Reflections During the COVID-19 Pandemic: Science, Education, and Everyday Life

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Abstract  During the COVID-19 crisis, we have been able to witness, in many countries, a substantive resistance to the science-based arguments of politicians and to the calls from the medical field to implement safety measures (masks, distancing) and to get vaccinated. In this text, some reflections are provided on what this resistance might tell the science education community about the impact the field has had on individual persons specifically and society as a whole. It is suggested that we ought to think about science learning for life following formal education, and some features are described that make science in the classroom more relevant to students.

Résumé  Durant la crise causée par la COVID-19, nous avons pu constater dans plusieurs pays l’existence d’une importante résistance aux arguments fondés sur la science des politiciens ainsi qu’aux appels du monde médical pour mettre en œuvre des mesures de sécurité (masques, distanciation) et encourager la vaccination. Dans ce texte, nous présentons certaines réflexions sur ce que pourrait révéler cette résistance à la communauté pédagogique scientifique en ce qui a trait à l’influence de notre domaine sur l’individu et sur la société en général. Il est proposé que nous reconsidérons l’apprentissage scientifique comme un processus permanent après l’éducation systématique et l’on présente quelques aspects qui rendent la science en classe plus pertinente aux élèves.

Keywords  Corona pandemic · Science in society · Science on the job · Deinstitutionalizing science education

Science in/for Society: the Case of COVID-19

In truth, I believe that the Spanish citizenry has become a militant of science. Thus, denialism has lost the battle against science and rigor. We continue to trust that the citizens continue to use the
vaccine as the recipe for protecting themselves, and, in solidarity, protect others (Morant & Ruiz Valdivia, 2021)

When I was reading the words of the Spanish minister of science Diana Morant, we had almost completed the second year of the corona pandemic. The crisis has left me personally pretty unscathed, living in a semirural area of a beautiful part of this great country (Canada). During the pandemic, I have continued to teach a course on learning design in technology-mediated environments for non-education majors, which, even before the plague, had been online. With good internet connection and electronic access to literature and colleagues, I was simply continuing to work from my home office in the way I always had. Having a house and garden in a working-class neighborhood with lots of surrounding countryside where to practice my road and mountain cycling interests, I did not have to experience being cooped up during periods of confinement. My life has become quieter in any case, as I have reduced professional engagements in the face of my upcoming retirement. Perhaps unsurprisingly, the serenity of life under such circumstances have allowed reflections to arise in my mind about how people around the world reacted in different ways to the pandemic generally and to generalized vaccination more specifically. These reflections occurred through the lens of my earlier involvement with (science) education and, more generally, through the lens of someone who has studied human behavior across the lifespan more generally.

The introductory quotation derives from an interview in which the Spanish minister of science, a trained telecommunications engineer, talked about the high vaccination rates in the Spanish population, making the country a model to follow for many others around the world (at least in December 2021). The same assessment was provided by the opposition leader of the Autonomous Community of Madrid, a trained anesthesiologist, who stated that she was full of “pride in a country that is capable to trust and put itself into the hands of scientific evidence, of public health and its professionals. Pride in a society that has not made truce with pseudoscience and has demonstrated that—above all—we are just that, a society” (García Gomez, 2021). Both politicians attributed the Spanish success to science and the way in which the Spanish citizenry had taken up not only scientific findings with respect to the still-evolving pandemic but also to the very spirit of the scientific endeavor expressed, for example, in its rigor, which includes doubt and testing.

The two politicians’ assessments were reflecting something that I had pondered for quite some time. Some of my emergent thoughts during the past two years (2020–2021) with subsequent reflection concerned the reticence against and rejection of a vaccination against the coronavirus exhibited by many people around the world. In the Spanish cultural context at least, and whatever science educators in that country do, the society as a whole has been more open than the populations of other countries to the suggestions of scientists, medical specialists, and the government to get vaccinated when one’s turn has arrived.

