What Relationships Do We Want with Technology? Toward Technoskepticism in Schools

JACOB PLEASANTS
University of Oklahoma
DANIEL G. KRUTKA
University of North Texas
T. PHILIP NICHOLS
Baylor University

In this essay, Jacob Pleasants, Daniel G. Krutka, and T. Philip Nichols outline a vision for how technology education can and ought to occur through the core subject areas of science, social studies, and English language arts. In their argument for the development of a technoskeptical stance for thinking critically and making informed decisions about technology, they discuss past and current efforts to address both the teaching and use of technology within the subject areas and possibilities for a deeper and more coherent technology education. To support that goal, they present the Technoskepticism Iceberg as a conceptual framework to identify the technical, psychosocial, and political dimensions of technology and highlight ways of thinking with greater depth about those dimensions.

Keywords: curriculum, English language arts education, science education, social studies education, technology education

Previous generations were afforded centuries or decades to adjust to technological change. But it arrives much faster now. Smartphones and ubiquitous internet access have transformed societal institutions, relationships, and the pace of life. Silicon Valley companies are pursuing the creation of a digital metaverse, autonomous cars for transportation, generative artificial intelligence (AI), and large-scale genetic engineering. These technological projects often seem to march forward at the whims of technologists, investors, and

Harvard Educational Review Vol. 93 No. 4 Winter 2023

markets, giving people little chance to pause and consider, *What relationships do we want with technology?*

This question is especially consequential for young people, who will live with the technological decisions of today for years to come. Considering the pace of technological change, a critical question for educators is, *How are students being prepared to discuss and make decisions about technologies that could have lasting impacts on their collective lives?* We contend that public education ought to prepare students for technological decision-making using a multifaceted, coherent, and intentional technology education. Technology education ought to do more than provide students with technical skills; it should prepare them to critique the technical, psychosocial, and political dimensions of technology, both in relation to themselves and the communities to which they belong. This sort of technology education should not be restricted to modern digital technologies. We take a broad view of technology that includes all products of human intention, from physical artifacts like pencils and windows to processes and techniques like agriculture and oil refinement. All of these technologies have had, and continue to have, profound effects on students' lives. While we recognize that technology has long been part of public school curricula, we contend that its inclusion has largely failed to meet the needs of highly technological societies. Our schools generally prepare students to be consumers and users of technology more than thoughtful and empowered participants in public debates and decisions.

We are not the first to advocate for this kind of technology education, and we acknowledge and are informed by scholars from various disciplines who have called for more critical engagement with technology in schools (Dakers, 2006; Martorella, 1997; Selber, 2004; Vakil, 2018; Waight et al., 2022; Yadav & Heath, 2022). At the same time, it is important to note that educational practice has not readily taken up those proposals. Our goal is not to rehash previous arguments but chart a path for technology education that is more friendly for uptake in schools and classrooms. We describe a set of overarching aims as well as practical conceptual tools that teachers and educators can use to develop instruction that supports those aims. Importantly, the approach we propose draws on lessons from prior efforts that failed to gain, or sustain, traction.

As a starting point, we use Postman's (1995) vision for a technology education that emphasizes critically examining technology's effects on humans. In practical terms, we argue that this sort of technology education is most likely to be achieved within the core content areas of science, social studies, and English language arts (ELA). Technology already appears in the standards and curricula of these subject areas, which means that opportunities for technology education exist if teachers are prepared to leverage them. To assist educators with taking advantage of those opportunities, we introduce a conceptual framework for teaching about technology. Our *Technoskepticism Iceberg* framework describes dimensions of technology that serve as starting points for fruitful and critical lines of inquiry. By establishing a coherent, intentional, and sustained approach to teaching technology, we aim to prepare students to pursue more humane, democratic, and just relationships with technology.

