HPS&ST NEWSLETTER

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The HPS&ST NEWSLETTER is emailed monthly to about 8,400 individuals who directly or indirectly have an interest in the contribution of history and philosophy of science to theoretical, curricular and pedagogical issues in science teaching, and/or interests in the promotion of innovative, engaging and effective teaching of the history and philosophy of science. The NEWSLETTER is sent on to different international and national HPS lists and international and national science teaching lists. In print or electronic form, it has been published for 25+ years.

The NEWSLETTER seeks to serve the diverse international community of HPS&ST scholars and teachers by disseminating information about events and publications that connect to concerns of the HPS&ST community.

Contributions to the NEWSLETTER (publications, conferences, opinion pieces, &.) are welcome and should be sent direct to the editor: Michael R. Matthews, UNSW (m.matthews@unsw.edu.au).

The NEWSLETTER, along with RESOURCES, OBITUARIES, OPINION PIECES and more, are available at the website: http://www.hpsst.com/

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Teaching philosophy of science to students from other disciplines, *European Journal of Philosophy of Science*, Thematic Issue

Guest editors: Joeri Witteveen & Sara Green (University of Copenhagen) Description: Philosophy of science courses are increasingly taught not only to philosophy students, but also to students from other disciplines. While this offers a unique opportunity to engage with other fields and make philosophy of science relevant for other target groups, it also calls for reflection on *what* and *how* to teach. Whereas philosophy of science critically examines the methodological approaches in other fields, much less attention has been given to the didactical strategies used within philosophy of science, and to discussions of how we, through teaching, can make philosophy of science relevant to other target groups.

The aim of this topical collection is for scholars to reflect on the challenges associated with teaching philosophy of science to non-philosophers and to discuss ways to overcome these. We especially welcome contributions that draw connections between philosophy of science and science education, and that consider how to improve learning strategies for philosophy of science. We encourage authors to reflect on their own experience with teaching philosophy of science to non-philosophers in a scholarly way. Questions that could be addressed by contributions in the topical collection are not restricted to, but could include the following:

- What makes teaching non-philosophy students different from teaching philosophy students and how should we (historians and philosophers) adapt to an audience of practitioners of a field of study that we are reflecting on?

- To what extent do the learning objectives differ when targeting other student groups, and to what extent do different goals of teaching influence the selection of topics, teaching formats, and modes of examination?

- How can the teaching of philosophy of science to students in the natural and life sciences benefit from recent developments in integrated HPS, practice-oriented philosophy of science, and socially relevant philosophy of science?

- How can research in science education inform teaching of philosophy of science – and vice versa?

- What pedagogical approaches (such as inquiry- or case-based teaching) are proved useful or useless for a successful learning and teaching experience?

Papers submitted to the topical collection should not exceed **5000 words** in total (excluding references). Timeline
Deadline for submitted contributions: **Dec 1, 2020**
First round of reviews completed: **Feb 1, 2021**
Deadline for revisions: **April 1, 2021** Submitted papers will be peer reviewed following the journal's standard, and accepted papers will be published online on a rolling basis. Please anonymise submissions for peer review prior to submission and chose [Teaching philosophy of science] in the drop-down menu on the EJPS submission page. Questions about the topical collection can be addressed to:
Guest editors: Sara Green (sara.green@ind.ku.dk) and Joeri Witteveen (jw@ind.ku.dk).

Science & Education, "Science Education in the Era of a Pandemic", Contributions Invited

Members of our community are facing new ways of working and some have no work or reduced work due to illness and/or care responsibilities. *Science & Education* considers it important to engage our community in constructive debates about how science education can contribute to understanding and solving the COVID-19 crisis. We aim to make these uncertain and distressing times purposeful and productive for the research and learning communities engaged in the improvement of science education through history, philosophy and sociology of science.

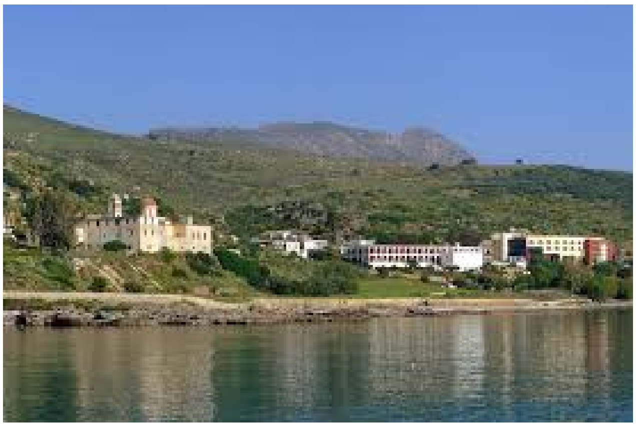
More information in the open access Editorial here.

Sibel Erduran, Editor-in-Chief

UNILOG 2021 – The 7th World Congress on Universal Logic, Kolymbari, Crete, March 28 – April 7, 2021

The congress is being held at the Orthodox Academy of Crete, Kolymbari.

UNILOG is a series of events (combining a congress and a school) promoting logic in all its aspects: mathematical, philosophical, computational, semiological, historical the relation between logic and other fields: physics, biology, economics, law, politics, religion, music, literature, pedagogy, colour theory, medicine, psychology, psychoanalysis, cognitive science, architecture, artificial intelligence, sociology, linguistics, anthropology.



7th UNIVERSAL LOGIC SCHOOL
The school will have a duration of 5 days: from March 28 to April 1st 2021 with: – an opening round table on the topic "Why study logic?", 30 tutorials, a poster session.

7th UNIVERSAL LOGIC CONGRESS
The congress will have a duration of 6 days: from April 2 to April 7 2021 with invited speakers, contributing speakers, workshops, and a contest.

2nd WORLD LOGIC PRIZES CONTEST
The 1st World Logic Prizes Contest took place in Vichy, France, during the 6th UNILOG in 2018. This contest is a competition between winners of logic prizes of different countries.
To the winner is awarded the Universal Logic Prize.

UNILOG 2021 is organised under the Aegis of the

Government of Crete. Crete is an island with a history of about 5,000 years, the cradle of Western civilisation, including the Labyrinth, Plato's cave and much more.
Everybody is welcome to join and enjoy this wonderful place.

Details available at https://www.uni-log.org/

Interuniversitary Institute for Science Studies (IILP)

The Interuniversitary Institute for Science Studies (IILP) is an academic institution involving four universities (http://www.instinterlp.org/) which supports research projects and other activities related to social and historical studies on science, technology, medicine and the environment.

The IILP organises online master and doctoral programs (registration has been just open here) and online talks as part of the seminar series organised around research programs or particular topics.

Many of these talks are now available at the website.

José Ramón Bertomeu Sánchez, Universitat de València

Lakatos Award, 2021

Applications are invited for the 2021 Lakatos Award, with a strict deadline of **Tuesday 1 September 2020**. The 2021 award will be for a monograph in the philosophy of science broadly construed, either single authored or co-authored, published in English with an imprint from 2015 to 2020, inclusive. Anthologies and edited collections are not eligible. Any person of recognised standing within the philosophy of science or an allied field may nominate a book. Nominations must include a statement explaining the nominator's reasons for regarding the book prizeworthy. Self-nominations are not allowed.

Please address nominations, or any requests for further information, to the Award Administrator, Tom Hinrichsen, at t.a.hinrichsen@lse.ac.uk.

A Layperson's Gude to Epidemiological Modelling

Quite suddenly, many people came to hear about scientific models who have never studied science beyond secondary school. Even less are they familiar with the relevant philosophy of science. These newly famous models are epidemiological models, the models that are being used by governments and their advisors in their attempts to forecast the evolution of the COVID-19 pandemic and to develop a strategy for dealing with it. These epidemiological models have therefore become the focus of much attention and discussion. Many tens or hundreds of thousands of people have expressed views via social media on what the correct strategy towards COVID-19 should be. Yet only a small minority of those commentators will have even the first idea of how any of the epidemiological models works. The predictions of some models have been used to berate governments, even though those models make extremely dubious assumptions (I am thinking here in particular of the model used by the IHME at the University of Washington to make some very alarming and implausible projections).

Because understanding epidemiological modelling is essential to reasonable participation in these public debates, the Philosophy & Medicine project at King's College, London, funded by the Peter Sowerby Foundation, has produced a series of videos (and related resources) explaining how one central epidemiological model (the SIR–Susceptible-Infected-Recovered–model) works and discussing what the UK government's strategy towards textsccovid-19 might be. So far we have produced three videos:

1. A Layperson's Guide to Epidemiological Modelling
2. Herd Immunity
3. What is the UK Government's COVID-19 Strategy?

These are available online here.

If there is demand, we might do a fourth video one comparing the use of models by different teams of epidemiologists (e.g. Oxford, Imperial, and perhaps the IHME too).

We hope that the introductions to epidemiological modelling will be of use to philosophers of science who are not familiar with these particular models. Scientific models have been an important topic for philosophers of science. Most often the models discussed are from physics, though the Lotka-Volterra equations from biology are a favourite too. The SIR model may be less familiar, but is a nice example of a simple model that may be elaborated in various ways in order to capture more complicated cases.

Furthermore, philosophers of science can contribute to the discussions mentioned previously, by explaining both the value and the limitations of using models.

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Opinion Page I: *Replicable, Reproducible, and Generalisable: Implications of Scientific Hallmarks for Research in Education*

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Introduction

As a not so innocent undergraduate student sitting in an animal physiology class (approximately 50 years ago), my professor said prior to a laboratory investigation, 'No matter how controlled the situation is with respect to sampling, research procedures, ambient temperature, ambient lighting, organism satiety, and all other relevant variables *the rat will do whatever he damn well pleases*'. It was a humorous comment to which my classmates ascribed no significant meaning. I was reminded of my professor's comment when reading Alger's (2020) commentary on the importance of reproducibility in science in the February issue of the HPS&ST NEWSLETTER and his brief discussion of the influence of the personalities of rats and mice on experimental investigations. Indeed, my professor's comment was more poignant than I thought at the time. Additionally, Alger's discussion is also reminiscent of the 2002 debates about "scientific research in education (NRC, 2002) and the formation of the What Works Clearinghouse (WWC) by the U.S. Department of Education.

The discussion of the hallmarks of scientific research conveniently begins with the idea of 'ways of knowing'. As humans we have various approaches to knowing. Each of the academic disciplines we encounter are characterised by different ways of knowing. That is, each develops knowledge in similar, but different, ways. Some of the more common ways of knowing are appeals to authority, *a priori* knowledge, and scientific (also known as the scholarly approach). Appeals to authority are exemplified by the numerous marketing advertisements that state things such as 'nine out of 10 doctors say…' or 'Linus Pauling says that vitamin C cures the common cold' or 'John Dewey says…'

Alternatively, sometimes knowledge is established through logic. For example, 'since vitamins are good, the more the better' or 'the more subject matter knowledge a teacher has, the better they will be as a teacher'. These are examples of *a priori* knowledge and are based on logical connections to assertions that we have always known to be true. Finally, there is the category of scientific knowledge, which is a systematic, empirically based, and self-correcting. Furthermore, scientific research generally follows three general forms: descriptive, correlational, and experimental. Education, and the social sciences, value and try to adhere to the scientific approach to knowing. Hence the knowledge established by educational research seemingly should be replicable, reproducible and generalisable. But is this the case or is it even a reasonable expectation?

