A New Direction for Public Understanding of Science

Toward a Participant-Centered Model of Science Engagement

By

Christopher Rickels

A New Direction for Public Understanding of Science: Toward a Participant-Centered Model of Science Engagement

By Christopher Rickels

This book first published 2025

Ethics International Press Ltd, UK

British Library Cataloguing in Publication Data

A catalogue record for this book is available from the British Library

Print Book ISBN: 978-1-80441-920-5

eBook ISBN: 978-1-80441-921-2

To Kayla and Grace

Acknowledgements

I am grateful to those who supported this endeavor in myriad ways. I want to acknowledge my wife, Kayla, for her support in creating the intellectual and temporal space for this work to come to fruition. Too, I am grateful to my dissertation committee at the University of Louisville, Dr. Guy Dove, my chair, and committee members Drs. Andreas Elpidorou, Judith Danovitch, and Linda Fusilier who supported and challenged this work when it was in dissertation form. I am thankful to my mentor and colleague, Dr. JT Spence for his helpful comments on the manuscript as it neared completion. Lastly, I would like to thank the members of the Socially Engaged Philosophy of Science group (later called the Research and Development group) at the University of Cincinnati's Center for Public Engagement with Science as the germ of this project was in our conversations during the summer of 2019. Particularly, I thank Drs. Angela Potochnik and Melissa Jacquart and fellow graduate student, Dr. Andrew Evans for allowing me to develop those ideas into this book.

Table of Contents

List of Tables

Preface

Engaging the public with science is not an easy task. When presented, scientific findings, public health recommendations, and other scientific information filter through the personal values, beliefs, and biases of members of the public. Science communicators must contend with these differences in order to be effective in cultivating a public understanding of science. Given the importance of scientific understanding for living well in a complex world, increasing science understanding through science engagement is imperative. The field of public engagement with science is dichotomized by a public information deficit approach and a contextualist approach. The deficit approach prizes the factual content of science, its epistemic authority, and its communication to the public while the contextualist approach recognizes the sociocultural embeddedness of science in society, how science is received by publics, and how local knowledges intersect with science. I contend both approaches are incomplete and I put forth a synthesis. My approach, the participant-centered model of science engagement, incorporates the factual content of science and its epistemic authority, but in a way that is sensitive to context. I argue for a deliberative democratic approach to public engagement with science and articulate a model inspired by learner-centered approaches to teaching in the formal education literature. I outline and assess six participant-centered strategies along with recommendations for particular practices associated with each.

Chapter 1

Introduction

Dual Crises

Beginning in 2020 and stretching several years beyond, the US found itself in a public health crisis (COVID-19) and a public information about science crisis. Scientific, medical, and public health misinformation and disinformation ran rampant across social media and other public channels. One estimate found that 29% of social media posts about COVID-19 contained some form of misinformation or disinformation (Gabarron et al., 2021). Public health experts suggested at the time and continue to argue that the pandemic did not need to unfold as it did. Models indicated, and public health experts recommended, that the institution of universal mitigation strategies could have decreased transmission rates and reduced total deaths.

Unfortunately, such recommendations from public health officials and medical experts were not universally heeded or given good faith consideration. In fact, the recommendations of public health officials and medical experts (and those political, business, or other organizational leaders who *did* institute their recommendations) became the subject of obtuse skepticism, vicious mockery, and even outright disdain within the public sphere.[1] Moreover, some leaders who called for, or who had the power to institute, disease trans-

[1] I want to make it clear that the point is not to erase spaces for reasonable disagreement. Rather, the intention is to target agents of misinformation, disinformation, and other forms of bad faith engagement in the space of reasons.

mission mitigation strategies faced death threats from members of the public (Bosman, 2020). Those not in positions of power, but who simply asked that others follow guidelines became collateral damage – for instance, a New York City restaurant hostess was violently attacked by patrons when she asked for their proof of vaccination status (Thorbecke, 2021). The rampant spread of misinformation, disinformation, and the deployment of intimidation strategies is, as I have called it, a public information crisis. Social media posts blatantly misrepresented the dangers of the virus. Politicians nefariously highlighted and manipulated normal scientific disagreement as a reason to reject scientific expertise root and branch. Some news anchors told viewers that things were just not *that* bad. Over the course of a few years, many across the world – particularly in the US – observed the social consequences of science, medicine, and policy more conspicuously than they had before.