Toward a Vision for Technology Education

In the United States, what is typically referred to as "technology education" has ties to vocational education and evolved from what was previously called "industrial arts education" (de Vries, 2009; Dugger, 2009; Herschbach, 1997; Raizen et al., 1995; Sanders, 2001). More recently, technology education has aligned itself with "STEM" while remaining separate from core academic subjects like math and science (Kelley & Kellum, 2009; Sanders, 2008). Computer science occupies a similar space in schools as a separate "technology" subject that is increasingly offered to students (Grover & Pea, 2013; Wilson et al., 2010). These forms of technology education are largely concerned with conveying technical skills and information. In a typical computer science classroom, for instance, students often learn a coding language and the technical skills to create computer programs. However, they are unlikely to explore the social or political implications of the technologies they are learning about (Dakers, 2006; Vakil, 2018). While there is advocacy for developing a "technological literacy" that extends beyond technical skills (de Vries, 2009; ITEEA, 2020), it is not clear that those broader objectives have been meaningfully taken up in technology classrooms (Dugger, 2009).

Rather than rely on these existing forms of technology education, we turn to a vision espoused by media theorist Neil Postman (1963, 1985, 1992, 1995), who across his career argued that technology is a central force in reshaping cultures, values, and meanings in ways that often are overlooked. In addition to critiquing modern technology, he sought to bring technology criticism into schools. In his 1995 book *The End of Education,* he proposed "technology education" as a core school subject:

> Technology education aims at students' learning about what technology helps us do and what it hinders us from doing; it is about how technology uses us, for good or ill, and about how it has used people in the past, for good or ill. It is about how technology creates new worlds, for good or ill. (191)

While Postman did not specify a curriculum, he argued that students should learn about the "psychic and social effects" of technologies that have remade the world—from the alphabet and printing press to clocks and X-rays. Postman's (1995) vision was therefore not at all oriented toward technical knowledge. He wrote that "educators confuse the teaching of how to use technology with technology education" (190). In emphasizing social and political dimensions of technology, he built on academic studies of technology from the humanities, including works by sociologists, philosophers, and historians (Ellul, 1964; Illich, 1973; McLuhan, 1964; Mumford, 1964). He believed that body of work, as well as the work of science fiction writers (e.g., Huxley, Orwell, Bradbury), ought to form the foundation for the study of technology in schools.

We use Postman's ideas about technology education as a starting point but extend and modify them in ways that make them more accessible to teachers, more applicable to school settings, and more responsive to the growing research literature that spotlights the differential impacts of technology on nondominant communities. We diverge from Postman's (1995) proposal that technology education be a separate subject area, which was an idea that gained little traction. Instead of asking that space be made for an additional school subject, we contend that technology education can, and should, occur within subject areas that are already required for all students: science, social studies, and ELA.[1] Technology is already a part of these subject areas, appearing within standards documents (National Research Council, 2013; NCSS, 2010; NGACBP & CCSSO, 2010) and published curricula (OpenSciEd, IEEE REACH, StudySync). Students are therefore already learning *something* about technology, although it is often not what we (or Postman) think it should be. A more fruitful technology education does not require adding entirely new components to our education systems but, rather, modifying what already occurs so that it is more coherent, intentional, and sustained.

Our vision for technology education also leverages contemporary developments in the field of critical technology studies. In the years since Postman's writing, critical studies of technology have expanded into new conceptual spaces, especially regarding the roles that it plays in problems of social justice (Broussard, 2023; Eubanks, 2018; Noble, 2018). Benjamin (2019), for instance, describes how racial discrimination is built into technologies ranging from Kodak's Shirley cards to medical instruments to AI facial recognition software. Mukherjee (2020), likewise, shows how the "radiant infrastructures" of cell towers and nuclear reactors that link communities in the Global South to narratives of connectivity and development also subject them to protracted surveillance, environmental degradation, and public health risks. Contemporary technology education needs to be informed by these critical perspectives.

Like Postman, we view technology education as occurring when technologies are taken as objects of inquiry and critique, and we agree with his central contention that technology education must be about much more than learning how to use technology. Rather than focus on technical skills, we view the purpose of technology education to be the development of a *technoskeptical stance*. This stance is not antitechnology, just as an art critic is not antiart. Instead, *technoskepticism* is a disposition toward and practice of asking skeptical questions about technology. Such questions include:

- What are the costs (material, environmental, social) of creating and using this technology? Who bears those costs?
- Who decided how this technology would be designed? What values might they have brought to that process?