In many other contexts, however, a sizable number of adults have reacted in a manner that the Nobel Prize–winning Mexican poet Octavio Paz (1968), referring himself to Jean Piaget, ascribes to children and their penchant for magical thought: “between two explanations of a phenomenon, one rational and the other wonderful they fatally choose the latter because it appears more convincing to them.” My thoughts concerning antivaccination manifestations tended to begin with the USA, where I had lived, taught, and been part of numerous National Science Foundation (NSF) committees making decisions about which science education projects ought to receive funding. In particular, I was asking myself how it can be that there is so much resistance against vaccination in a nation that has spent a tremendous amount of money on science and science education since the 1950s and 1960s—when people my age attended elementary and secondary school. One of the primary objectives of NSF has been, from the beginning (on May 10, 1950, President Harry S. Truman signed the bill that de facto created), the fostering of science education (Mazuzan, 1994). How can it be, I have been asking myself over the past year, that, after so much money, time, and effort spent on science
education, there exists a wide-spread rejection not only of scientific findings but also of the very critical spirit in which the scientific community operates? Does this not mean that science education—the community of which I had been part for a number of decades—has fundamentally failed? Have there not been tremendous contributions to the knowledge, understandings, and practices of science education that should have made a difference in the way new science teachers were and are going about their work in elementary and secondary schools?

The USA—61% of population fully vaccinated while I am writing a first draft of this text in mid-December 2021—is not the only country where such resistance to vaccination efforts is observable. It might be understandable that those who have suffered in the past from the work of scientists might resist vaccination—such as indigenous peoples subject to non-consented experimentation and vaccination (e.g., Mosby & Swidrovich, 2021)—but why might there be such high resistance rates in countries such as Austria (69%), Germany (69%), The Netherlands, and the UK (69%), as shown by the daily manifestations reported in the media not only of the respective countries but also in those of their neighbors? In all of these nations, ranging among the most industrialized nations in the world, with access to good schooling for all children, vaccination rates have been lagging far behind those of Spain (80%), South Korea (81%), Chile (85%), or Portugal (88%), to take but a few examples. Why, if all children and students have been exposed not only to the teaching of basic scientific knowledge but also to various aspects of scientific practice and scientific epistemology (c.f., the articles in the *Science & Education*, a journal specialized in history and epistemology in science education), are there still large parts of the population against the vaccination recommended by scientists from the different disciplines contributing to the endeavor (e.g., epidemiology, vaccinology)?

In part, the devaluation of science, scientific evidence, and scientific practice often goes with culture—as seen in the rejection of science among evangelical groups in the Southern United States or in Brazil. As one study showed, co-authored by a high school student (now professor), evangelicals may experience a radical opposition between science and their faith, generally leading to the rejection of the former (Roth & Alexander, 1997). Other culturally based rejection can be seen against mandated vaccination or vaccination passports exhibited by many French citizens, a rejection motivated by the mere fact that there is a mandate. (Being a French citizen, I know firsthand that there often is resistance against anything mandated or implemented as law.) The anti-vaccination movement also has affinities with the far-right and its many conspiracy theories, which, as suggested above, are among those magical forms of explanations, are more convincing than rational scientific explanations. Equally important, and perhaps more damaging, as the ongoing corona crisis shows, is the rejection of science on the part of heads of state such as Donald Trump (USA), Andrés Manuel Lopez Obrador (Mexico), and Jair Bolsonaro (Brazil). In such cases, required emergency measures were not taken despite the advice of relevant scientists, leading to tremendous rates of death. In Mexico, for example, the excess mortality from the beginning of the pandemic to October or November 2021 (fully or partially) attributed to COVID was on the order of 600,000 individuals (Barragán, 2021), nearly 1 million in the USA, more than 1 million in Russia, and about 660,000 in Brazil (cf. The Economist, 2021). The wide acceptance of (scientific) misinformation on COVID-19 and vaccination is another aspect leading to the rejection of vaccines (e.g., Loomba et al., 2021). This study published in the journal *Nature* showed that—as of September 2020—the acceptance of misinformation was associated with a 6% decrease of the number of individuals who anticipated that they would “definitely” get vaccinated.