What is Meant by 'Replicable' and Why is it Important?

In general, replicable refers to the ability of a researcher to exactly, as much as possible, follow the same procedures (e.g., data collection approach, instrumentation, data analysis, etc.) in an investigation to see if the same results are obtained. This does not mean that the specific statistical values are the same, but rather that the overall findings of rejecting or failure to reject hypotheses are achieved. For example, do humans with higher levels of cholesterol consistently exhibit higher levels of heart disease? If the results of an investigation can be consistently repeated, researchers have more confidence in the findings.

At the most mundane level, statistical analysis has a stated level of significance (e.g., .05 or lower), which means that any probability of .05 or lower is considered as evidence that the achieved results are the result of something other than chance. Alternatively, it can also mean that the significant results also have a .05 level of probability of occurring by chance. By convention researchers have agreed that a .05 probability of results is rare enough that something other than chance is at play. It also means, unfortunately, that if the same study is performed enough times, significant results will be achieved most of the time, both significant and non-significant results will be achieved. The researcher does not know from a single investigation whether the results achieved are part of the chance occurrence group or the rare and significant group. Consequently, it is essential that attempts to replicate findings are necessary.

If you are attempting to see if you are holding a normal two-sided coin, you could flip the coin 100 times. If the coin is "normal" you would expect the number of times it lands on one side versus the other side to be approximately equal. If we get one side appearing 95 times or higher, we would conclude that something other than chance has occurred. However, we could be wrong because there is a chance, albeit small, that the coin may land on one side 95 or more times due to chance. Hence, the importance of have replications of science investigations.

This point was stressed by Alger (2020) and we all stress this to our students in science classes as well as in our education research courses. So, it would be appropriate to conclude that replication is important in science research as well as in educational research. The one glitch is that in educational research we are usually studying animate objects as opposed to inanimate objects and "the rat will do whatever he damn well pleases." This same point is made eloquently by Cziko (1989) in his discussion of free will. It is certainly true that in many areas of science animate subjects are used. But most of the time the target of interest are molecules and their interactions. These molecules do not make mindful decisions as to how they will respond to a certain condition.

What is Meant by 'Reproducible' and Why is it Important?

Reproducibility is the main focus of Alger's (2020) commentary and he discusses the topic in much more detail than will be found here. The concept is closely related to replication, but slightly different, for practical reasons. Let us return to the previous example relating cholesterol to heart disease. Two different studies may be attempting to answer the same question. However, it is inevitable that different samples will be used and there also could be different approaches to the measurement of cholesterol levels as well as the form of the cholesterol when it was taken into the human system. For example, was the cholesterol in the same foods eaten or was there a variety of foods that lead to the ingestion of cholesterol? So, in such cases, the studies are not replications of each other. Additionally, the two studies may have handled 'outliers' differently in their data analyses. There are inevitable differences, but the results may be equivalent and lead to the same conclusion about the relationship of heart disease to cholesterol.

Consistency across these studies, as well as others, is important and leads to building confidence among researchers, even though the studies are not technically replications. The same factors that can impact conclusions reached in replication studies hold in studies that document reproducibility. As with replication, reproducing findings is valued in education research, but with important qualifications, that will be discussed later. In the end 'the rat will still do whatever he damn well pleases'.

What is meant by 'Generalisable' and Why is it Important?

The third hallmark of scientific research is generalisability. Quite simply it pertains to how well the research findings from an investigation apply to situations extending beyond the current investigation and its context. For example, do the findings of research on cholesterol and heart disease in Massachusetts apply to samples of individuals from other locations in the U.S. or other countries around the world? This is difficult to establish because of a multitude of extraneous variables (i.e., variables that affect the results of an investigation that were ignored or were unknown). Certainly, replication and reproducibility studies enhance the ability to generalise findings, but they do not guarantee it. Generalisability is a cornerstone of progress in science. It is this hallmark that lends the most confidence to research findings and marks the progress of science with respect to one or more aspects of the natural world. However, it is difficult to achieve.

Generalisability is more easily attained with inanimate objects. Most would agree that gravity functions in the same manner globally. Although the effects on the earth's surface differ because of the earth's oblate shape, the law of gravitation does not take a different form in South Africa, Israel, and in Japan. Animate objects provide another perspective, and this is especially true in educational research. Students vary with respect to gender, culture, identity, religion, cognitive ability, among others. Each of these characteristics individually, or in tandem, impact the success of a particular curriculum. This is a perennial problem for education researchers. Generalisability is generally valued, but quite difficult to achieve. Additionally, it is important to note that some qualitative researchers make no claim that their findings are generalisable, nor do they think that it should be a goal of their research.

What is the Applicability of Scientific Hallmarks to Educational Research?

This commentary has provided a general overview of the concepts of replicable, reproducible, and generalisable in science. They are related hallmarks of scientific knowledge and goals of science as a way of knowing. However, Alger (2020) provides a much more tempered view of their importance in science, as well as their necessity. His view is refreshing.

Since educational research attempts to develop knowledge in a scientific way it would seem that the aforementioned hallmarks are important to research in education. Their importance in education must be qualified even further. The concepts are largely positivistic and posit a view of nature of science and scientific inquiry that is reminiscent of the 2002 debates about "scientific research in education (NRC, 2002) and the formation of the *What Works Clearinghouse* (WWC) by the U.S. Department of Education. These debates focused on what constitutes scientific evidence and the relative value of qualitative and quantitative research paradigms.

The film and book titled *Never Cry Wolf* chronicles an actual account of a scientific study designed to document that the decrease in the population of caribou in the arctic was due to wolves preying on the caribou. Scientific data to document this assertion did not exist and the work of Tyler (i.e, the scientist) was to provide these data and lead to a plan that would intervene by reducing the wolf population. Upon arrival in the arctic location, it became clear to Tyler that much of the supplies were not useable in the frigid north. Nevertheless, the research plan was to kill several wolves and then investigate the contents of their stomachs. Tyler did not see any wolves at first so he began to observe their scat for remnants of caribou. No remnants were found. When he finally did observe some wolves, he noted that they were not getting their daily sustenance from consuming caribou. It was clear that the original premise of the research was not adequate to solve the original problem and so he drastically altered the design of his investigation. He proceeded to observe all aspects of the wolves' behaviour; he tried to integrate himself as much as possible into the wolves' daily lives. He chose to perceive with '*what worked*'.

In the end, Tyler found that the wolves were living primarily on rodents. The times that they did prey on caribou was on the weakest and most diseased members of the heard. In short, the wolves were actually enhancing the genetic pool of the heard and helping the future survival of caribou as opposed to being a menace to their ultimate survival. The scientist's change of plans worked. He was able to answer his research question by finding 'what worked'.

What this book illustrated was that scientists pursue the answers to their questions in various ways. These approaches differ within the various sciences and vary even more across the different sciences. There is no single set or sequence of steps that scientists always follow. There is no *single scientific method* or any single approach that can be used to characterise all of science. The questions that scientists have guide their research approaches/design and scientists, within certain limits, do 'what works'. Much of the tempered view of science taken by Alger (2020) is echoed in this book.

Never Cry Wolf and Alger's (2020) commentary remind me of the policy debates about scientifically-based educational research in 2002-2003 (Berliner, 2002; Eisenhart & Towne, 2003; Erikson & Gutierez, 2002; National Research Council, 2002; Slavin, 2002; St. Pierre, 2002). These debates lead to the development of the WWC by the Department of Education, whose mantra was '*what works*'. The WWC advocated that educational research needed to be more scientific and that the reason we are in a quandary about what constitutes good practice in educational settings. It was clear that varying methods were appropriate in educational research, designs that established cause were strongly preferred. Underlying the debates was a misrepresentation of 'what is science?' This is quite similar to the position of Alger (2020) that certain attitudes about reproducibility are less than accurate.

Historically, during the latter part of the 20th century, a systematic and concerted effort to study teaching and learning was undertaken. Researchers borrowed from the same models of agricultural designs used in mainstream science. Perhaps the primary reason for this decision was the cultural status possessed by science and/or the reigning popularity of positivist thinking. Although this approach to research was virtually the same as that advocated by the WWC, it provided important foundational knowledge about teaching and learning, but it was clearly limited. In depth understandings of teachers' thought processes and how students mediate instructional experiences were not accessible through such means. Educators realised that many questions remained, and new questions had arisen. In their search to find out 'what works', they needed to consider alternative research approaches that worked. The situation was really no different than what confronted Tyler and his wolves.

Educational researchers in all areas began to view classrooms as systems and cultures. They began to see the importance of the dynamic interactions among participants (i.e., teachers and students), as groups and as individuals. Borrowing from anthropology and sociology, educational researchers began to research instruction from a totally different perspective than what was afforded by the 'scientific' agricultural designs (Howe, & Eisenhart,1990). The situation is not much different than the shift from reductionist to systems thinking in environmental studies. As a consequence, there are few today who do not realise the difficulty in generalising educational research from one class to another (with the same teacher), let alone generalising across teachers, schools, states, and countries.

Interestingly, classroom teachers have known this all along. Most teachers' complaints about research findings that failed to resonate with their local situations were in response to rigorously quantitative studies that over generalised in deference to sampling theory. The difficulty, or the impossibility, of generalising as is commonly conceived is aligned with Alger's (2020) as well as within current thinking by educational researchers.

Misconceptions some have about the existence of a single scientific method aside, there are other problems with the application of classical experimental scientific research designs to classroom situations. It is absolutely critical, if one wants to imply cause, to carefully control or account for extraneous variables in research. There are problems, however, when you are dealing with situations involving living organisms that exhibit voluntary or free will and individuals that react differently, for a variety of reasons, to the same environmental conditions/stimuli. Remember my physiology professor's rat and how it behaved.

There has been a history of attempts to conduct carefully controlled experiments in classroom settings. However, the situation becomes so contrived that little external validity can be ascribed to the investigation. Quite simply, the situation is so deviant from general classroom life across settings that attempts to generalise to other situations have become futile at best. Much of the research conducted in 'laboratory schools' suffered from this problem. The research, in and of itself, was fine for the specific situation, but generalising to other populations was difficult. Nevertheless, the WWC would like to pursue this path again, to the degree that they place little value on designs that do not attempt to make definitive causal claims.

The WWC, and those promoting that educational research become more scientific, claim to be moving educational practices toward a 'medical model'. The medical clinical trial has been posited as the 'gold standard'. That is, educational practitioners are asked to seek the results of 'scientifically controlled studies (like clinical trials)' to make instructional decisions. To be clear, most medical research, for ethical reasons, does not follow experimental research models. It is simply not acceptable to randomly solicit participants for an investigation and then randomly assign them to treatments, one of which has potential harm. In most cases, medical research involves ex-post facto designs (e.g., heart disease studies, smoking/cancer studies), which are correlational by nature.