- Whose needs and interests are served by this technology, and whose are not?
- Who will benefit from this technology, and who will be harmed?
- How does using this technology cause people to act or think differently?
- How does this technology change the pace, pattern, and scale of human experiences?
- Which of the changes brought by this technology are desirable, or not, and for whom?

Through questions like these, technoskeptical individuals and communities continuously examine the relationships they want to have with technology.

At its core, technoskeptical thinking requires individuals to regard technologies as more than value-neutral tools. One aim of technology education is to illuminate the broad and complex ways that technologies are created and used within complex and interacting social, political, and material systems. Another purpose is to prepare students who can critically evaluate technologies to align their development and uses with human values like democracy, justice, human autonomy, environmental sustainability, and equity. Technoskepticism is an essential educational goal for the contemporary technological moment, and we view it as especially vital to the broader educational goal of promoting social justice. As many recent critiques of digital technologies indicate, ostensibly neutral systems often uphold, reinforce, and amplify social and racial inequities and injustices, including systems that administer social safety net programs (Eubanks, 2018), administer health care (Benjamin, 2019; Broussard, 2023), impose legal penalties (Benjamin, 2019), provide access to loans (O'Neil, 2016), place people into demographic categories (Chun, 2021; D'Ignazio & Klein, 2020), and recommend information online (Noble, 2018). These issues deeply affect the lives of our students and their families, particularly those from nondominant groups. Our students already, and differentially, experience the effects (both intended and not) of technological systems that are inequitable and unjust. They already see the ways that technologies were designed by and for certain people, rather than others, and how the benefits and burdens of those technologies are shared unequally.

Our vision of technology education involves critique, but we align ourselves with critical perspectives that are generative rather than wholly deconstructive or pessimistic (Latour, 2004; Macgilchrist, 2021). A technology education that is oriented toward technoskepticism not only illuminates the profound roles that technologies play in injustices but also reveals alternative and more just ways of designing, utilizing, and relating to technology (Costanza-Chock, 2020; D'Ignazio & Klein, 2020). Our vision for technology education therefore positions students as critical agents who can shape technological futures. This is a much more broad and ambitious goal than the much narrower technical project of preparing students for a future "STEM" workforce (Alonso

Yanez, et al., 2019; Takeuchi et al., 2020; Vakil, 2018). In the face of continued technological change, projects of justice depend on preparing students who can find ways to resist oppressive technological systems and orient technologies toward more desirable values and goals—not simply find gainful employment in an unjust system.

Technology Education in the Subject Areas

Central to our vision of technology education is building on the ways technology is already addressed in subject area classrooms. To further develop that idea, we discuss the place of technology within K–12 science, social studies, and English education, both in current and past practice. A comprehensive history of technology in each subject is beyond what we can accomplish here, and we do not provide such an account. Instead, our discussion focuses on approaches that most closely align with the goal of fostering technoskeptical thinking. We consider missed opportunities as well as forces that have limited the uptake of technoskeptical approaches. After addressing each of the subject areas, we review common themes from the three accounts.[2] The curriculum projects and educational movements we highlight might imply that our focus is on secondary education. Though many prior efforts to address technology have occurred in the secondary grades, technology education has not been, nor should be, so confined. Elementary classrooms are important sites to build the foundations of technoskeptical thinking. They are also particularly well suited for building cross-disciplinary connections.

Technology in Science Education

Given the close historical relationship between science and technology, science classrooms are logical places for technology education to occur. Technologies are often used as examples of how scientific ideas can be applied to practical and everyday situations (DeBoer, 1991; Rudolph, 2019). More recently, attention has turned to how students might also engage in technological design in the science classroom (Apedoe et al., 2008; Raizen et al., 1995; Roth, 2001). Although science classrooms have often addressed technology, they have typically done so only in narrow ways, focusing on its technical dimensions while avoiding any discussion of its social or political aspects.