Of course, I am aware and have noted previously that there is a difference between what appears in the pages of science education journals and what actually happens in science classrooms (e.g., Roth, 2020). Thus, for example, although science teacher educators at the three major universities in the geographic area where I live (southwestern British Columbia) have been promoting constructivist approaches, what I was able to observe when visiting actual science classrooms with teachers
from one of the three programs had little to do with what the science or mathematics education community has been promoting for several decades. Stand-up and deliver or keeping-kids-busy-with-anything typical of the middle of the past century when I attended elementary and high school continued and continue to be the norm in many schools and classrooms—as one British Columbia preservice teacher during those days observed, “mathematics and science classes equated to sitting in a classroom … filling in a textbook as the instructor worked through it on the board” (Sadownik, 2018, p. 9). Memorizing facts, which students will have forgotten once the exams are over, still is a dominant and prized school activity. With such takes on science, we ought not be surprised that many students, however advanced the country in which they attend schools, have not been afforded developing even the slightest understanding of what science is about and how it operates—including how it deals with certainty and doubt, and what the role of theory is.

In part, the fault may lie with science itself and how it is communicated, especially in the press. For example, new “discoveries” in the medical or nutritional sciences are presented in causal terms, when in fact such causation cannot be derived through the statistical inference mechanisms used (e.g., Ercikan & Roth, 2014). This is so because trends at the population level are very distinct from effects at the level of the individual or subgroups. Thus, even though smoking may be bad at the population level, individual smokers may well live to be over 100 years old (e.g., Dovey, 2018). A medication that, on average, improves a condition at the population level may lead to dire consequences at the individual level or sub-population level (the often downplayed “side effects”). Any person can, therefore, find one or more cases that appear to contradict the generalizations published in the media. This is so because the concept of “causation” used in those sciences based on population statistics are different from causation as it is understood in the physical (“hard”) sciences where every billiard ball hit by a cue will move in determinate ways or fall to the floor when the hand is opened.

Scientific findings may be significant statistically, even though the effect size is small, just as the relevance of a finding might be low, though the probability compared to the non-treatment is high (e.g., the probability of death might be 100% greater, but rather irrelevant if one death rate is 1 in 1,000 and the other 2 in 1,000). Allowing students to develop some sense of what statistics-based findings mean and what their limitations are ought to be something of interest to science (and mathematics) education. Statistical inferences may lead to contradictory results, with the consequence that the news media will report the benefits of a treatment or diet one day and an opposite one on the next. How can the general publication learn to be more trustful of science and scientific procedures if scientists themselves are not more cautious about the claims they make?

Science Education and Learning for Life After Formal Education

In the present coronavirus crisis, we might conclude that science education has had little impact on how students go about making decisions later in their lives, decisions in which the results of scientific research and a methodical/critical approach typical of scientific practice are involved. (The churches and their marvelous stories about the origin of the world as it is today have had more success in some areas of the USA, as the continuing debate about creationism and science appears to indicate.) In part, this may have to do with the (perceived) usefulness of what students learn in science classrooms. On the one hand, there are continued exhortations of science (as mathematics and technology) as an important factor for doing well in later periods of life. On the other hand, students can well see that their parents and neighbors are doing quite well without knowing much (formal) science (as mathematics or technology) at all. And, in this, I have to agree, for all my science background (an MSc in physics and PhD level work in physical chemistry) has not been of much use in everyday activities around the house—including
gardening, beekeeping, dealing with technological devices—or in dealing with doctors and the medical system (e.g., Roth, 2009).

During my professional career, in conversations with colleagues, I have often pointed out that science educators tend to emphasize knowing that an atom consists of protons and neutrons in a nucleus surrounded by electrons but that they fail to prepare students to deal with the simple technologies that surround us in our homes. During the fall of 2021, I found myself in a situation of this kind. While attempting to start my gas-powered shredder/mulcher to reduce the branches from the earlier pruned trees and bramble bushes, the machine gave off smoke, died down, came back up, only to die down again. After stopping it, I checked the oil and noticed that the fluid was thinner than it should have been, and then noticed the smell of gas. Perusing the internet, I found that the symptoms were consistent with a carburetor problem. And then I was stuck. I went to see a neighbor, a retired metalworker/mechanic. He came over to my place (socially distanced, of course), took the carburetor apart—which I might have been able to do on my own—but then asked me to get a screwdriver. There was a deep-seated screw that I would have never thought about to tinker with. From behind it, he eventually took out a tiny pin with holes, and pointed out to me that these were plugged up with dirt. Using a single thread from the twisted clothesline wire that I had provided him with, he cleaned all of the plugged holes and then put the carburetor back together again. I told my neighbor that with all of the basic and advanced science courses I had taken in my life, I was unable to clean a carburetor. I added that there was something wrong with what and how we teach science and technology in schools. (He had grown up in a European country where, in those days, school ended for most students with eighth grade, followed by a three-year apprenticeship with occasional attendance of vocational school.) After some additional cleaning and drying, which I was doing on my own, the shredder was working again.