Surely, many readers will now want to direct my attention to the plethora of experimental studies in medicine that involve human models (substitutes for humans in terms of physiology). Surely, they would say, all of the research done on various drugs and medicines began with experimental studies on rats or other mammals with the only inference being the similarities between the physiology of the human and the physiology of the animal being used as a model. In this case, my detractors would be absolutely correct.

However, there is a vast difference between generalising results of experimental medical studies using human models and generalising experimental studies in education. The studies with drugs, medicine, etc., involve inanimate effects in the sense that what is involved is the interaction of various molecules within the physiological systems of the human or human model. In education we transcend the organic level and have to grapple with motivation, free will, emotions, attitudes, etc.

Certainly, inanimate factors influence all of these human characteristics, but virtually everyone interested in learning beyond a passing curiosity knows learning to be far more complex. I don't know anyone who would currently assume that using a particular teaching approach with birds would generalise to human learning. Wasn't this the problem that we all had with operant conditioning and the work of behaviourists? When it comes to complex thinking, human behaviour is just not that simple. Or it is not simple enough to allow the high levels of predictability and generalisability.

It is interesting to note that there was a period of time in recent history when experimental studies in learning involving human models was in vogue. Do you remember the investigations in which worms or rodents were taught certain skills and then were sacrificed and fed to other animals of the same type? This approach was entrenched in the belief that learning was organic and learning could be transferred through the transfer of organic material. Again, the medical model of experimental research only holds for investigations involving the inanimate, not such things as complex learning in humans or other mammals.

Conclusions

By now you may have concluded that educational researchers must be total relativists and would not admit to any progress in our knowledge of teaching or learning. Nothing could be further from the truth. We are strong supporters of the value of both quantitative and qualitative research. My colleagues and I also believe that studies with small sample sizes can be as valuable as studies with large sample sizes. The most critical issue is the relationship among the research questions, research design, and the nature of the data collected.

Research questions should guide design and data choice. Researchers should pursue "what works," and this depends on the question being asked, not some idealised scientific method that is incorrectly purported to be the only method to produce scientific evidence. In addition, it is critically important that all researchers remain intimately aware of the assumptions embedded in their research questions, designs, and analyses and the implications these assumptions have for results being replicable, reproducible, and generalisable to the rest of the world. Such a perspective is consistent with the views of Alger (2020) about the expectations for scientific knowledge.

Overall, although the intentions of the WWC and those advocating that educational research become more scientific are admirable, the advocacy is flawed for at least two critical reasons. There is a clear underlying (and sometimes not so subtle) belief that scientific evidence can only be provided by causal research designs (aka The Scientific Method) and that research findings from studies of teaching and learning can be reproducible, replicable, and generalised freely across contexts and situations if derived from rigorously controlled studies scientific studies. In our attempts to enhance teaching and learning from systematically collected empirical evidence let us never lose sight of the unpredictability and indeterminate nature of human behaviour (Cziko, 1989).

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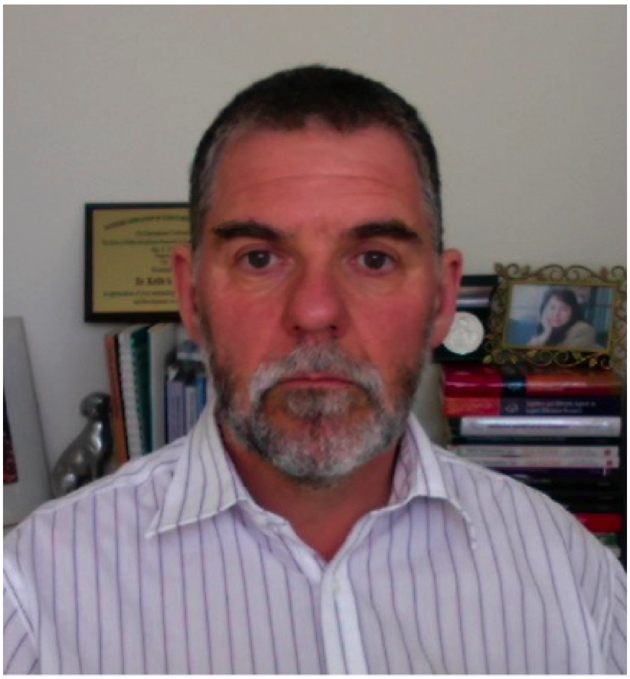
Opinion Page II: *Is Reproducibility a Realistic Norm for Scientific Research into Teaching?*



Keith S. Taber
Professor of Science Education, University of Cambridge
UK

In a recent Opinion piece in the HPS&ST NEWSLETTER, Bradley Alger (February 2020) asked if we should be concerned about non-reproducibility in science. It could be argued that if much scientific work is not (and, perhaps, cannot be) replicated, then this might present some kind of existential crisis for science.

At the risk of reducing a nuanced argument to a few bullet points, Alger was suggesting that reproducibility is seen as norm in science, perhaps sometimes even a criterion for work to be seen as scientific, and that recent discussions of the extent to which published studies may resist attempts at replication presented a challenge for the scientific community. If a substantial proportion of the studies in the scientific literature cannot be replicated, then we may seem to be faced with a choice between downgrading reproducibility as a criterion for science, or, alternatively, accepting that there is something very rotten in the state of the scientific literature.

Alger explored different understandings of reproducibility, and highlighted the implications of using statistical significance as a basis for claiming that an experiment gives a positive result. Given that the conclusions of many studies are based on inferential statistics, there is an inherent tolerance (in the technical sense) for a level of non-reproducibility that is to be expected across published studies, such that the scientific community should show a level of tolerance (in the psychological sense) of non-reproducibility of published results.

Alger's essay concerned scientific studies; that is, research in what are commonly termed the natural sciences. In this essay I wish to *complement* Auger's discussion by focusing on educational research. Education is commonly seen as falling within the social, rather than the natural, sciences. However, the breadth of work actually undertaken in education is very wide – from research in cognitive science that employs laboratory conditions and adopts strict experimental paradigms; to studies that deconstruct texts through literary analyses, or are purely philosophical in nature, and which are better considered part of the humanities. This is too great a spectrum to readily consider as being of a kind (even a 'social kind' as discussed below), and so my remarks here relate to a subcategory within empirical educational research investigating classroom teaching. What I have to say here applies across that category, but the focus will be taken to be studies on science teaching.

An impression given by the research literature is that many of my fellow science education researchers, having initially trained in the natural sciences, consider that the methods of those sciences can be relatively unproblematically applied to educational research. Consideration of the different nature of natural and social phenomena suggests that this is not so.

I will argue that research into education cannot be approached like research in physics laboratories because educational research concerns social kinds (such as 'teachers', 'classes', 'lessons', etc.) which do not support the assumptions made about natural kinds underpinning much work in the natural sciences. It might also be provocatively suggested that to the extent that research into teaching is sometimes like some studies in natural science, this is because some scientific studies fall subject to the kinds of complexities inherent to social science research (e.g., inability to identify all relevant variables; inability to isolate the phenomenon of interest from interactions with its context), as in the examples of 'unforeseen impediments to reproducibility' cited by Alger.

A key purpose, indeed rationale, of educational research is to inform teaching. There is a substantive literature on effective pedagogy in science teaching, including many empirical studies claiming to test the effectiveness of different teaching approaches, or reform curricula, or new learning resources. Many of these studies adopt an experimental approach, or, at least, a quasi-experimental approach, and then draw conclusions on the relative effectiveness of some pedagogy or resource or curriculum innovation, usually based on measures of student learning gains or changes in attitudes. These studies draw upon the experimental method used in the natural sciences to compare outcomes in two or more distinct conditions that differ in terms of some independent variable. So, perhaps, in one condition a group of 13-14 year old students study the topic of acids and alkalis through co-operative group-work, whilst in the 'control' condition a similar group of students is taught the same topic through what might be (and often is) termed 'traditional' instruction. If statistical analysis suggests that the students in the co-operative group-work condition show significantly greater learning gains (or shifts in attitude, etc.) than those in the traditional condition then researchers conclude that the co-operative group work condition is superior.

I have suggested these studies *draw upon*, rather than *adopt*, the experimental method used in the natural sciences, as, although educational experiments are superficially like experiments in the physical sciences, an engagement with the details of research designs often raises serious concerns. There are certainly substantive issues in relation to generalisability and control of variables.

I have recently undertaken a review of work of this kind, exploring the methodological and ethical challenges of experimental work intended to test teaching innovations (Taber, 2019a). The key *ethical* issue raised is how learners in 'control' or 'comparisons' are treated instrumentally in many studies that pass journal peer review: it may be perfectly acceptable to set up a control condition expected to be deleterious when the experimental subject is a copper wire, or a crystal, or a rivet, or even a mustard seedling (or indeed, to many people's thinking, a rat), but it is a different matter to set up teaching conditions which can reasonably be expected to disadvantage the learning of whole classes of students attending public schools. It is not only that many studies actually do this: it is often made quite explicit in the published reports that this is a deliberate aspect of the research design.

Here, however, I want to consider some of the *methodological* challenges of such work, and how the nature of what is being studied undermines notions of replication or reproducibility of studies. Space here only allows a limited discussion, and interested readers are referred to the full review article (Taber, 2019a) for further detail.

Natural kinds and social kinds

One very relevant concern that is often ignored in educational research (and indeed from my reading, often also in psychological research) is the distinction between natural kinds (Dupré, 1981) and what have been called social kinds. The notion of natural kinds is based on an ontological assumption: that nature offers us certain regularities of experience that justify classifying recurrent features of our experience as having inherent, essential, properties. We can class this as gold (which will therefore have *these* properties) and that as phosphorus (which will therefore have *those* properties); we recognise *this*, but not *that*, as an instance of torque. *These* are dogs, and *those* are cats.

Of course, there are limits to this. There is probably no such thing as an absolutely pure sample of gold, but we can decide on a level of impurity low enough to be negligible. There is a diversity of varieties of dogs, and, since Darwin, we no longer think that there are absolute boundaries between species or indeed any taxonomic categories. We may be fairly clear what extant specimens are, or are not, mammals; but go back into the fossil record, and there will a point where it becomes a matter of debate, and indeed, potentially, scientific controversy.

We can identify a particular strain of microorganism that we know has certain genetic characteristics that give it particular properties in certain environments. At the type of writing the world is suffering from, and responding to, a global pandemic. The disease concerned is known as COVID-19, and it is considered to be caused by infection with a transmissible virus known as SARS-CoV-2 (severe acute respiratory syndrome coronavirus-2). Not only the scientific community, but the population generally, accepts both that the infectious agent is a virus, and, moreover, that it is a particular type of virus, indeed a particular type of coronavirus (SARS-CoV-2); *and* also that one specimen of SARS-CoV-2 is much like another in that any specimen has the inherent property of being able to infect human beings leading to the 'same' disease.

Even if the layperson has never heard the term 'natural kinds', and indeed has no technical knowledge about such matters as the means by which viruses cause disease, they will still have an implicit notion of the natural world such that they have no difficulty accepting that billions of specimens of virus particles around the world are causing the same disease because they are of one kind.