The way that technology is addressed in science education is best understood against the backdrop of larger trends in science education in the United States. An important tension is the competition between what Roberts and Bybee (2014) call the "two visions of scientific literacy." "Vision I" focuses primarily on the preparation of future scientists, engineers, technologists, and others in the STEM professions. It is a *technical* education project concerned with developing the knowledge and skills that would be needed to enter a science discipline or a related technical career. "Vision II," in contrast, pursues a broader goal of preparing students to be informed decision-makers in modern society, regardless of their profession. It is a *humanistic* (Donnelly, 2004) education project that prioritizes problems and issues that are more than just technical puzzles. The Vision II orientation is therefore far more aligned with our vision of technology education.

There is a long history of advocacy for Vision II (Donnelly, 2004; Levinson, 2010; Rudolph, 2014), but science education policy and classroom practice have largely aligned with the technical priorities of Vision I (Roberts & Bybee, 2014). Influential policy reports, such as *A Nation at Risk* (NCEE, 1983) and *Rising Above the Gathering Storm* (National Academy of Sciences et al., 2007), have foregrounded the development and expansion of the STEM workforce, argued to be vital to national security and international competitiveness. An emphasis on the "STEM pipeline" into that workforce has persisted into contemporary policy discussions (Holdren et al., 2013; Olson & Riordan, 2012; Snyder & Dillow, 2009). Despite those trends, the Vision II notion of preparing societal decision-makers has endured in science education rhetoric (Levinson, 2010). Various curriculum projects, such as those of the Sputnik era, attempted to promote the public understanding of science as well as prepare future scientists (Aikenhead, 2003; Rudolph, 2019). Unfortunately, despite their Vision II rhetoric, those projects were often more aligned with Vision I in practice (Feinstein, 2011; Rudolph & Horibe, 2016).

These broader trends within science education would not seem to be conducive to promoting technoskeptical thinking. Nevertheless, several science education efforts are noteworthy for their attention to technology and their potential to promote a technoskeptical stance. Although those efforts have limitations, their potentialities as well as their shortcomings show how progress might be made.

Most notable is the science-technology-society (STS) movement that emerged in the late 1970s (Aikenhead, 2003) and foregrounded societally relevant problems related to science and technology (Aikenhead, 1992, 1994; Bennett et al., 2007; Bybee, 1987; Ziman, 1980). Its influence is evidenced by the fact that it was embraced by the National Science Teachers Association (NSTA, 1982). However, there was a hesitancy to engage with social, cultural, or political dimensions of STS problems. Venturing beyond the technical invited concern that scientific concepts would be given short shrift (Kromhout & Good, 1983). Bybee (1987), a staunch supporter of STS, described that desire to "retreat to the technical":

> Science teachers often complain that they do not know about social studies so they cannot teach this component of the [STS] approach. Teachers should concentrate on the scientific and technological dimensions of the issue, and understand that they are being asked to teach no more in the social studies than they should know as citizens who participate in the democratic process. (680)

Despite enthusiasm in the 1980s, STS failed to gain a lasting foothold in the United States. This was likely due to the ascendency of standards and high-stakes tests that prioritized technical science content (Fensham, 2016; Hughes, 2000; Rudolph, 2019), as well as the pedagogical demands the STS approach placed on teachers (Donnelly, 2004; Lee & Witz, 2009; Pedretti et al., 2008).

Two successors to STS are noteworthy, one for its foregrounding of societal issues and the other for its foregrounding of technology. An emphasis on societal issues was taken up in the early 2000s under the banner of "socioscientific issues" (SSIs), conceived as an approach that can prepare students to confront, negotiate, and make decisions in scientific situations (Sadler, 2011; Zeidler et al., 2005). Those who advocated for bringing SSIs into the classroom emphasized the importance of addressing technical (scientific) and social (ethical) dimensions of issues. The SSI approach embraces nontechnical aspects of problems, yet the issues are often constructed in ways that give limited attention to technology, preferring instead to focus on science. In SSIs, technologies are often treated as strictly technical tools that define the context of the problem but play a minimal role in analyses of what societies ought to do.