That afternoon, a long-forgotten earlier teaching experience resurfaced in my mind. In the early to mid-1980s, I was teaching general science and computer science in the secondary school of a small town in Newfoundland. I also had been asked one year to teach a class of what at the time were called EMR (“educationally mentally retarded”) students. (Their room was labeled with a sign “EMR,” which I found to be an insult given that, outside of school, it would have been difficult to impossible distinguishing these students from others their age.) The students were 14 to 17 years old and were reading and doing mathematics at a third-grade level. I did hands-on science and technology with them. One of the activities I had designed concerned investigating how a bicycle worked (e.g., shifters, gears, brakes), which included completely taking it apart and putting it back together again. Not only did the students consider it to be more interesting than filling in the blanks in readers for 8-year-old students as they did in other courses and with other teachers, but also, not long after the unit, one of the seven students got a part-time job putting together bicycles sold in a local store. In this case, the students did not just get a mark for their report card but developed, at least in that one case, a marketable skill that could be turned into making some money.

In that same context of the conversation about the usefulness of what students learn in science classrooms, my thoughts also went to that mechanic neighbor’s son. He had not been a good student (mostly Cs and Ds), and he had flunked his second-to-last year of mathematics. His father always had blamed the son’s poor school performance on the boy’s preoccupation with computers, with which the kid was spending almost all of his time. Once graduated, the son had a hard time knowing what he wanted to do with his life or, for that matter, finding work. He began working in a burger joint, but eventually landed a job in the computer department of a consumer electronics retail store. While working there, he received specific training from one of the large multinational computer manufacturers the products of which the store sold. A few years later, the young man was hired by a local hospital as an IT specialist making $35 an hour (the minimum wage at the time in the province of British Columbia was less than $13). That is, even though the neighbor’s son had not done well in school science and mathematics, he not only has done quite well in life generally but in a technology-related area specifically, where good preparations
in science and mathematics often are said to be necessary preconditions. Indeed, in the course of my research in everyday workplaces—among fish culturists, pilots, electricians, seafarers, environmental activists—I have heard many stories of that ilk, people doing poorly in school science and mathematics and later becoming highly qualified professionals in fields that have to do with one or another technology.

My research at the intersection between everyday workplaces and school or formal training has revealed that many professionals experience a disjunction between what is taught in school or special training courses and the knowledgeability required in their everyday work lives. Our research among seafarers showed how college instructors and their seafarer students conspired to make the latter successfully pass courses and obtain the desired certification well knowing that the competencies the latter brought with them were irrelevant in college, and what they were learning in college was irrelevant for their work on the job (e.g., Emad & Roth, 2008). My work among pilots showed how they tended to complete their required professional development courses, complaining that it had nothing to do with making everyday decisions in the cockpit (Mavin & Roth, 2015). At the same time, the research among electrician apprentices revealed tensions between school knowledge and everyday practices (Roth, 2014). Licensed journeyman electricians talked not only about the differences between knowing in school and knowing in the workplace but also about how—even though they would not use school knowledge (e.g., trigonometry) while completing their job—they would need to be able to display it to inspectors should these ask craftsperson about why they had done a particular wire-covering pipe bend in a certain way. The identity work of electricians included knowing the difference between college and workplace knowledge, rejecting the former, all the while being able to demonstrate it when required during routine inspections.

Steps Forward?