Generally, the subjects of scientific studies are samples/specimens of natural kinds where it can either be assumed (i) that swapping the particular specimen would not change the results, or (ii) that there is some relevant variation between specimens such that we should work with a sample and draw conclusions statistically, so that drawing a new sample from the same population should give substantially the same results. If we find a pure copper rod is a good conductor, then this applies to all pure copper rods and not just the one(s) we decided to test. If we find a sample of a variety of wheat plants grow taller on average when we provide a phosphorus-based fertiliser then we assume this will generally apply to other samples of wheat of that kind.

Often, in science education, we find that learners have intuitions about the natural world that are contrary to canonical science and can impede school learning (Taber, 2009). So, many students have intuitions contrary to Newton's first law for example, and so expect all motion to naturally come to a stop; or assume the force acting on an orbiting body acts tangentially to, rather than perpendicular to, its instantaneous direction of motion. Many such 'intuitive theories' or 'preconceptions', as they have been called, make learning canonical science more challenging.

However, an informal commitment to objects being specimens of natural kinds is a common intuition which works to the advantage of teachers of physics and chemistry. So, learners usually readily accept, for example, that all protons have the same amount of positive charge, all samples of copper wire will conduct electricity, and that all samples of potassium dichromate will act as oxidising agents. It is quite common for school laboratory work to be used to generalise results from a single run on one sample of materials (usually without any explicit attention to the grounds for, or validity of, making such generalisations), before moving on in the next lab. session to a completely different practical demonstrating some other principle or concept. This approach tends to persuade most students – if at the same time providing an unauthentic representation of how science is actually done.

This same intuition *often* helps biology teachers, too, as students do not question that they are shown models of 'the' human skeleton or asked to label diagrams showing the parts of 'the' digestive system. If they learn the function of 'the' kidneys then they do not need to ask who's kidneys in particular they are discussing, and what alternative functions someone else's kidneys might have. However, this common ontological intuition may work against learning about arguably the most important organising idea in biology – evolution by natural selection, which shows that species are not completely discrete, but blend into one another. That is, to see species as natural kinds is only approximately or contextually true (for example, not when considering geological timescales). The assumption that different kinds of animals and plants (and fungi, of course) are separate fixed types generally works well in most everyday contexts, but is counter to the insight underpinning much of modern biology (Taber, 2017).

In the social sciences we are not dealing with natural kinds at all, but what are sometimes called social kinds. Science teachers, classes of learners, schools, and the like do not have the degree of essential qualities we expect of natural kinds. What science teachers have in common *qua* science teachers is largely contingent – science teachers are developed ('trained') and not born.

Genuine natural kinds retain their properties regardless of human culture (even if what humans *know of* their properties can clearly change). Arguably, a much-used category like acid (or oxidising agent) does not strictly label a natural kind in the way potassium does (Taber, 2019b). The potassium concept has changed over time, but the natural kind, potassium, itself has not. Yet the acid concept – if indeed there is a single canonical concept, which is moot – has changed its defining properties in ways such that membership of the category has changed over time. (That is, not just the range of acids we know of has changed, but so has which substances *should* be considered acids according to different historical scientific accounts.) This is not a matter of better understanding the qualities of a natural kind, acids, but of chemists redefining the acids concept to be more convenient – and so shifting the demarcation between acid and not acid. However, those (more genuine) natural kinds subsumed under the broader acid concept (sulphuric acid, ethanoic acid, etc.) can be considered to have their own essential properties.

Social kinds are quite different. What actually counts as a school is a matter of social convention and can change over time. The same point can be made of effective teaching. A quiet classroom where all the students sit at their desks with their eyes on their textbooks or writing under the watchful gaze of a teacher would have been seen as a positive indicator in some cultural contexts, and a busy, noisy, classroom with students moving about and interacting in groups while one of their classmates actively disputes their teacher's presented account of some subject matter would have been seen as unacceptable. This has shifted over time, but not to the same extent in all national contexts.

Is replication overplayed in science?

We all learn that reproducibility is important in science, and this is indeed so. When it was claimed that power could be generated by 'cold fusion', scientists did not simply accept this, but went about trying it for themselves (Close, 1990). Over a period of time a (near) consensus developed that, when sufficient precautions were made to measure energy inputs and outputs accurately, there was no basis for considering a new revolutionary means of power generation had been discovered. That this process took some time reflects something bench scientists will know, but which does not fit the popular image of science. It has long been recognised that there is a tacit dimension to scientific work (Polanyi, 1962), and the formal published technical account of a novel experiment is often insufficient by itself to allow scientists to replicate each other's work (Collins, 1992). Indeed, it has been claimed more generally:

In the normal way, scientific phenomena are not reproducible with great reliability, but this is usually explained as being a consequence of scientists' mistakes, or 'anomalies', or some anodyne formulation such as 'gremlins' or the 'fifth law of thermodynamics'. (Collins & Pinch, 1982/2009, p. 159)

However, it has also been argued that when historical cases of scientific replications are studied, it is found that, generally, scientists do not spend a great deal of time trying to precisely reproduce the published studies of others (at least, not unless they have reasons to suspect flawed work), but actually usually set out to deliberately undertake a related, but modified, experiment (Shapin & Schaffer, 2011).

In part, this may relate to the widely discussed belief that getting published in the most prestigious journals is unlikely when your paper reports that you did exactly what was reported in a previously published study and found entirely comparable results. Even if scientists value replication as a principle, the community awards novelty. Nobel laureates are not normally cited for their careful replication studies and contributions to the reproducibility of someone else's novel findings. However, this is also related to that assumption about natural kinds: if one person has carefully obtained a result with a sample or specimen of some natural kind, then, as long as they have worked carefully using appropriate, well-maintained, and calibrated apparatus, the reasonable default assumption is that others should get similar findings when working with another sample or specimen of the same kind (Millikan, 1999). Precise replications are therefore more likely to be attempted to challenge, rather than support, published results.

We can (or, rather, should) seldom make such an assumption in educational research. *This* class of 14 years old students learning physics cannot be assumed to respond to our interventions the same way as *that* class of 14 years old students learning physics; *this* chemistry teacher cannot be assumed to be able to master a new pedagogy as well as *that* chemistry teacher; *this* biology undergraduate cannot be assumed to have the same intuitions about the natural world as *that* biology undergraduate.

To a lesser extent, the life sciences face similar issues: even genetically identical individuals can vary considerably (Vogt et al., 2008) which is why biologists, where practicable, commonly use large sample sizes and statistical methods rather than compare one mouse in condition A with one mouse in condition B. However, nearly always biologists are only having to deal with physiological variation – and do not have to consider cultural issues, such as social class, cultural norms, language of instruction, local national curriculum, school ethos, and so forth.

The ideal of random control trials

Social scientists know how to respond to such a challenge in principle. Perhaps you want to know whether having students work in pairs will better support learning about forces than individual working of 11-12 year old students. To set up a study all you need to do is:

1. Define your population of interest – so perhaps you do not claim your research is about 11-12 year olds *per se*, but rather about 11-12 year olds in England (or perhaps 11-12 year olds attending state schools in England, or perhaps 11-12 year olds attending non-selective state schools in England, or perhaps 11-12 year olds attending mixed-gender, non-selective state schools in England, or…).
2. Then you identify the members of that population – so, all the 11-12 year olds in England (or all those attending state schools, or…).
3. Then you select a random sample of the population, large enough for the statistical tests you intend to apply to be able to *potentially* offer positive outcomes, and randomly assign the sample to the two conditions.

Even readers with no experience of educational research are likely to appreciate that this never happens. Steps 2 and 3 are clearly non-feasible when dealing wither large populations of this kind. Even the issue of the unit of analysis is problematic: unless one has the resources to set up experimental classes in laboratory conditions, one usually relies on intact classes in schools being assigned to conditions.

Not only do studies rarely draw upon a national population, but many published studies in decent journals are based only upon one class being assigned to each of two conditions. This usually means that results can only be obtained by considering the individual learners as the units of analysis (even though it is well known that there are interactions within classes such that the learner variables cannot be assumed to be changing independently).

Despite few, if any, studies approaching procedures including steps 2 and 3 above, it is notable that both the titles and conclusions of so many educational studies offer universally generalised findings about such social kinds as '14 year old students learning physics' or 'chemistry teachers' or 'biology undergraduates'. Just as the results of physics experiments carried out on Earth are assumed to also apply in the vicinity of Alpha Centauri, many educational studies are reported as though their findings about classes of 14 years old students learning physics, or chemistry teachers, or biology undergraduates, would be just as applicable whether these students or teachers were based in Oxford, Tehran, St. Helena, or, indeed, on a planet somewhere near Alpha Centauri.

There are many other complications: such as choosing between having different teachers in the different conditions, or assuming that employing the same teacher for both classes controls for the teacher effect – as if any teacher is just as effective in any teaching condition or working with any class. (Again, the reader is referred to Taber, 2019a for further discussion). Arguably, being a teacher is a social role, and is enacted interactively with a particular class: most teachers will acknowledge that there is a sense in which they have not been the same teacher across all their classes. (Just as mischievous schoolchildren tend to be naughty with some, but not all, their teachers.) This is before it is considered that, unlike the experimental subjects manipulated in the physical sciences, teachers and school children's behaviour and teaching/learning can be strongly affected by their expectations about the research they are part of (Rosenthal & Rubin, 1978). Teachers are regularly reminded that it is important to have high expectations of their students as this can make a substantial difference to classroom outcomes – yet this factor is seldom mentioned as a caveat in the published reports of experimental studies in education.

Experimental work in the science laboratory can be useful because it allows identification, control, and measurement of variables. Educational experiments seldom identify all relevant variables (as phenomena such as classroom teaching and learning are very complex, and embedded in diverse and very particular contexts), let alone control or measure them all. That does not make an experimental study invalid *in its own context* – but it raises very substantial barriers to generalisation from the context to some wider population.

What makes educational work scientific?

This leads me to the question, hinted at near the outset of this essay, of whether we make our educational studies more scientific by aping scientific research. I think that depends what is taken as the model. A good deal of scientific work is experimental in nature: yet, certainly not all. When experimental methods are inappropriate or not feasible, then more naturalistic, observational methods are the more 'scientific' approach.

This has been recognised in education as well (National Research Council Committee on Scientific Principles for Educational Research, 2002). Unfortunately, some national governments and funding agencies are seduced by the perceived gold standard of the randomised control trial (Phillips, 2005), rather than recognising that when the conditions needed for rigorous experiments are not possible, it is better to choose what is viable in the actual fieldwork circumstances that researchers face, rather than look to an ideal that needs to be so compromised that studies cannot possibly be judged robust. In educational contexts, this will often (certainly not always) mean that more is learnt from an in-depth case study of an authentic episode of teaching-learning in a well characterised and described particular context, than attempts to use small, non-random, unrepresentative samples of populations to attempt to draw general conclusions about 'what [universally] works'.

Unfortunately, although these debates are widely rehearsed in educational research circles, science education is disproportionally staffed by scientists! Unlike, for example, history teachers or literature teachers, science teachers (and so, often, science teacher educators, and science education researchers) come to educational work with a background in the natural sciences where working with natural kinds, and the *implicit* assumptions that such experimental subjects allow one to make in undertaking and reporting research, colours how they think about educational studies.