Technology has arguably risen to a zenith of prominence due to the influence of the Next Generation Science Standards (NGSS), which have been adopted by many states, and movements toward integrated STEM education (NRC, 2014; Roehrig et al., 2021). The NGSS (National Research Council, 2013) emphasize engineering design, and many science curricula have responded by adding engineering design experiences within units of instruction (e.g., OpenSciEd). Yet, while engineering and technology are highly visible in contemporary science reform documents and curricula, current efforts are largely a retreat from any serious consideration of technological issues (Ellis et al., 2020). To the extent that societal problems are present within STEM education discourse, they are framed in purely technical terms (Pleasants, 2020).

There is an enduring potential for science classrooms to be sites for meaningful technology education, but also an enduring hesitancy to commit to that work. Societal issues that involve technology and science are seen as motivations for learning science, but there remains the strong assumption that preparing students to engage with such issues requires only the development of technical reasoning skills (Feinstein, 2011; Rudolph & Horibe, 2016), and stepping beyond the technical dimensions of an issue is often viewed as exiting the purview of science education. Cultivating a technoskeptical stance toward technology is also at odds with the dominant capitalist-oriented "workforce development" project of science/STEM education (Takeuchi et al., 2020; Vakil, 2018). Nevertheless, there continue to be scholars (albeit outside the mainstream) who call for humanities-oriented approaches that attend to the social and political in the pursuit of transformation (Bencze & Carter, 2011; Klopfer & Aikenhead, 2022; Levy et al., 2021; Morales-Doyle et al., 2019; Sjöström & Eilks, 2018; Waight et al., 2022).

Technology in Social Studies Education

Understanding how technology has been taught in social studies is challenging because of the contested nature of the field. While the generally accepted purpose of social studies is citizenship education, there have long been debates as to how this should play out in classrooms. Drawing on classifications from the literature (Evans, 2004; Jay, 2022; Thornton, 2005), we can understand technology education in social studies through the lens of three approaches: traditional, disciplinary, and social problems.

A traditional approach to social studies prioritizes the transmission of canonical social science knowledge, including cultural narratives, standard historical accounts, and basic knowledge of political systems. Within the traditional approach, technology most often appears in history curriculum, in specific aspects of geography curriculum, and less frequently in political science and economics curricula (Krutka et al., 2022b). Traditional approaches tend to communicate narratives of technological progress; in a US history course, for example, students will likely read simplistic technological accounts of the opportunities that railroads brought to encourage westward settlement and economic growth. Such curricula rarely acknowledge collateral, unintended, or disproportionate consequences of technology.

The disciplinary approach to social studies emphasizes the professional practices of social scientists, including historians, geographers, economists, or political scientists. Students might practice “historical thinking” by employing strategies such as sourcing, contextualizing, or corroborating (Santiago & Dozono, 2022; Seixas, 1998). Technology sporadically appears within this approach when the topic of study happens to coincide with technological change. For example, “Reading Like a Historian” lessons on the Stanford History Education Group website focus on technological topics like early-nineteenth-century factory life in England and the atomic bomb dropped on Hiroshima and Nagasaki in 1945.[3] These disciplinary lessons can show the social effects of technology through primary sources, but they are generally presented as isolated accounts disconnected from longer technological histories (Krutka et al., 2022b).

A social problems approach is distinguished by its use of disciplinary knowledge and inquiry to critically focus on contemporary problems. Curriculum initiatives that took this approach include those promoted by social reconstructionists of the Depression era, the new social studies programs of the 1960s and 1970s, and the inquiry approach of the National Council for the Social Studies, as seen in the College, Career, and Civic Life (C3) Framework for Social Studies State Standards (NCSS, 2013), which centers questions that are compelling to students and society while often maintaining disciplinary methods. The social problems approach provides the most promising avenue for developing technoskeptical thinking, though it has been sparsely taken up in the field with varying levels of depth.

