
University of Maribor, Slovenia

Introduction

From Socrates onwards, the Greek cultural life began to take shape, and the whole nature of philosophical and scientific thought also began to change. From the natural sciences, interest shifted towards man and his societal role. Starting with the Sophists, a critical look at the surviving myths became pivotal at the time. Even if humans are still unable to get answers to all the riddles of nature, for which, among other things, mythology offers supernatural explanations, we (as human beings) do realize that we are only human. And humans need to learn to live together in different forms of social life. The Sophists were interested in man and his place in society. Socrates used conversations and tried to help his interlocutors generate valid reasoning and knowledge. According to him, proper knowledge must arise inside the individual, which is today's constructivist approach; no one can instill knowledge in the individual from the outside. Only knowledge that comes from within is true understanding. Socrates also wanted to find a solid basis for human knowledge. He believed he had found it in *human reason*.

From the Past to the Future

Understanding the processes of science can protect people against misinformation. One of the most intriguing moments in science is noticing when something is "weird". For example, the period between the years 2020 and 2022 has been a memorable one, unfortunately, for the most part, not in a good way. There was a historic disregard for scientific advice regarding the newest case of the pandemic virus. However, while the events of 2020 may feel unprecedented, the social pattern of rejecting scientific evidence did not suddenly appear in that year. There was never any sound scientific reason for rejecting the expert advice on viruses and vaccines, just as there has never been any good *scientific reason* for doubting how humans evolved, that vaccines save lives, or that AI and ChatGPT can help people and make our lives better (or worse). To understand the social pattern of rejecting scientific findings and expert advice, one needs to look beyond science, towards the past, which reveals that many of the various forms of rejecting expert evidence and promoting disinformation are rooted in the history of tobacco (Oreskes, 2020).

Throughout the first half of the 20th century, most people saw science and technology as something that makes our lives better. Science has deepened our understanding of the natural world, which has helped us to cure diseases; technology lights our homes and brings new forms of entertainment into our lives. Research and development have produced products that measurably improved many lives. However, science was also developing the playbook for science denial and disinformation. The chief culprit in this darker story was the tobacco industry. It

https://doi.org/10.33225/jbse/23.22.952

disparaged science by promoting the idea that the link between tobacco use and lung cancer and other diseases was uncertain or incomplete, and that the attempt to regulate it was a threat to human freedom. The tobacco industry made products even more addictive by increasing their nicotine content while publicly denying that nicotine was addictive. With these tactics, the industry was able to delay effective measures to discourage smoking long after the scientific evidence of its harms was clear. The same arguments were used to delay action on acid rain, the ozone hole and climate change, and in the year 2020, one could see the spurious "freedom" argument being used to disparage mask-wearing or vaccinating. This kind of 'tobacco strategy' has also seeped into social media, which influences public opinion and which many people feel needs to be subject to greater scrutiny. Computer scientists have complained that social media contributes to the spread of AI denial by permitting false or misleading claims while hobbling responses by mainstream scientists by labelling their posts as "political". Without a historical perspective, it might seem that this problem was created by a novel technology. Like the tobacco industry, social media and IT companies have been selling people a toxic product, while insisting that it was simply giving consumers what they wanted.

With computer-related anxiety, addiction, dependence, stress, and post-traumatic stress disorder on the rise, a contingent of mental health professionals are developing a new standard of mental healthcare for our technologically changed world. Their profession faces a steep learning curve. There is growing recognition in psychology and cognitive science that people are experiencing distress over technological changes. This means that mental health impacts could worsen in the future. The human society will have to adapt to many changes, including technological ones. People today are dealing with personal problems in the context of such technological changes. Moreover, these changes will impact how one deals with personal problems (Kordigel Aberšek, Aberšek, 2020).

A bottom-up model should be used to address technological changes, regardless of its illusory appearance (Kordigel Aberšek, Aberšek, 2022). It needs to be clear that the interests of influencers (the IT industry) and the interests of the everyman are usually worlds apart. Influential people from IT are aware that they can "buy" their world, their own (private) school system, their part of the "paradise", where they will create "ideal conditions" at the expense of others. However, the everyman is the one who will have to actually go to these public schools in the (part of the) world that will remain. The strength, the power of the everyman, is in the masses (Aberšek, Pesek, Flogie, 2023). But the problem is very often a lack of awareness, a lack of faith, and failure to realize that the only way to achieve change is to join forces – and that with this in mind, everything that divides us should be forgotten and instead, connections should be made between fellow humans, regardless of the differences. Time is running out: even in the optimistic scenario, humans are at a deception point, from which there is no return, although pessimists would say that we have already crossed this point a long time ago. People have entered a period of chaos and possible great change. The only problem with this is that they need to really know what they want, and to be aware that there is only little time left to take action! With all this in mind, it can be said that human beings have at least two enemies:

1. The *inner* one, ourselves; we (human beings) are (unfortunately) our greatest enemy.
2. *The outer enemy – time*, which will keep breathing down our necks and forcing us to make decisions. Just think of how the pandemic was (and still is) being addressed: the results are not how we would like them to be! The problem, however, is that a permanent solution is possible only in the long term, by creating awareness starting with young people throughout the whole vertical of education.