Seeking incremental generalisation, rather than reproducibility, in educational research

Inevitably, the evidence for the effectiveness of most pedagogic, curriculum, or resource innovations is not based on random control trials undertaken with representative samples of the populations that results are claimed to apply to. For any particular innovation, it is likely the positive evidence comes from a handful of studies, perhaps scattered across different types of schools, different grade levels, different languages of instruction, and carried out with somewhat arbitrary (rather than random) teachers and classes where researchers could negotiate access and persuade teachers to implement something novel in that context.

Perhaps, where these scattered studies do report positive results from a wide range of teaching and learning contexts we might be encouraged: something seems to work both in elite schools and in comprehensives; when taught in Spanish, and in Chinese, language contexts; in single-sex Catholic schools, and in mixed-gender community schools serving multi-cultural communities; etcetera. However, we then run into the problem of publication bias (Franco, Malhotra, & Simonovits, 2014): the likelihood that the literature is systematically biased to report studies that found significant differences, over those that failed to obtain 'positive' results. With so many variables at work, we cannot be confident that there are not just as many unpublished studies, from a similarly diverse set of unique teaching-learning contexts, where the innovation did not seem to offer any improvement in desired educational outcomes.

This is without considering the contribution of studies that report those 'rhetorical' experiments I referred to earlier, where the researchers ensure that the comparison condition by which the innovation is judged is a teaching condition widely recognised as ineffective. This almost guarantees that the experimental conditions, where the teacher is given special training and the class have a learning experience notably different from the norm, will be more effective than the deliberately humdrum instruction in the control condition, almost regardless of the actual innovation supposedly being tested.

Despite being quite critical of the state of experimental research in education, I do not think the situation is hopeless, as long as the community can become more scientific by better following *the logic behind* experimental work, rather than simply trying to transfer the appearance of controlled laboratory studies into messy social contexts where meaningful control is never going to be possible.

One of the arguments made in my review (Taber, 2019a) is that even if strict replication is never going to be feasible in educational contexts, there is still much value in seeing whether what worked in one context will also work in another. It is never possible to entirely characterise something as complex as a teaching-learning episode embedded in, and entangled with, its particular multi-layered (classroom, plus institutional, plus curriculum, plus cultural) context – or even to specify the relevant characteristics of different classroom teachers observed in different studies (what night make a difference: age? gender? years of experience? teacher preparation regime? degree specialism? relationship with own parents?…).

There are going to be some teaching or curricular innovations that will be generally effective when implemented by enthusiastic and well-prepared teachers. However, others will quite reasonably only tend to be found useful with, say, older students, or with higher achieving students, or with students in countries with a strong Confucian tradition, or in contexts where students have already mastered the basic skills needed for productive classroom dialogue, or perhaps only in a particular educational context that is found on that planet somewhere near Alpha Centauri.

It is therefore very important to move away from treating social kinds as if they are natural kinds, and so expecting that pedagogic or other innovations either 'work' or 'do not work' and so be universally worth (or not worth) implementing. It is possible, however, to make some judgements about *where and when* particular innovations are worth recommending and expending resources implementing, if instead of focusing on replication *per se* we put the emphasis on profiling generalisation in terms of the range of effective application.

This will only be possible when researchers (and journal editors) recognise the importance of characterising the study context as well as they can for readers of the research, rather than just reporting along the lines that the work was undertaken with 15-16 year old students from an urban school in Melbourne. Efficient *programmes* of research of this kind require those planning individual studies to be able to gauge the variation across previously published studies. If the literature suggests mixed outcomes from previous testing, then what is indicated are further tests which can help determine the kinds of conditions that (do and do not) favour the effectiveness of the innovation *from within the broad range of populations that have given inconsistent outcomes*. If, however, the literature suggests something is very widely effective, then further tests will be most useful in situations *outside the scope of existing studies* (has it yet been tested with very young learners, with very disengaged learners, with the gifted, with traumatised students in migrant camps, with visually impaired students…?)

Over time, then, such programmes of 'replications' offer an opportunity to build up an account of the (multi-dimensional) ranges of effectiveness of different teaching approaches/curricula/resources. This does rely on 'negative' results being published as well as 'positive' results. Knowing the characteristics of contexts where some innovation does not seem to be effective avoids wasting the expenditure of precious teacher time and other resources implementing something when the available evidence suggests (we can never be sure of course) it is unlikely to offer an educational return in a particular teaching context. Indeed, it is not appropriate to think of study outcomes as *positive* or *negative* replications, but contributions to building up a *profile* of the pedagogic effectiveness of some innovation. In this context, reporting a poor educational outcome is as valuable as reporting a good outcome – as long as we ignore our intuitions about research studying natural kinds, and sufficiently characterise *the particular* class of 14 years old students learning physics, or chemistry teacher, or biology undergraduate, that the study focuses on.

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Invitation to Submit Opinion Piece

In order to make better educational use of the wide geographical and disciplinary reach of this HPS&ST NEWSLETTER, invitations are extended for readers to contribute opinion or position pieces or suggestions about any aspect of the past, present or future of HPS&ST studies.

Contributions can be sent direct to Michael Matthews or Nathan Oseroff-Spicer.

Ideally, they might be pieces that are already on the web, in which case a few paragraphs introduction, with link to web site can be sent, or else the pieces will be put on the web with a link given in the NEWSLETTER.

They will be archived in the OPINION folder at the HPS&ST web site: http://www.hpsst.com/.

PhD Theses in HPS&ST Domain

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- Candidate's name and email
- Institution
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- Thesis title
- Abstract of 100-300 words
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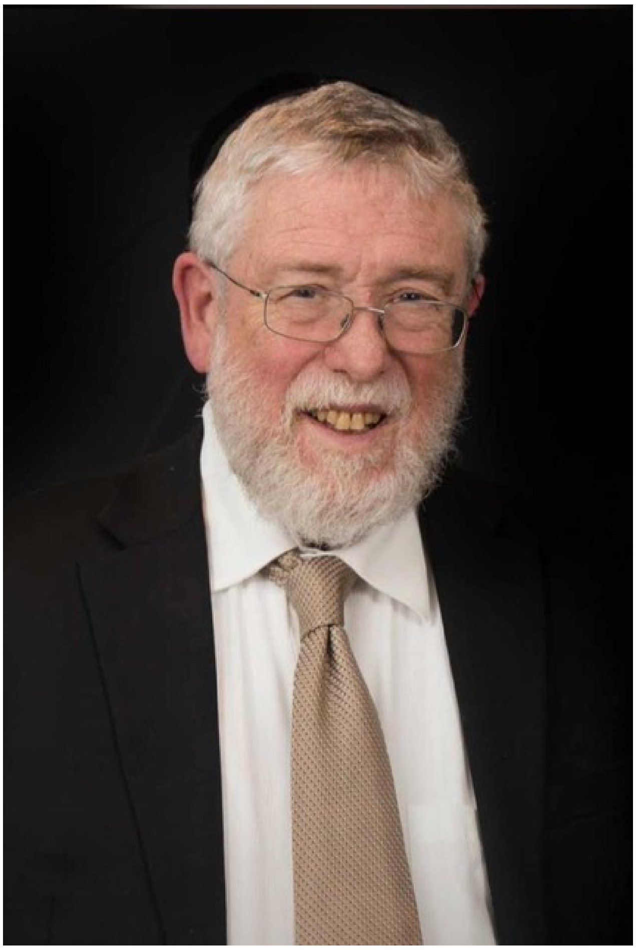
Vale: Mark Steiner (1942-2020)

Locked down in our homes, like so many around the world, we, in Jerusalem, and elsewhere in the philosophical community, are mourning the loss of a beloved colleague, teacher, friend, and an outstanding philosopher of science and mathematics. Mark Steiner, Professor of Philosophy at the Philosophy Department of the Hebrew University of Jerusalem, passed away on Monday, the sixth of April after a relatively short struggle with the Coronavirus. A week earlier he was still preparing his classes on David Hume (via Zoom) and pursuing his work on Maimonides, work that continued to occupy him even during his first days in hospital. That his intense intellectual activity continued almost to the very end is perhaps some consolation, but at the same time it intensifies the feeling of loss and untimeliness.



Mark Steiner was a wonderful person, cheerful and optimistic, outspoken in his critique, but immensely generous in his evaluation of colleagues' and students' work. A loving spouse and devoted father, he was sensitive to the demands of student's personal lives, in particular the demands of motherhood. He not only believed in gender equality, he practiced it. His terrific sense of humour made his profound classes and talks extraordinarily witty and amusing.

Born in New York City, Steiner graduated from Columbia College in 1965 (Summa cum Laude) and gained his Ph.D. from Princeton University in 1972. His teachers in Columbia, among them Isaac Levi, Sidney Morgenbesser, and Charles Parsons became lifelong correspondents and friends, as did his Princeton Dissertation Director, Paul Benacerraf. He held several prestigious fellowships and grants, including a Fulbright Fellowship in Oxford in 1965-66, a Dibner Fellowship at MIT in 1997-8, and grants from the National Science Foundation and the Israel Academy of Arts and Sciences. He was associate Professor at Columbia University until 1977, when he moved to the Hebrew University of Jerusalem, his home university ever since. Here he became Full Professor, Chair of the philosophy department (1989-1996) and, in the last decade, Editor of *Iyyun, The Jerusalem Philosophical Quarterly*. Of the numerous talks he gave at conferences and lecture tours in distinguished universities throughout the world, Steiner was especially proud of the connection he established with Chinese philosophers. In 2013, he gave a two months graduate seminar on Wittgenstein at the Sun Yat-Sen University and on other occasions he delivered talks in Beijing, Shanghai, and Guangzhou

In addition to the many papers he published in leading philosophical periodicals and collections, Steiner authored two influential books, *Mathematical Knowledge* (Cornell University Press, 1975) and *The Applicability of Mathematics as a Philosophical Problem* (Harvard University Press, 1998). He translated three volumes from the Yiddish (adding notes an introduction): *Faith and Heresy*, *Principles of Philosophy*, and *Ancient Greek Philosophy*, all by Reuven Agushewitz (published by Yeshiva University Press, 2006, 2008, 2010 respectively). He is the Academic Editor of a translation into Hebrew of Hume's *A Treatise of Human Nature*, to which he wrote an extensive interpretive essay as introduction (translation by Iftach Brill, Shalem Press, 2013). In what follows, I will try to provide a brief survey of some of Steiner's major contributions to philosophy.