The pandemic and public health responses to COVID-19 became highly politicized in unfortunate ways with unfortunate social consequences. Some US governors and other local officials called for or signed executive orders mandating the wearing of face coverings in indoor spaces to reduce the spread of the virus. Other US governors rejected such an approach. Some elected officials even went to court against the decision-making bodies in local school districts that wished to institute district-wide mask mandates to protect their students, staff, and faculty. The public divided on mask wearing generally along US political party divides. Republicans were generally opposed while Democrats were in favor (van der Linden et al., 2020).[2] Viral spread mitigation policies, strategies, and practices became the subject of baseless skepticism, rage,

[2] In studies, independent voters would be asked about which way they leaned.

mockery, and even violence. Years on, studies provide supporting evidence that these mitigation strategies, when followed consistently and correctly, were effective tools for preventing the spread of the virus (Greenhalgh et al., 2024).

As the impact of COVID-19 progressed and time elapsed, vaccinations would become available; however, their legitimacy and safety – as well as their uptake –became another front in the public information crisis. Vaccine skepticism rooted in misinformation and disinformation is an already prevalent feature of some online communities in the US, but with the politicization of the COVID-19 pandemic response, others would soon join their ranks as the COVID-19 timeline unfolded into late 2020 and 2021. The US Food and Drug Administration (FDA) granted Emergency Use Authorizations (EUA) to two vaccinations – from Pfizer and BioNTech – in December 2020. Both vaccine programs (named programs since they both required two doses) demonstrated high efficacy against spread and pathology in large scale clinical trials; however, the vaccination push would face politicization much as face covering guidance and calls for social distancing. Vaccine hesitancy tracked along political lines just as mitigation strategy guidance skepticism – with Republicans showing much higher levels of vaccine hesitancy than Democrats (Cowan et al., 2021).

In 2024, Kansas Republican Attorney General Kris Kobach filed a lawsuit against Pfizer presenting false claims about vaccine safety (regarding myocarditis and pregnancy complications) and relying on misinformation in the supporting evidence (Pierson, 2024). In 2025, Robert F. Kennedy, Jr. was nominated and confirmed as the US Secretary for Health and Human Services by Republican Donald Trump. Kennedy has expressed doubts in the past about the effectiveness and safety of vaccines including spreading misinformation about links between vaccination and autism (Mnookin, 2017). In March 2025, Kennedy vowed to ‘revisit’ the issue of a supposed link between vaccines and autism (Nunn, 2025) even though a preponderance of scientific evidence has debunked the supposed link (Taylor et al., 2014). Furthermore, in March 2025, the National Institutes of Health (NIH) under the Trump administration abruptly terminated grants to projects seeking to research vaccine hesitancy and evaluate strategies to increase vaccine uptake (Reardon, 2025).

Why would there have been and why would we continue to see a political divide around matters of scientific import? In a March 2025 interview, Dr. Sara Cody, health officer and director of public health for California’s Santa Clara County – who issued one of the first stay-at-home orders in 2020 – was asked what we have learned since the COVID-19 pandemic. Specifically, how has the experience of COVID-19 changed the way in which we might address a future pandemic. Her response was this,

> Honestly, I’m quite worried. I think that we are in a much weaker position now, for a variety of reasons, than we were five years ago. And I think that we’re going to have to face it in a different way. Local is important. That’s where the rubber hits the road. That’s where you can make change. That’s where you can be nimble. I don’t have the answers, but we’re in a really, really, really tough place right now. The country is incredibly polarized. We’ve had this, like, radical change in norms about how we behave and how we speak with each other and how we solve problems together. We need coalitions of like-minded people to express themselves and try to make change (Martin, 2025).

This book takes up this notion of how we solve problems together and provides some strategies to mitigate polarization as we will see in due course.

To be clear, this book is not a book on COVID-19 and the subsequent fallout around public health and health science, generally. There are myriad other issues which require re-thinking science engagement and public understanding of science. I bring the COVID-19 pandemic to the fore only because of its relevance to the aims of the project and, on a many-worlds interpretation, the COVID-19 pandemic unfolded in the timeline I found myself living and writing in. As well, it continues to be a hotspot for misinformation, disinformation, and bad faith actors in the space of reasons.