Conclusion

If one was to sum up two historical paradoxes, the Moravec paradox[1] and Simpson's paradox[2] (Moravec, 1988, Simpson 1951), one could conclude that it is not enough simply to "conduct research" and produce statistics using all its high-flown statistical methods, without knowing and understanding the problem at hand. One can quickly see that what should, by definition, be hard (planning and conducting research or coding) becomes easy, and what should be easy (interpreting the results obtained) becomes complicated, and that without understanding the problem itself, this can quickly lead to wrong conclusions (Aberšek, 2021).

1 Moravec's paradox is the observation in artificial intelligence and robotics that, contrary to traditional assumptions, reasoning requires very little computation, but sensorimotor and perception skills require enormous computational resources.

2 Simpson's Paradox is a statistical phenomenon where an association between two variables in a population emerges, disappears, or reverses when the population is divided into subpopulations.

https://doi.org/10.33225/jbse/23.22.952

ISSN 1648–3898 /Print/
ISSN 2538–7138 /Online/

To focus only on the technological transformation of today's society: in light of everything said above, it can be said that the term STEAM in the context of digital competence and/or digital literacy does not take into account all the components needed for the 21st century (Kordigel Aberšek, Aberšek, 2020). A possible solution could be that educators would approach the challenge of teaching students to engage safely and responsibly with science or with technology by focusing on the role of the 4C's[3]:

Critical thinking. It is easy to read an article or see a photo and take it for face value, however, as we all learn from "fake news" and social media, this can also imply certain dangers. Students need to learn how to evaluate sources and make decisions about how to use the new information. This is of key importance in an age where there is an overwhelming amount of information.

Creativity. Anyone can easily create digital content, but the quality of this content is another question. Teachers can help students tap into their strengths and areas of interest while emphasizing original content and developing a quality product. To make it relevant and authentic, teachers should encourage students to publish their work using a variety of digital tools and elicit feedback in the process.

Communication. Teachers cannot protect their students from using the internet or AI (for example, ChatGPT), but they can help students understand how to generate a positive and safe digital footprint. Communication does not take place only face to face or over the phone; it also happens when deciding what to share and whom to share it with on the internet. In the age of schools' massive adaptations to digital learning environments, communicating responsibly on the internet has become a vital skill.

Collaboration. Connecting with other people from diverse backgrounds enhances the ability to understand multiple perspectives. Learning from and with others worldwide is possible with digital tools like X, Skype, Padlet, ChatGPT, etc. Students can work beyond the confines of their classroom to find answers to real-life problems. Students become better prepared to participate successfully in our global economy through this type of collaboration.

Including the 4C's in all applications of technology in the classroom allows teachers to validate what students are already interested in, and provides relevant and personalized opportunities for them to grow and learn. It is an excellent opportunity for teachers to learn *with* and *from* students. Suppose teachers find out what their students' favorite digital tools are and why they like to use them (while stressing how such tools need to be used safely, responsibly, and effectively). In that case, these tools can be leveraged within the classroom and used to take students outside – even to another country (Kordigel Aberšek, Aberšek, 2020).

On the other side, because of the growing importance of technology and engineering (STEAM) in the "digital" and AI-oriented educational landscape, proposals of the US National Assessment Governing Board[4] should be taken into account. The NAGB decided that technological and engineering literacy would be an essential addition to the National Educational Progress (NAGB, 2018). When answering test questions, students are expected to demonstrate the following kinds of practices in particular:

- Understanding Technological (Digital and AI) Principles,
- Developing Solutions and Achieving Goals,
- Communicating and Collaborating,
- Teaching/Learning for Citizenship of the 21st Century (Society 5.0), and, finally,
- Teaching for Living Skills and Competences in Society 5.0.

References

Aberšek, B., Pesek, I., & Flogie, A. (2023). *AI and cognitive modelling in/for education.* Springer.

Aberšek, B. (2021). The paradox between truth and lies. *Problems of Education in the 21st Century*, *79*(6), 834-837. http://dx.doi.org/10.33225/pec/21.79.834

Kordigel Aberšek, M., & Aberšek, B. (2020). *Society 5.0 and literacy 4.0 for the 21st century*. Nova Science Publishers.

Kordigel Aberšek, M., & Aberšek, B. (2022). Digital competence for science technology and engineering education. *Journal of Baltic Science Education*, *21*(1), 108-120. https://doi.org/10.33225/jbse/22.21.108

3 *http://www.battelleforkids.org/networks/p21)*

4 *www.nagb.gov*

https://doi.org/10.33225/jbse/23.22.952

Moravec, H. (*1988). Mind children.* Harvard University Press
NAGB (2018). *Technology and Engineering Literacy Framework for the 2018 National Assessment of Educational Progress*. National Assessment Governing Board.
Oreskes, N. (2020). History matters to science. *Scientific American, December 2020.*
Simpson, E. H. (1951). The interpretation of interaction in contingency tables. *Journal of the Royal Statistical Society. Series B (Methodological)*, *13*(2), 238-241. https://www.jstor.org/stable/2984065

Received: *November 14, 2023* Revised: *November 25, 2023* Accepted: *December 08, 2023*

Cite as: Aberšek, B. (2023). A historical understanding of how science works. *Journal of Baltic Science Education*, *22*(6), 956-955. https://doi.org/10.33225/jbse/23.22.952

Boris Aberšek PhD, Professor, Faculty of Natural Sciences and Mathematics, University of Maribor, Koroška cesta 160, 2000 Maribor, Slovenia.
E-mail: boris.abersek@um.si
Website: https://scholar.google.com/citations?user=aRid0w4AAAAJ&hl=en
ORCID: https://orcid.org/0000-0002-4198-4240