Making the assumption that 'most people know some mathematical truths, and some people know many', *Mathematical Knowledge* raises the question of how that knowledge is *acquired*, how mathematical truths come to be known. Although in this form, the question has been mostly ignored, Steiner maintains that answers (purported answers) could be extracted from some of the central positions in the philosophy of mathematics. If these purported answers turn out to be unsatisfactory, or worse, if a philosophical position implies that mathematical knowledge is *impossible*, that would count, according to Steiner, against the position in question. The book consists in an in depth examination of logicism, formalism and Platonism from the perspective of their replies to the question regarding the acquisition of mathematical knowledge. The examination casts Platonism in a more favorable light than either logicism or formalism, but even Platonism, Steiner argues, is hard pressed when faced with the challenge of providing an epistemology for mathematics. Ontologically, Platonism is driven by an analogy between the concrete material world and the abstract realm of mathematics. But whereas the typical answer to the question of how we come to know the material world invoke perception, it is not clear that there is an analogue of perception that can play the same role in the mathematical realm. Epistemically, then, the analogy may break down. (This worry is the focus of Benacerraf's 'What Numbers Could not Be', *Philosophical Review* 74, 47-73). Seeking to retain the analogy, Steiner concludes with a (cautious) defence of mathematical intuition. Like perception, intuition is not infallible, and does not provide conclusive justification, but acknowledging its existence throws light on how mathematicians (and sometimes ordinary people) come to 'see' mathematical truths.

Steiner's commitment to mathematical truth and mathematical knowledge sets him apart from positions that construe mathematics as formal, contentless or conventional, and more generally from positions that drive a wedge between mathematics and the empirical sciences. Indeed, like Quine and Putnam, Steiner views mathematics as continuous with these sciences. 'Mathematics is a science, whose methods differ little, in principle, from those of other sciences. …Mathematics can be distinguished from the other sciences only by its subject matter–not on the grounds that it has none' (MK, p. 21). Further, he is sympathetic to the indispensability argument according to which mathematics is part and parcel of science and is therefore justified in the very same way that scientific theories are justified, that is, by the truth of the observation sentences these theories imply. It would seem that this account of mathematics provides a different answer to the question of how we come to know mathematical truths than that reached at the end of *Mathematical Knowledge*, for we could say that the acquisition of mathematical knowledge is no different than the acquisition of scientific knowledge. Steiner distinguishes, however, between justification and acquisition. While it may be true that the indispensability argument is relevant to the justification of mathematical truths, it does not provide an answer to the question of how we come to know them.

Interestingly, Steiner's understanding of mathematics as a science, on a par with other sciences, led him (towards the end of *Mathematical Knowledge*) to dismiss the problem of the applicability of mathematics: 'Only a pseudoproblem, therefore, lurks in the 'applicability' of mathematics to the world' (MK, p. 129). As it turned out, Steiner could not leave it at that. His efforts to come to grips with the allegedly 'pseudo' problem culminated is another book – *The Applicability of Mathematics as a Philosophical Problem*. It's not (I guess) that Steiner thought he was completely wrong. Rather, he realised that there are several different problems going by the same name and that philosophical work is required to distinguish between them and sieve out the ones that had been solved from those that are still pending. Thus, Steiner argues, two of the problems often referred to as problems of the applicability of mathematics–the semantic problem (of how the deduction from arithmetical theorems to their applications works) and the metaphysical problem (pointing to the ontological gap between mathematics and the world) – had already been solved by Frege. In both cases, the crux of the matter is that for Frege numerals are second-order predicates and the laws of arithmetic are second-order laws which apply to concepts. The concepts, in turn, are applicable to the physical world.

It is the *un*solved problem of the applicability of mathematics, however, that occupies Steiner in this book and it is his response to this problem that makes this work so daring and original. The problem can be divided into two: First, how exactly is mathematics applied; in what ways does it underpin physical theory? Second, what makes this kind of application work? Steiner takes it to be an empirical fact that physicists describe the world in mathematical language and argues that in so doing they base themselves on mathematical *analogies*. Mathematical analogies, he maintains, have become crucial for physics with the exploration of the atomic and subatomic world. For it then became evident that as far as its physical laws are concerned, the new terrain is fundamentally different from the old and that in exploring it physical analogies would be of no avail. Mathematical analogies use laws that cannot be couched in nonmathematical terms, laws that *prima facie* have no nonmathematical meaning. Moreover, in some cases, the analogies used in modern physics are completely *formal*, that is, they are based on the notation of the theories in question, not on their contents. Steiner substantiates these claims in great detail by analysing the development of quantum mechanics, quantum chromodynamics, and gauge theory. The abundance of examples leads Steiner to claim that it is the overall strategy that we should ponder, not its individual instances.

Why should this strategy work? As the title of the book indicates, grasping the depth of the question is no less important than answering it. According to Steiner, mathematics is anthropocentric! It is guided and defined by *human* criteria of beauty and convenience, attributes to which the world 'out there' is supposedly utterly indifferent. On this account of mathematics the success of mathematical physics is indeed mind boggling. Why should the world accommodate our idiosyncrasies? Mainstream philosophy of science is naturalistic, that is, it denies homo sapience a privileged standing in the universe. Giordano Bruno, Copernicus and Darwin, we are told, heralded the naturalistic message and modern astronomy and cosmology further confirm it. Steiner, however, begs to differ. The universe, he believes 'is (or rather: appears to be) an intellectually "user friendly" universe, a universe which allows our species to discover things about it' (p. 8). The applicability of mathematics thus provides strikingly new support for Divine grace. Hence, also, 'the importance of the enterprise of scientific inquiry from a religious point of view' (ibid.).

Let me now say a few words about some of Steiner's philosophical papers. In the years following the publication of *Mathematical Knowledge*, Steiner turned his attention from the notion of knowledge to the notion of explanation. Noting that mathematical proofs, even when equally valid, can vary dramatically in explanatory force, he sought to find out what it is that makes a proof explanatory. Having shown that simple answers such as generality and abstractness won't work, he proposed that 'an explanatory proof makes reference to a characterising property of an entity or structure mentioned in the theorem, such that from the proof it is evident that the result depends on the property' ('Mathematical Explanation,' *Philosophical Studies*, 34, p. 143). To support this claim Steiner goes over various proofs in different areas of mathematics, the most familiar of which is perhaps the proof of the Pythagorean Theorem based on the characteristic property of the right triangle–its decomposability into two triangles similar to each other and to the whole. While there are other proofs of the theorem, none of them passes Steiner's test for explanatory import. This paper has spawned an ever growing literature about mathematical explanation itself and about the relation of mathematical explanation to scientific explanation, (For more on these developments, see Paulo Mancosu's entry 'Explanation in Mathematics' in the *Stanford Encyclopedia of Philosophy*).

In 'Mathematical Realism' (*Noûs* 17, 1983, pp. 363-385) Steiner addresses the question of realism in mathematics, comparing it with the question of scientific realism. In both areas, he contends, the key is independence. If the same physical term (property, quantity) plays an essential role in two independent theories, there is good reason to see the entity referred to by this term as real. And similarly for mathematics. The number π is a salient example: its independent appearance in two different areas of mathematics, geometry and in analysis, attests, according to Steiner, to its reality. From early on, Steiner was intrigued by Wittgenstein's philosophy of mathematics. Though critical of several of Wittgenstein's ideas, Steiner was attracted to the view that mathematical rules develop out of empirical generalisations 'hardened' into fixed rules. Steiner expounded this position both as a novel interpretation of Wittgenstein's later philosophy of mathematics and as a viable understanding of mathematics, one that ties mathematics to the empirical world.

Steiner had a long-standing interest in Jewish philosophy. His earliest work was on non-canonical figures like R. Israel Salanter (1810-1883), the founder of the Musar movement, in whose writing he identified a novel version of virtue ethics. As part of his impressive knowledge of rabbinics which he pursued throughout his life, Steiner was also an accomplished scholar of Maimonides' halakhic, or legal, writings. But in the last decade Steiner 'discovered', as he put it, Maimonides the philosopher and his *Guide of the Perplexed* and over the last three years was deeply engaged in its study. He was especially interested in Maimonides' metaphysics (e.g., his conception of God, divine unity and incorporeality, and the nature of divine knowledge), its ramifications for idolatry and freedom of action, and the relation between the philosophical views put forth in the *Guide* and in Maimonides' legal code, the Mishneh Torah. He also explored uncanny parallels between Hume's physics in the Treatise and the physical theory of the Kalam as presented by Maimonides and implications for our understanding of possibility and imaginability (including contemporary work on this topic by, e.g., Charles Parsons. At the time of his untimely passing, he was deeply engaged in exploring Maimonides' acquaintance with the great Islamic critic of the falasifa (Aristotelian philosophers), Al-Ghazali. Although their relation is a topic of current live debate, Steiner was focusing on surprisingly unexplored sources for Maimonides' arguments concerning creation, causation, and immortality. And philosopher that he was, Steiner, unlike most other contemporary Maimonides scholars, was most interested not in what Maimonides believed, but in whether he had the arguments that would justify his claims. Three papers on these subjects have been published in the last three years; additional manuscripts will hopefully be prepared for publication in the near future.

Writing these notes was a painful experience, but at the same time it had a therapeutic effect in giving me the illusion of being able to continue the conversation, a conversation that went on for several decades and ended, traumatically for me, when Mark called from hospital but could no longer talk.[1]

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[1] I am grateful to Carl Posy for reading these notes and correcting a number of infelicities and to Josef Stern for writing the section on Steiner's engagement with Jewish Philosophy.

Recent HPS&ST Research Articles

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Beveridge, A. (2020). Thomas Szasz: An Appraisal of His Legacy. *The British Journal of Psychiatry*, 216(4), 236-236. doi:10.1192/bjp.2020.13 [Book Review]

Chen, Y. (2020). Dialogic Pathways to Manage Uncertainty for Productive Engagement in Scientific Argumentation. *Science & Education*. doi:10.1007/s11191-020-00111-z online first

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Stadermann, H.K.E. & Goedhart, M.J. (2020). Secondary school students' views of nature of science in quantum physics. *International Journal of Science Education*. doi:10.1080/09500693.2020.1745926 online first

van Dongen, J. (2020). In Europe. *Phys. Perspect*. doi:10.1007/s00016-020-00252-2 online first

Recent HPS&ST Related Books

Blockley, David (2020). *Creativity, Problem Solving, and Aesthetics in Engineering: Today's Engineers Turning Dreams into Reality*. Dordrecht: Springer. ISBN: 978-3-030-38257-5

"This book illuminates what engineering is and how it relates to other disciplines such as art, architecture, law, economics, science, technology, and even religion. The author explains, from an intrinsic as well as descriptive perspective, why engineering is essential for our collective well-being, and how, like medicine, it is undertaken by people, and for people, to improve the human condition. He brings out the 'magic' of engineering practice as well as addressing the darker aspects such as warfare and the misuse of the internet. A too commonly held view assumes that the practice of engineers is a cold, purely quantitative and wholly technical enterprise of applying know science, and devoid of creativity or aestheticism.

In 2013 the United States National Academy of Engineering launched a campaign called "Changing the Conversation, Messages for Improving Public Understanding of Engineering" with four messages to impart about engineers: that they make a world of difference; are creative problem solvers; that they help shape the future, and are essential to health, happiness, and safety. In this volume, Professor Blockley incorporate these messages into an engaging exposition of engineering accomplishment in all of its evolving diversity, from the technician to the academic research engineer, illustrating the continuum of thinking and purpose from the fixer of the gas boiler to the designers of the A380 and the iPhone." (From the Publisher)

More information available here.