COVID-19 pandemic notwithstanding, other issues similarly call for increased public *engagement with* and *understanding of* science. Consider global climate change. It similarly requires collective social action from the public; however, political divides complicate this issue too. In 2023, the Intergovernmental Panel on Climate Change (IPCC) released its Sixth Assessment Report Summary for Policymakers on global climate change. The report, approved by 195 governments and relying on over 14,000 studies, raises the alarm for policymakers to take action or see irreversible and detrimental effects of climate change (IPCC, 2023). According to Dunlap (2013), the divides on climate change – in the US in particular – are due, in part, to concerted disinformation campaigns. He writes, "The primary strategy employed by this campaign has been to 'manufacture uncertainty' over [anthropogenic global warming], especially by attacking climate science and scientists" (p. 692). Both the pandemic response and climate change share a collective social action call whereby people must communicate with one another about the issues, the stakes, their interests, etc.; however, other scientific issues open socio-political or ideological divides without the kind of collective action imports which COVID-19 and global climate change have.

A prominent example of this kind of scientific issue is degree of belief in evolution by natural selection. Acceptance of evolution by natural selection has surged in recent years in the US from 40% in 2005 to 54% in 2019 (Miller et al., 2021). Though, as one might expect given the preceding discussion of political divides, gaps in acceptance of evolution by natural selection run along the same political/ideological lines. According to the study, as of 2019, only 34% of conservative Republicans accepted evolution compared to 83% of liberal Democrats (Miller et al., 2021). Given the scientific community's consensus on this matter – among other issues of scientific import – what explains the gap in acceptance? The cases rehearsed so far motivate the need for re-thinking science engagement. The pervasiveness and effectiveness of scientific and health misinformation/disinformation; distrust of scientists, public health officials, and other science adjacent experts; and hesitancy or skepticism toward some technologies give us good reasons to revise our current approaches to engaging the public in science. It is important to admit that no one should seriously demand a univocal public. A cognitively homogenous public is undesirable as such a public would be incapable of birthing new ideas. However, one should expect that public discourse about issues of science and related to science be informed by available evidence and be productive. So, how might we think differently about the problems? How might we do things differently? In the remainder of this book, I propose a new way, rooted in a pragmatist philosophical orientation and informed by research in education studies and psychological science (among other related fields).

A New Model

In what follows, I articulate and defend a novel, revisionary model of science engagement which I argue offers solutions to the challenges of science engagement and public understanding of science. I see the challenges as issues of social or political resistance, content-related challenges to understanding (difficulty in making sense of findings), and issues of trust in science. I call my model the *participant-centered model of science engagement*. The model is novel because it is a public engagement with science model with a deliberative democratic ethos scaffolded by findings in the formal education literature – and no extant models follow this lead. Particularly, my project is inspired by American pragmatism and learner-centered approaches to teaching and learning (which have shown to be efficacious in formal educational settings and beyond).

The participant-centered model of science engagement is applicable in a 'wide' sense. Science engagement can be conceptualized in two ways, wide and narrow. On the one hand, a narrow concept of science engagement limits it to cases of just informal science education.[3] By informal education, I consider museums of natural history, planetariums, science lectures, STEM (science, technology, engineering, and mathematics) camps, online science video series, or other informal educational content, institutions, and projects. On the other hand, a wide definition of science engagement includes those narrow cases given above but it also includes cases where participants are invited into the process of science either via direct participation (like participatory science or what has

[3] I exclude formal education settings – schools – since these spaces have already garnered much attention in the literature; however, I do think my overall approach could be extended to formal educational spaces. I leave this open for future research.

been called ‘citizen science’), direct feedback and discussion (like science roundtables or consensus conferences), or other bi-directional science and public forums (like public comment sessions). Each of the domains I have specified here (with the aspiration of effectiveness in those unmentioned) would do well with a dose of deliberative democracy scaffolded by research and practice in the formal education studies literature.