What ought and can we do about the continued gap between science (mathematics, technology) at school and in everyday life, during work or leisure times? After more than 40 years in the field of education and educational research, I do not have a ready answer—at least not a simple one that could be elaborated in a few paragraphs. I know what has been working for me while teaching general science, physics, mathematics, and computer science in middle and secondary schools in northern Quebec, Newfoundland, and Ontario. One important aspect was the involvement of students in the design of their learning environment and content. Even before having taken any education courses for teacher certification purposes—I had come straight from doing an MSc in physics to teaching—my eighth-grade mathematics students, working in groups of about the same ability, wrote their own work plans for each week. My science and computer science classes always had been lab-based, and the computer science students wrote their own two-week workplans that were added to the completed work when submitted. In later years, my physics students designed their own experiments. In some cases, the students wrote their own curriculum for a specific period—e.g., a unit on electricity, which the education ministry determined to be six weeks—in the context of the knowledge and practices outlined in the official curriculum guide that was made available to the students. I recently saw the documentary *La escuela en la nube* (The school in the cloud) (Rothwell, 2021), where students even contributed to the design of the physical space where their learning would be occurring. In all of these learning contexts, the main aspect is not that students “have fun,” but that they (are expected to) work hard in realizing their own goals with tools and through processes of their own choosing.

Above I suggested that I do not have a ready answer for what to change in school science. This is so because teaching in the previously sketched way does not appear to work for everyone, especially when teachers in their training are not prepared for doing so. I had always been enthusiastic about how students in my classes were involved in science, so much so that I invited and had been visited by many fellow teachers. (I went to do a PhD
because a superintendent, seeing that students were spending time in the science and computer science lab at (mid-) night, suggested to get an advanced degree so that I could take on a school board level senior position.) I had also done coteaching experiments on how teachers can change their teaching when accompanied for a few months by someone competent in open-inquiry teaching (e.g., Roth, 1998). Many coteachers and visitors found the learning environment inspiring, though at least one visitor clearly told me that my classroom was “messy” and that students were “all over the place.” (A few years later he admitted that—despite his earlier resistance—he had found his own teaching to have changed because of what he had experienced in my classroom.) Some teachers may not feel enabled to teach in this manner. In one instance, I had brought the videotapes shot in an experimental 6–7th-grade science class I had taught a year or two previously to a science methods course, where the future teachers acknowledged that they had seen “great teaching.” But they then went on to say that I ought to teach them something that they actually could do in their own classrooms.

I also know, and have written about, the constraints that current school culture places on what can be learned and how it can be learned. In the current cultural context, the object of schooling is not the coming to be competent in some subject but the marks, grades, report cards, and international assessments such as PISA, and this is so for students, parents, teachers, school administrators, and politicians alike (Roth & McGinn, 1998). Because the object (focus) of a cultural-historical activity is an essential aspect of the relevant cultural practices displayed, observable knowledgeabilities (learning) differ depending on whether learning or grades are the primary goal (open or hidden). Knowledgeability and practices required to do well in school are very different from those required to cope with the demands encountered in the diversity of everyday life (work, leisure). Simply tinkering with the curriculum, adding science in society courses, including foci on social issues, etc. will simply be efforts in building a better mousetrap (see the debate in this journal following a contribution by Peter Fensham, 2002). In my own reply to Peter, I was arguing against building better mousetraps and for taking science education beyond schooling (Roth, 2002). In this light, I subsequently concluded, including in this journal, that we need to deinstitutionalize science learning (e.g., Roth, 2015) and have students learn while participating in everyday life concerns—such as environmental activism (e.g., Roth, 2010).

Deinstitutionalizing science education and turning the focus away from grades and grading means that (science, mathematics, technology) educators do more than merely attempt teaching in new ways or designing new curriculum content. As long as (middle-class) parents, universities, and governments demand grades (grade point averages), students and teachers will feel themselves constrained to learning and teaching accordingly. On the other hand, when students do something in the community, they often find it useful to draw on science to strengthen their findings, thereby underscore the importance of their conclusions, and increment the impact they may have (Roth & Lee, 2004). When students and everyday folk participate in everyday community activities, such as controversies over natural resources, science becomes more democratic and individuals previously antagonistic to science actually appropriate its ways of going about critical issues in their community (Lee & Roth, 2006). It is a win–win situation, for as the result of science education in the community, both science and the general society tend to become more informed. When science becomes relevant to students’ everyday lives, they may be more prone to accepting the advice of scientifically trained professionals in relevant societal issues, such as the vaccine mandates in the current COVID-19 pandemic.

**Declarations**

**Conflict of Interest** The author declares no competing interests.
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