Cowles, Henry M. (2020). *The Scientific Method: An Evolution of Thinking from Darwin to Dewey*. Cambridge, MA: Harvard University Press. ISBN: 978-0-674-97619-1

"Henry Cowles has produced an extremely rich history of the idea of 'the scientific method.' He recounts its eventful life from the crucial period when modern science took shape, tracing the influences of many diverse intellectual trends such as Darwinism and pragmatism. This is a unique and exemplary blend of philosophical and historical scholarship, with pertinent lessons for the troubled relationship between science and politics today." – Hasok Chang

"The idea of a single scientific method, shared across specialties and teachable to ten-year-olds, is just over a hundred years old. For centuries prior, science had meant a kind of knowledge, made from facts gathered through direct observation or deduced from first principles. But during the nineteenth century, science came to mean something else: a way of thinking.

"*The Scientific Method* tells the story of how this approach took hold in laboratories, the field, and eventually classrooms, where science was once taught as a natural process. Henry M. Cowles reveals the intertwined histories of evolution and experiment, from Charles Darwin's theory of natural selection to John Dewey's vision for science education. Darwin portrayed nature as akin to a man of science, experimenting through evolution, while his followers turned his theory onto the mind itself. Psychologists reimagined the scientific method as a problem-solving adaptation, a basic feature of cognition that had helped humans prosper. This was how Dewey and other educators taught science at the turn of the twentieth century–but their organic account was not to last. Soon, the scientific method was reimagined as a means of controlling nature, not a product of it. By shedding its roots in evolutionary theory, the scientific method came to seem far less natural, but far more powerful.

"This book reveals the origin of a fundamental modern concept. Once seen as a natural adaptation, the method soon became a symbol of science's power over nature, a power that, until recently, has rarely been called into question." (From the Publisher)

More information available here.

Lee, Edward A. (2020). *The Coevolution: The Entwined Futures of Humans and Machines*. Cambridge, MA: The MIT Press.
ISBN: 978-0-262-04393-9

"Are humans defining technology, or is technology defining humans? In this book, Edward Ashford Lee considers the case that we are less in control of the trajectory of technology than we think. It shapes us as much as we shape it, and it may be more defensible to think of technology as the result of a Darwinian coevolution than the result of top-down intelligent design. Richard Dawkins famously said that a chicken is an egg's way of making another egg. Is a human a computer's way of making another computer? To understand this question requires a deep dive into how evolution works, how humans are different from computers, and how the way technology develops resembles the emergence of a new life form on our planet.

"Lee presents the case for considering digital beings to be living, then offers counterarguments. What we humans do with our minds is more than computation, and what digital systems do–be teleported at the speed of light, backed up, and restored–may never be possible for humans. To believe that we are simply computations, he argues, is a "dataist" faith and scientifically indefensible. Digital beings depend on humans–and humans depend on digital beings. More likely than a planetary wipe-out of humanity is an ongoing, symbiotic coevolution of culture and technology" (From the Publisher)

More information available here.

Mazzotti, Massimo (Ed.) (2020). *The History of Science*. Abingdon, UK: Routledge.
ISBN: 978-0-415-74441-6

"Science is one of the main features of the contemporary world, and shapes our lives to an extent that has no precedents in history. Yet science as we know it today is the outcome of contingent social processes, and its global success is far from self-explanatory. How did it happen? How did science emerge in history and became the most authoritative source of knowledge available in late modern societies? This set of volumes addresses these crucial questions through a selection of exemplary publications spanning antiquity to the present day. The reader will find an effective survey of the best scholarship in this rapidly growing field, and a map of the main revolutions as well as the long-term continuities that have characterised our understanding the world and our attempts to control it.

The collection brings together areas of inquiry that have become increasingly distant and specialised, such as the history of antique science or Cold War studies, within broader narratives of the making of the modern world. They also reassess the traditional assumption of the exclusively Greek and Western origins of modern science, situating relevant knowledge, practices, and artefacts within the global networks that sustained them: in ancient as well as in modern times. The gathered materials address key historiographical issues, such as the relationship between science, magic, and religion; the role of science in nation-building processes; and the relationship between science and technology." (From the Publisher)

More information available here.

McEvoy, Rory, & Betts, Jonathan (Eds.) (2020). *Harrison Decoded: Towards A Perfect Pendulum Clock*. Oxford, UK: Oxford University Press.

ISBN: 978-0-198-81681-2

"The essays in this fascinating book effectively chart the progress of an extraordinary experiment, conducted over decades but with a recent, and very remarkable outcome" – James Nye, The Antiquarian Horological Society Chairman

"Combining historical context, technical details and experimental information, this well-illustrated edited collection describes the challenges as well as the delights of historical reconstruction." – Patricia Fara, Emeritus Fellow of Claire College, Cambridge

"The authors provide a wonderful vindication of a native genius, following the original work of Martin Burgess. They give us an explanation of an alternative technology to the one accepted for the past 300 years, when it comes to the design of a mechanical precision timekeeper." – Anthony Randall, Winner of the Tomplon Medal from The Clockmaker's Company

"This authoritative and accessible collection of essays tells the fascinating story of [the great clockmaker John Harrison], and how Harrison's enigmatic and astute eighteenth-century account of high-reliability pendulum motion and timekeeping was at last vindicated." – Simon Schaffer, University of Cambridge

More information available here.

Mercelis, Joris (2020). *Beyond Bakelite: Leo Baekeland and the Business of Science and Invention*. Cambridge, MA: The MIT Press.

ISBN: 978-0-262-53869-5

"The Belgian-born American chemist, inventor, and entrepreneur Leo Baekeland (1863–1944) is best known for his invention of the first synthetic plastic–his near-namesake Bakelite–which had applications ranging from electrical insulators to Art Deco jewellery. Toward the end of his career, Baekeland was called the "father of plastics"–given credit for the establishment of a sector to which many other researchers, inventors, and firms inside and outside the United States had also made significant contributions. In Beyond Bakelite, Joris Mercelis examines Baekeland's career, using it as a lens through which to view the changing relationships between science and industry on both sides of the Atlantic in the late nineteenth and early twentieth centuries. He gives special attention to the intellectual property strategies and scientific entrepreneurship of the period, making clear their relevance to contemporary concerns.

"Mercelis describes the growth of what he terms the "science-industry nexus" and the developing interdependence of science and industry. After examining Baekeland's emergence as a pragmatic innovator and leader in scientific circles, Mercelis analyses Baekeland's international and domestic IP strategies and his efforts to reform the US patent system; his dual roles as scientist and industrialist; the importance of theoretical knowledge to the science-industry nexus; and the American Bakelite companies' research and development practices, technically oriented sales approach, and remuneration schemes. Mercelis argues that the expansion and transformation of the science-industry nexus shaped the careers and legacies of Baekeland and many of his contemporaries." (From the Publisher)

More information available here.

Merchant, Carolyn (2020). *The Anthropocene and the Humanities: From Climate Change to a New Age of Sustainability*. New Haven, CT: Yale University Press. ISBN: 978-0-300-24423-6

"From noted environmental historian Carolyn Merchant, this book focuses on the original concept of the Anthropocene first proposed by Paul Crutzen and Eugene Stoermer in their foundational 2000 paper. It undertakes a broad investigation into the ways in which science, technology, and the humanities can create a new and compelling awareness of human impacts on the environment.

"Using history, art, literature, religion, philosophy, ethics, and justice as the focal points, Merchant traces key figures and developments in the humanities throughout the Anthropocene era and explores how these disciplines might influence sustainability in the next century. Wide-ranging and accessible, this book from an eminent scholar in environmental history and philosophy argues for replacing the Age of the Anthropocene with a new Age of Sustainability." (From the Publisher)

More information available here.

Niaz, Mansoor (2020). *Feyerabend's Epistemological Anarchism: How Science Works and its Importance for Science Education*. Dordrecht: Springer. ISBN: 978-3-030-36858-6

"This book argues that the traditional image of Feyerabend is erroneous and that, contrary to common belief, he was a great admirer of science. It shows how Feyerabend presented a vision of science that represented how science really works. Besides giving a theoretical framework based on Feyerabend's philosophy of science, the book offers criteria that can help readers to evaluate and understand research reported in important international science education journals, with respect to Feyerabend's epistemological anarchism. The book includes an evaluation of general chemistry and physics textbooks.

"Most science curricula and textbooks provide the following advice to students: Do not allow theories in contradiction with observations, and all scientific theories must be formulated inductively based on experimental facts. Feyerabend questioned this widely prevalent premise of science education in most parts of the world, and in contrast gave the following advice: Scientists can accept a hypothesis despite experimental evidence to the contrary and scientific theories are not always consistent with all the experimental data. No wonder Feyerabend became a controversial philosopher and was considered to be against rationalism and anti-science. Recent research in philosophy of science, however, has shown that most of Feyerabend's philosophical ideas are in agreement with recent trends in the 21st century. Of the 120 articles from science education journals, evaluated in this book only 9% recognised that Feyerabend was presenting a plurality of perspectives based on how science really works. Furthermore, it has been shown that Feyerabend could even be considered as a perspectival realist. Among other aspects, Feyerabend emphasised that in order to look for breakthroughs in science one does not have to be complacent about the truth of the theories but rather has to look for opportunities to 'break rules' or 'violate categories.'" (From the Publisher)

More information available here.

Nielsen, Michael (2020). *Reinventing Discovery: The New Era of Networked Science*. Princeton, NJ: Princeton University Press.
ISBN: 978-0-691-20284-6

"*Reinventing Discovery* argues that we are living at the dawn of the most dramatic change in science in more than three hundred years. This change is being driven by powerful cognitive tools, enabled by the internet, which are greatly accelerating scientific discovery. There are many books about how the internet is changing business, the workplace, or government. But this is the first book about something much more fundamental: how the internet is transforming our collective intelligence and our understanding of the world. From the collaborative mathematicians of the Polymath Project to the amateur astronomers of Galaxy Zoo, Reinventing Discovery tells the exciting story of the unprecedented new era in networked science. It will interest anyone who wants to learn about how the online world is revolutionising scientific discovery–and why the revolution is just beginning." (From the Publisher)

More information available here.

Taber, K. S. (2019). *The Nature of the Chemical Concept: Constructing chemical knowledge in teaching and learning*. Cambridge: Royal Society of Chemistry. ISBN: 978-1-78262-460-8

"The features of chemistry that make it such a fascinating and engaging subject to teach also contribute to it being a challenging subject for many learners. Chemistry draws upon a wide range of abstract concepts, which are embedded in a large body of theoretical knowledge. As a science, chemistry offers ideas that are the products of scientists' creative imaginations, and yet which are motivated and constrained by observations of natural phenomena.

"Chemistry is often discussed and taught largely in terms of non-observable theoretical entities – such as molecules and electrons and orbitals – which probably seem as familiar and real to a chemistry teacher as Bunsen burners: and, yet, comprise a realm as alien and strange to many students as some learners' own alternative conceptions ('misconceptions') may appear to the teacher.