The deliberative democratic ethos I envision is informed by the writings of American pragmatist philosopher, John Dewey. Effective science engagement is an amalgam of both educational and social aims and so Dewey’s vision of democracy squares well. I will say much more about the educational and social aims in Chapter II. It is in the learner-centered principles of teaching and learning where I make those educational and social aims actionable. Learner-centered principles of teaching and learning serve to inspire what I call *participant-centered principles* within my proposed model of science engagement. Since (1) learner-centered principles are meant to provide educators with a framework for understanding learners, designing curricula, effectively managing classrooms, and delivering content and (2) relevantly similar practices imbue the work of science communicators and science engagement professionals, the benefit of drawing on these principles for science engagement comes into better focus. A further bootstrap to drawing on learner-centered principles is that they are informed by decades of research in the psychology of learning and practice in education studies. I recognize there may be some reluctance to accepting the applicability of classroom practices to science engagement and I do take up that possible objection in Chapter II. For now, I will forge ahead with further details of the learner-centered principles.

Learner-centered principles are informed by factors critical to learning and these factors include the following: cognitive, metacognitive, motivational, affective, developmental, social, and individual difference. Cognitive and metacognitive factors refer to the constructive nature of knowledge and the importance of active self-awareness in encountering and encoding new information.[4] Motivational and affective factors include the finding that more information is encoded by learners when the material to be learned is relevant to the lives of learners – as they filter information through their own belief-value systems (Hidi & Renninger, 2006; Rosenzweig & Wigfield, 2016).[5] Developmental and social factors emphasize that learners encode information different depending on a number of variables – like age, ability, and so on (Snowling, 2000; Zsolnai, 2002). Lastly, the individual difference factor acknowledges human cognitive, social, and cultural diversity in the processes of learning. The participant-centered model of science engagement harnesses these principles with some modifications from their original applications in formal classroom settings.

The participant-centered principles I develop form a hard core from which to establish new strategies and practices in the pursuit of effective science engagement. In the book, I *begin* the work of developing and defending some efficacious strategies for engagement in light of the framework established by the principles as well as formulate some particular practices. However, I concede that the practices I put forward are only the beginning. Those I propose in Chapters III, IV, and V will need to be assessed and evaluated

4 By constructive nature of knowledge, this simply refers to psychological constructivism and does not necessarily entail social constructivism in any strong or weak sense.

5 John Dewey was one of the first to make this point – see Dewey, J. (1913). *Interest and effort in education*. Houghton Mifflin Co.

empirically. Other particular practices may – and will be – derived from the principle framework, strategies, and the general ethos of the participant-centered model of science engagement. Given the preceding discussion of the effects of the model, if adopted, I turn now to positioning the model amongst the extant models of science engagement and science understanding which inform current practices. Much of the literature on these models comes out of the field of public understanding of science.

The field of public understanding of science is a relatively new field of inquiry, all things considered, only taking on an institutional form somewhere in the mid-1980s (Wynne, 1995). The primary academic journal and space for debating values, frameworks, and presenting empirical research in the young field, *Public Understanding of Science*, is founded a bit less than a decade later (in 1992). As one might expect in any burgeoning field, particularly a field within the social and behavioral sciences (like public understanding of science), foundational theoretical and paradigmatic debates took center stage in the early years.[6] The debate of interest for this project is the framing of the science and society relation.

The Intellectual Landscape in Public Understanding of Science

Two positions on the science and society relation emerge in the public understanding of science literature. The first position goes something like this: The public (read, society), as an entity, has a scientific knowledge deficit as demonstrated by results from large-

---

[6] This comment is not meant as defamatory toward the social/behavioral sciences in any way. It is just an observation confirmed by research into the history of the social sciences. They tend to have theoretical framework debates which arise early and can rage, well, forever.

scale science literacy questionnaires. Science, as a set of institutions, can fill this deficit by providing more scientific facts to the public. Thus, the scientific knowledge deficit is filled. Call this the public knowledge deficit approach to science engagement. The second position goes something like this. Publics (pluralized to emphasize heterogeneity) must be understood on their terms as engaged in the processes and products of the sciences. Those studying and connecting with publics must do so in ways relevant to the individual contexts of those publics. Call this second approach the contextualist approach. More will be said to fill out the details of these positions later in the chapter, but, for now, let us take the first position to highlight a problem of *understanding* and the second position to highlight a problem of *engagement*.