"All chemistry teachers know that chemistry is a conceptual subject, especially at the upper end of secondary school and at university level, and that some students struggle to understand many chemical ideas. This book offers a step-by-step analysis and discussion of just why some students find chemistry difficult, by examining the nature of chemistry concepts, and how they are communicated and learnt. The book considers the idea of concepts itself; draws upon case studies of how canonical chemical concepts have developed; explores how chemical concepts become represented in curriculum and in classroom teaching; and discusses how conceptual learning and development occurs. This book will be invaluable to anyone interested in teaching and learning and offers guidance to teachers looking to make sense of, and respond to, the challenges of teaching chemistry." (From the Publisher)

More information available here.

Valles, Sean A (2019). *Philosophy of Population Health: Philosophy for a New Public Health Era*. Abingdon, UK: Routledge.
ISBN: 978-0-367-35862-4

"Population health has recently grown from a series of loosely connected critiques of twentieth-century public health and medicine into a theoretical framework with a corresponding field of research–population health science. Its approach is to promote the public's health through improving everyday human life: afford-able nutritious food, clean air, safe places where children can play, living wages, etc. It recognises that addressing contemporary health challenges such as the prevalence of type 2 diabetes will take much more than good hospitals and public health departments.

"Blending philosophy of science/medicine, public health ethics and history, this book offers a framework that explains, analyses and largely endorses the features that define this relatively new field. Presenting a philosophical perspective, Valles helps to clarify what these features are and why they matter, including: searching for health's "upstream" causes in social life, embracing a professional commitment to studying and ameliorating the staggering health inequities in and between populations; and reforming scientific practices to foster humility and respect among the many scientists and non- scientists who must work collaboratively to promote health.

"Featuring illustrative case studies from around the globe at the end of all main chapters, this radical monograph is written to be accessible to all scholars and advanced students who have an interest in health–from public health students to professional philosophers." (From the Publisher)

More information available here.

Watson, Katherine D. (2019). *Medicine and Justice: Medico-Legal Practice in England and Wales, 1700-1914*. Abingdon, UK: Routledge.
ISBN: 978-1-472-45412-6

"This monograph makes a major new contribution to the historiography of criminal justice in England and Wales by focusing on the intersection of the history of law and crime with medical history. It does this through the lens provided by one group of historical actors, medical professionals who gave evidence in criminal proceedings. They are the means of illuminating the developing methods and personnel associated with investigating and prosecuting crime in the eighteenth and nineteenth centuries, when two linchpins of modern society, centralised policing and the adversarial criminal trial, emerged and matured. The book is devoted to two central questions: what did medical practitioners contribute to the investigation of serious violent crime in the period 1700 to 1914, and what impact did this have on the process of criminal justice? Drawing on the details of 2,600 cases of infanticide, murder and rape which occurred in central England, Wales and London, the book offers a comparative long-term perspective on medico-legal practice – that is, what doctors actually did when they were faced with a body that had become the object of a criminal investigation. It argues that medico-legal work developed in tandem with and was shaped by the needs of two evolving processes: pre-trial investigative procedures dominated successively by coroners, magistrates and the police; and criminal trials in which lawyers moved from the periphery to the centre of courtroom proceedings. In bringing together for the first time four groups of specialists – doctors, coroners, lawyers and police officers – this study offers a new interpretation of the processes that shaped the modern criminal justice system." (From the Publisher)

More information available here.

Wilson, Ross J. (2020). *Natural History: Heritage, Place and Politics*. Abingdon, UK: Routledge. ISBN: 978-0-367-24412-5

> "The concept of 'natural heritage' has become increasingly significant with the threat of dwindling resources, environmental degradation and climatic change. As humanity's impact on the condition of life on earth has become more prominent, a discernible shift in the relationship between western society and the environment has taken place. This is reflective of wider historical processes which reveal a constantly changing association between humanity's definition and perception of what 'nature' constitutes or what can be defined as 'natural'. From the ornate collections of specimens which formed the basis of a distinct concept of 'nature' emerging during the Enlightenment, this definition and the wider relationship between humanity and natural history have reflected issues of identity, place and politics in the modern era.
>
> "This book examines this process and focuses on the ideas, values and agendas that have defined the representation and reception of the history of the natural world, including geology and palaeontology, within contemporary society, addressing how the heritage of natural history, whether through museums, parks, tourist sites or popular culture is used to shape social, political, cultural and moral identities. It will be of interest to scholars and practitioners within heritage studies, public history, ecology, environmental studies and geography." (from the Publisher)

More information available here.

Wragge-Morley, Alexander (2020). *Aesthetic Science: Representing Nature in The Royal Society of London, 1650-1720*. Chicago, IL: Chicago University Press. ISBN: 978-0-226-68086-6

> "The scientists affiliated with the early Royal Society of London have long been regarded as forerunners of modern empiricism, rejecting the symbolic and moral goals of Renaissance natural history in favour of plainly representing the world as it really was. In *Aesthetic Science*, Alexander Wragge-Morley challenges this interpretation by arguing that key figures such as John Ray, Robert Boyle, Nehemiah Grew, Robert Hooke, and Thomas Willis saw the study of nature as an aesthetic project.
>
> "To show how early modern naturalists conceived of the interplay between sensory experience and the production of knowledge, *Aesthetic Science* explores natural-historical and anatomical works of the Royal Society through the lens of the aesthetic. By underscoring the importance of subjective experience to the communication of knowledge about nature, Wragge-Morley offers a groundbreaking reconsideration of scientific representation in the early modern period and brings to light the hitherto overlooked role of aesthetic experience in the history of the empirical sciences." (From the Publisher)

More information available here.

Authors of HPS&ST-related papers and books are invited to bring them to attention of Paulo Maurício or Nathan Oseroff-Spicer for inclusion in these sections.

Coming HPS&ST Related Conferences

May 11-14, 2020, Sixth International Conference on the Nature and Ontology of Spacetime. Al-

bena, Bulgaria.
More information available here.

May 13-15, 2020, Public Engagement with Science, Workshop. University of Cincinnati
Details: https://ucengagingscience.org/workshop/.

May 15-16, 2020, Public History of Science Conference, Railway Museum, York, UK
Details available here.

June 8-12, 2020, Philosophy of Biology at the Mountains (POBAM), Workshop, University of Utah.
Details available here.

June 16-17, 2020, International Workshop on Disciplinary Identity: Insights from the History and Philosophy of Chemistry. Hebrew University of Jerusalem, Israel.
Details available here.

June 17-19, 2020, Fourth International History of Physics Conference, Trinity College Dublin
Details available here.

June 29 – July 3, 2020, Objects of Understanding: Historical Perspectives on Material Artefacts and Practices in Science Education. Europa-Universität, Flensburg, Germany.
Inquiries at OoU-conference@uni-flensburg.de

June 29 – July 1, 2020, Measurement at the Crossroads 2020 – Measuring and Modeling. Milan, Italy.
More information available here.

June 30 – July 2, 2020, 7th annual conference of the International Association for Philosophy of Time. Barcelona, Spain.
Inquiries at iapt7barcelona@gmail.com

July 1-3, 2020, 'STEMM and Belief in Diverse Contexts: Publics, Praxis, Policy and Pluralism', Stellenbosch, South Africa
Details available here.

July 2-4, 2020, 4th International Conference on Science and Literature, University of Girona, Spain.
Details at: http://icscienceandliterature.com/

July 7-10, 2020, Society for Philosophy of Science in Practice (SPSP) Eighth Biennial Conference, Michigan State University, USA
Details available here.

July 8-11, 2020, British Society for History of Science Annual Conference, Aberystwyth University, Wales.
Information at: http://bshsaberystwyth2020.info/

July 9-11, 2020, 6th International STEM in Education Conference, Vancouver, Canada.
Details at: www.stem2020.ubc.ca

July 15-17, 2020, 8th Integrated History and Philosophy of Science Conference (&HPS8). Virginia Tech, Blacksburg VA.
Information: Lydia Patton (critique@vt.edu) or Jutta Schickore (jschicko@indiana.edu)

July 21-23, 2020, 24th Conference of the International Society for the Philosophy of Chemistry. Buenos Aires, Argentina.
More information available here.

July 27-31, 2020, Summer School on "Open science": ambivalences and tensions – New borderlands between science, technology and society (Donostia-San Sebastian, Spain.
Details available here or
Lilia Bolz (lilia.bolz@humtec.rwth-aachen.de).

August 10-14, 2020, Bayesian Epistemology: Perspectives and Challenges. MCMP, LMU Munich.

Details available here.

August 18-21, 2020, EASST + 4S Joint Conference, Prague
Details available here.

August 31 – September 3, 2020, European Society for History of Science Biennial Conference, Bologna
Details available here.

September 9-11, 2020. The 8th Congress of the Society for the Philosophy of Science. University of Mons, Belgium.
Details available here.

September 14-19, 2020, 39th annual symposium of the Scientific Instrument Commission, London
Details available here.

October 8-9, 2020 Conference on Science & Technology Education, Porto, Portugal
Details available here.

October 8-11, 2020, History of Science Society Annual Conference, New Orleans
Details available here.

November 19-22, 2020, Twenty-Seventh Biennial Meeting of the PSA. Baltimore, Maryland
Details available here.

July 4-8, 2021, IHPST 16th International Conference, University of Calgary, Canada
Details from Glenn Dolphin:
glenn.dolphin@ucalgary.ca.

July 25-31, 2021, 26th International Congress of History of Science and Technology (DHST), Prague
Information: https://www.ichst2021.org/

September 20-22, 2021, 'Developing Mario Bunge's Scientific-Philosophical Programme', Huaguang Academy of Information Science, Wuhan, China
Details from Zongrong LI 2320129239@qq.com.

July 24-29, 2023, 17th DLMPST Congress, University of Buenos Aires Information: Pablo Lorenzano, pablo@unq.edu.ar.

HPS&ST Related Organisations and Websites

IUHPST – International Union of History, Philosophy, Science, and Technology

DLMPST – Division of Logic, Mathematics, Philosophy, Science, and Technology

DHST – Division of History, Science, and Technology

IHPST – International History, Philosophy, and Science Teaching Group

NARST – National Association for Research in Science Teaching

ESERA – European Science Education Research Association

ASERA – Australasian Science Education Research Association

ICASE – International Council of Associations for Science Education

UNESCO – Education

HSS – History of Science Society

ESHS – European Society for the History of Science

AHA – American History Association

ISHEASTME – International Society for the History of East Asian History of Science Technology and Medicine

BSHS – British Society for History of Science

EPSA – European Philosophy of Science Association

AAHPSSS - The Australasian Association for the History, Philosophy, and Social Studies of Science

HOPOS – International Society for the History of Philosophy of Science

PSA – Philosophy of Science Association

BSPS – The British Society for the Philosophy of Science

SPSP – The Society for Philosophy of Science in Practice

ISHPSB – The International Society for the History, Philosophy, and Social Studies of Biology

PES – The Philosophy of Education Society (USA)

The above list is updated and kept on the HPS&ST website HERE.

HPS&ST-related organisations wishing their web page to be added to the list should contact assistant editor Paulo Maurício (paulo.asterix@gmail.com)

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