Over time, there has been a shift in contributions to the journal *Public Understanding of Science* which track a move from addressing problems of understanding to problems of engagement (Stilgoe et al., 2014). Policies, initiatives and practical experiments have accompanied this shift as well. Bauer (2009) offers an historical account of the evolution of public understanding of science discourse in the literature and in public policy across three distinct periods in the Twentieth Century.

The first period begins in the 1960s and ends in the early 1980s so it mostly pre-dates the institutionalized form of the public understanding of science field of study. Bauer terms this period the "Science Literacy" period and its germ is in the first survey on science perception in the United States from the *National Association of Science Writers* (NASW) published in 1958 (Cortassa, 2016). The dimensions studied in this survey were the following: levels of interest in science and knowledge of scientific information; information sources; understanding of scientific facts, methods and process; attitudes towards science; and images of scientists. The study sampled 1,919 adults (21 or older) – 828 men and 1,091 women – and surveyed their media consumption habits before delving into correlational analyses of interest, knowledge, and attitudes toward science. Cortassa (2016) writes,

> Since the mid-twentieth century, *interest, knowledge* and *attitudes* built the frame that accompanied the evolution of these kinds of studies. However, the NASW survey's heritage was not only to set forth the relevant aspects for further research. Even more importantly, its results led to the drawing of an inference about a linear correlation between the cognitive and attitudinal indicators (448).

One reason this conclusion about the linear relation may have been drawn from this study is the "portrait of the science consumer" outlined in its conclusion. In this portrait, the typical science consumer is said to be male, educated, urban/suburban, Midwestern/Western, and young to middle-aged and that "his interest in science is reflected in a high level of science information" (National Association of Science Writers, 1958, p. 224). Further studies implied a causal role from the cognitive (knowledge about science) to the attitudinal (attitudes toward science) (Cortassa, 2016). In other words, in order to change attitudes, one needed to provide more scientific information to the public. Bauer (2009) writes that this period of public understanding of science research and policy-making was characterized by conceiving the relation between science and society as society having some surmountable knowledge/information deficit. The proposed solution to "fill this gap" was education (in a very passive, fact-giving sense). It is here we see the inklings of the public knowledge deficit approach. In the public understanding of science literature, this approach is variously termed the knowledge deficit hypothesis, the information deficit model, the public deficit model, or just the deficit model. I will henceforth refer to it as the deficit model.

Examples of this type of thinking abound historically and even in contemporary discourse. Historically, consider the following passage from the Director of Public Understanding of Science with the American Association for the Advancement of Science (AAAS), Edward G. Sherburne, Jr. from a 1965 editorial in *Science*,

> Individual laymen have no one, except perhaps the more responsible representatives of the mass media, to whom to turn for the holistic point of view that the citizen needs. Add to this situation the fact that the high-school or college-educated citizen of today, aged 40, scarcely heard of or imagined during his years in school any of the scientific-social problems he faces as an adult…These facts, and the [National Science Foundation] budget figures cited, point to a gap in national thinking and planning. There is remarkably little formal assumption of responsibility by government agencies for informing and educating the public about problems, and solutions, to which scientific research gives rise (Sherburne, 1965)

The scientific-social problems Sherburne identifies are use of pesticides, threats of automation, smoking and health, choosing science curricula for schools, and automobile exhaust and health. The conclusion Sherburne draws is a kind of "if only they knew" conclusion – something like, "if only the public knew X, they would do/not do Y". As we will see, this underlying assumption of "if only they knew" is not entirely true. There is a temptation to suggest that the deficit model approach has been abandoned in contemporary discourse, but research has indicated otherwise. A recent survey found that scientists, in particular, prioritized defending science as their primary communication objective in online interactions with members of the public rather than engagement-focused objectives like building trust or tailoring messages to contextual factors (Dudo et al., 2016). The continued reliance on a strictly public deficit attitude by scientists or other science communicators motivates the need for continued scholarship on this issue and I take the view that a more dynamic, two-way model offers a richer approach to doing science engagement.

Firm reliance on the deficit model approach continues into the 1990s during a period that has been called the "Public Understanding" period (Bauer, 2009). In this period, as with the last, the identified problem to be solved is the public's information deficit. The solutions promulgated call for a need for public attitude shifts toward science and the solutions range from education reforms, as the previous period did, though it is also characterized by more emphasis on attitude-change measures. Particularly, through targeted public relations (PR) efforts. So, the resulting ethos is that, yes, the public (still) has a literacy problem which could be solved through education, but, also, science has a PR problem – which could be solved by some outreach or communicative efforts.

Taken together, this ethos lent itself to communication strategies designed to make science look informative and trustworthy to a (perceived or real) skeptical public. Most PR practiced amongst scientists and science organizations falls within the category of 'explanatory PR' and this kind of PR is generally referred to as 'public information practice' within the realm of scientific organizations (Borchelt, 2014). Borchelt (2014) explains, "The word [sic] that many people often use in referring to explanatory PR of this type is 'spin control' – making sure the public knows a lot about the science or the scientists, but only the 'right' things that the [organization] thinks the public should know" (149).

He gives two examples of this type of one-way communication practice. First is the United Kingdom's Department of Health downplaying and minimizing the risk of bovine spongiform encephalopathy (or otherwise called 'mad cow disease') when it first came to the public's attention. A second example is the reaction from a US national laboratory in Long Island reaction after it was discovered a research reactor's pool was leaking tritium into the groundwater. Lab officials insisted there was no health or safety issue even as residents protested and demanded action (Borchelt, 2014). Both cases demonstrate an image control stance in an attempt to sway public attitudes. Of course, both of these cases also demonstrate the limitations of this approach. The approach sows public mistrust of science, the institutions of science, and those institutions which deploy science in their operations and recommendations.[7] The public is really only invited to participate in communication as the organization sees fit. As Borchelt (2014) writes, "Explanatory PR may employ focus groups, polls and surveys, and other means of finding out what the public knows or thinks in order to determine the right 'spin', but it does not engage in any two-way dialogue

[7] The point I am making is that mistrust and science is complicated. It is not always abundantly clear at which target an individual take aim at when they either implicitly or explicitly mistrust science. One possibility is that one does not trust scientists qua scientific inquirers (that humans lack such a truth-seeking capacity). Another possibility is that one does not trust scientists qua political animals (that scientists have a political agenda, say). Another possibility is that the mistrust is not in scientists, but how science is deployed by governmental or non-governmental agencies (mistrust in policy-makers and not necessarily science). In some cases, the mistrust is a combination of these possibilities. In other cases, it's none of these. Messy is the effort to fully understand mistrust and science.

with its publics" (150). The approach relies solely on a one-directional information exchange – the filling of a deficit one might contend – in order to produce a desired result.

The final period, "Science-in-Society", finishes out the 1990s and spans to at least 2009 at the publication of Bauer's article. The problems identified are a bit more complex and they flip the focus from thinking about problems of the public to thinking about problems in the institutions and practices of science. The proposed solutions during this period suggest inviting the public to participate in the processes of science and to encourage public deliberation through science policy roundtables, public comments, and science festivals (Bauer, 2009). This is a marked improvement. It is at this juncture where we can recognize the transition from an understanding-centric approach to an engagement-centric approach. Cortassa (2016) contends that the practices within this final period were born out of influences from the social studies of science, technology, and medicine literature (usually referred to as just science and technology studies – STS) – an interdisciplinary field comprised of mostly historians, and sociologists, but also some philosophers, among others. The approach largely abandons the deficit model's underlying theoretical assumption of a public knowledge deficit and a dialectic of science (as the base of knowledge) versus public (as those needing the knowledge which science has). Here we see the blooming of the contextualist model.

The contextualist model becomes a dominant theoretical paradigm in the field of public understanding of science. The contextualist approach studies how scientific information and findings (and science itself) fits into society-at-large in ways sensitive to individuals, local communities, or other segments of society. For instance, contextualists engage with and analyze programs engaging with local knowledges (for instance, Traditional Ecological Knowledge beliefs among an Indigenous population). In addition to local knowledge engagement, Lewenstein (2003) adds the notion of 'lay expertise' to the landscape. He writes, "The lay expertise model argues that scientists are often unreasonably certain – even arrogant – about their level of knowledge, failing to recognize the contingencies or additional information needed to make real-world personal or policy decisions" (4). Miller (2001) writes that the contextualist approach in the new "Science-in-Society" era jettisons the *interest, knowledge,* and *attitudes* trifecta of the deficit model in bygone eras of Science Literacy and Public Understanding for a new trifecta of *dialogue*, *discussion*, and *debate*. In other words, the contextualist turn in the literature and in practice encourages public participation and engagement with science. Lewenstein (2003) calls the dialogue, discussion, and debate turn in public understanding of science the 'public participation model' and Reincke et al. (2020) call it the 'dialogue model'. Overall, the general contextualist ethos is toward engaging the public in important and, of course, context-dependent ways. I take this to be a marked improvement; however, I have reservations which I will outline below.

The contextualist model encourages a more textured view of both science (as both institution and practice) and the public. By a textured view, I mean that the contextualist model is more sensitive to historical and social factors that undergird our understanding of science. And regarding the public, the contextualist model recognizes that "the public" is not a homogeneous entity. In fact, as has already been introduced in this chapter, some researchers have moved to referring to 'publics' in their analyses of issues central to public engagement with science (Einsiedel, 2000).

Thus far, I have given a short history of these two approaches – deficit model and contextualist model – as they have emerged in the public understanding of science literature and how they have shaped or informed public policy, academic discourse, and even public discourse about public understanding of science. Further, I have outlined some of the key assumptions and themes in both the deficit and contextualist models. At this juncture, I want to turn to assessing these models and showing their limitations. I discuss their limitations in order to motivate a new way forward – I seek a synthesis of the two, harnessing the virtues of each.

Limitations of the Deficit and Contextualist Models

Asserting specific criticisms of the models is a complicated endeavor, but there are identifiable issues in each. I have used the terms 'model' and 'approach' when referring to both – this is intentional as they are not formalized in any particular fashion. The deficit model and contextualist model are, in my view, pre-theoretical models as opposed to the kinds of well-defined and explanatory models of phenomena we might find in the sciences. As pre-theoretical models, they are still important as they provide a basis for formulating research questions, designing studies, interpreting findings, constructing communications, and putting together learning experiences. It is not possible to identify a well-formed statement of *The Deficit Model* or *The Contextualist Model* toward which to articulate specific and direct criticisms. Instead, I – as others have – must operate by articulating limitations at an understanding of the models distilled from previous research and discussions (Cortassa, 2016; Einsiedel, 2000; Layton et al., 1993; Wynne, 1991; Ziman, 1991). With this caveat of relying on theoretical distillations made, I begin with a key limitation of the deficit model.

The problem I identify in the deficit model is its disregard for what I call ‘non-epistemic factors’. I will explain what I mean by this further in the following section. I call this limitation the *Non-Epistemic Factor Exclusionary Problem*. Turning to the contextualist model, I suggest that the contextualist model undermines the epistemic authority of science. For some, this is a desirable result; however, a deflated notion of science is neither necessary nor desirable for effective engagement and the cultivation of understanding. I call this problem the *Scientific Authority Deflation Problem*.

The Non-Epistemic Factor Exclusionary Problem for the Deficit Model

The limitation I highlight here is that the deficit model undervalues (or ignores) the non-epistemic factors central to what we know about effective science engagement and public understanding of science. I use the term “non-epistemic” to refer to social, pragmatic, moral, or other considerations regarding knowledge and belief. For instance, an epistemic value might be something like the internal consistency of a set of beliefs. In other words, do the beliefs contradict one another? If so, they must be revised accordingly. A non-epistemic value might be something like the social consequences of having a particular belief. For instance, a belief that it is safe to eat foods grown with pesticides might ostracize one from their family who vehemently disagrees with that view. As discussed previously, the public’s acceptance of scientific findings does not always follow from the presentation of true theories to the public. An effective theory of science engagement must be sensitive to and negotiate with social, moral, and pragmatic factors and not just epistemic factors. I claim this because a wealth of empirical research contradicts an alleged positive correlation between scientific literacy and appraisal or acceptance of science (Dunlap & McCright, 2008; Kahan et al., 2007; McCright et al., 2016).

Attitudes and values toward emerging science and technology may have little to do with knowledge about scientific findings or knowledge of technological capacities. Negative attitudes or divergent values about new scientific findings and technologies have been shown to be 'functional' in an anthropological sense (Wildavsky & Douglas, 1983). In other words, the negative attitudes toward some scientific finding or framework provide a basis for individuals to maintain cultural associations within their social milieu. For example, a family may have strong opposition to levying taxes on any business as a kind of 'job killing' initiative. For this reason, they may also oppose carbon tax schemes which seek to disincentivize companies from producing additional environmental pollutants, particularly carbon dioxide, a known contributor to global climate change. On the deficit model view, the choice of ignoring "objective" hazards – those hazards that pose a demonstrable, existential risk to oneself or one's community – should be overcome with more knowledge, but they are not.

Similarly, other predictors can intervene in the relation between knowledge and attitudes. While a significant positive correlation between knowledge and attitudes toward scientific research, generally, has been demonstrated, attitudes can vary significantly with specific kinds of research. For instance, when findings or research programs were categorized as 'non-useful issues', 'useful issues', and 'moral issues' researchers found varied attitudes (Evans & Durant, 1995). In addition, other predictors intervened on the correlations between science literacy and attitudes toward science – for instance, religiosity, authoritarianism (meaning deference to a political authority), left-right political affiliation, and powerlessness (meaning perceived lack of power in society) (Evans & Durant, 1995). In another example, political orientation was the most reliable predictor of concern over global climate change with level of education acting as an interactive predictor such that more education made one increasingly skeptical (if conservative) and increasingly convinced (if liberal) (Hamilton, 2011). These predictors – political orientation, age, religiosity, authoritarian/libertarian, and so on – complicate public scientific understanding and appraisal of science; however, they are not the whole story. Affective appraisals are also an important driver.

A growing body of literature has shown the effectiveness in emotionally charged rhetoric in anti-vaccination disinformation campaigns (Bean, 2011; Kata, 2010, 2012) – especially in light of the COVID-19 pandemic (Bonnevie et al., 2021). One study analyzed affective appeals on anti-vaccination websites. Some of the affective appeals identified were appeals to civil liberties and parental testimonies (Kata, 2010). These sites included presentations of cases where children were taken from parents by social services after it was discovered they were not immunized. Further, "Accusations of totalitarianism were made by 63% of websites. This included warnings that citizens were being prepared for draconian measures in the event of a pandemic" (1712)

Personal testimonies were the most common emotive appeals used on anti-vaccination sites with 88% containing some form. According to the study, "The majority were narratives from parents who felt their children were damaged by vaccines" (1713). Harnessing the cultural association finding previously discussed, this study also found that "Half of websites included the notion of 'us versus them', where concerned parents and vaccine objectors were portrayed as battling physicians, governments, corporations, or the scientific establishment" (1713). Direct pleas were made by 50% of websites calling for parents to be 'responsible' and to make decisions in the best interests of their children – the implication to avoid vaccination. It is widely recognized that emotions are integral to diverse cognitive processes important for learning (Goetz et al., 2006; Um et al., 2012), so it would seem prudent to incorporate this finding in a theory of science engagement.

Given the thoroughgoing discussion, the empirical findings give reason to think the deficit model's approach to science understanding and science engagement is incomplete. This is not to say that the deficit model is completely ineffectual; however, it is to say that there is a better way of structuring science engagements. The central aim of the deficit model is to present scientific information in a unidirectional way with the expectation that the information will be received and accepted by the recipient. One who adopts the deficit model approach might agree to much of what has been said thus far about emotions and social identities and grant that emotions and identity-protective reasoning are important factors in human cognition. They might agree that fear, for instance, is a powerful emotion and that it could (and perhaps should) be harnessed for science literacy ends – as in, harnessing it 'for good'. In this way, the deficit model proponent has acknowledged what I have taken as an objection to a strictly deficit approach and assumed it for their own purposes. The deficit model proponent's goal – to fill the deficit of knowledge of the public – remains the same but with some additional non-epistemic tools. This move for the deficit model proponent is undesirable, though.

The manipulation of emotions with science literacy as an end-in-view raises a clear problem for the deficit model defender (unless they add on some crucial provisos). A revised deficit approach