Calls for social studies educators to attend to technological topics as social problems, not simply tools of progress, have often been short-lived.

For example, Jennings (1957) argued in the 1950s that social studies teachers have a responsibility to encourage students' understanding of the "social consequences of technological innovation" (224), particularly since they were "rudely awakened" by the "advent of the A- and H- bombs" (241). He further believed it necessary "to analyze the nature and impact of scientific or technological innovation whenever it appears in our course of study, pursuing it more intensively, and introducing related materials to supplement the meager treatments found in our textbooks" (237). Jennings's call for wide-ranging technological inquiries was never adopted; the atomic bomb persists as one of the only technological topics where investigation of downsides is encouraged in state standards (Krutka et al., 2022b).

The most intentional and sustained effort at technology education in social studies was the STS movement that started in the late 1970s and influenced both science and social studies. It gained momentum in the 1980s and continued into the 1990s but has waning influence in social studies today. Studies suggested that social studies teachers and students view STS curriculum as important, but the lack of institutional (e.g., teacher education) or curricular (e.g., textbooks) support has resulted in STS failing to be widely implemented.[4] (Similar to science, there is a question of whether social studies teachers had the time, knowledge, or interest to include the technical and scientific aspects of interdisciplinary projects in their classrooms (Hickman et al., 1987; Jennings, 1957; Singleton, 1997).

Arguably the culminating achievement of the STS movement was its inclusion as the eighth of the NCSS (2010) ten themes of social studies. This theme incorporates technoskeptical questions and aligned STS with the social problems approach:

> *Science, and its practical application, technology, have had a major influence on social and cultural change, and on the ways people interact with the world.* Scientific advances and technology have influenced life over the centuries, and modern life, as we know it, would be impossible without technology and the science that supports it.
>
> *There are many questions about the role that science and technology play in our lives and in our cultures.* What can we learn from the past about how new technologies result in broader social change, some of which is unanticipated? Is new technology always better than that which it replaces? How can we cope with the ever-increasing pace of change, perhaps even the concern that technology might get out of control? How can we manage technology so that the greatest numbers of people benefit? How can we preserve fundamental values and beliefs in a world that is rapidly becoming one technology-linked village? How do science and technology affect our sense of self and morality? How are disparate cultures, geographically separated but impacted by global events, brought together by the technology that informs us about events, and offered hope by the science that may alleviate global problems (e.g., the spread of AIDS)? How can gaps in access to benefits of science and technology be bridged?[5]

Because program accreditation reviews were tied to the NCSS themes, this was a rare case in which technology education gained institutional acceptance in the curriculum.

Unfortunately, the momentum of the STS movement has diminished in the twenty-first century, likely due to renewed focus on standardized testing and waning use of the ten themes after the 2013 publication of the C3 Framework. There continues to be sporadic interest in critically engaging with "emerging technologies" like digital and computer technologies (Manfra, 2013), social media (NCSS, 2019), drones (Pearcy, 2018), and artificial intelligence (Wolla et al., 2019). Yet, these disparate efforts have little continuity in their pedagogical approaches.

Outside of STS, the C3Teachers website and IEEE Raising Engineering Awareness Through the Conduit of History (REACH) inquiry lessons offer some promising examples of a coherent technology education in elementary and secondary social studies curricula.[6] The C3Teachers website includes inquiries built around questions like:

- Was the development of agriculture good for humans?
- Which Ancient Chinese innovation has the greatest impact?
- Did Antebellum technology make life better?
- Should we still fight total wars?
- Were suburbs good for America?
- Social media, why can't I post that?

Many of these inquiries show seeds of technoskepticism, but some fail to show deep understandings of technological issues. For example, the suburbs inquiry shows a historic main street as representative of suburban design and a designated bike lane as equally likely in urban, suburban, and rural areas. Considering these sources, students might struggle to understand how sprawl, suburban design, and car-centric design increase the isolation of the nuclear family and segregation by race and class and decrease walking and bicycling as means of transportation.

The IEEE REACH initiative offers a rare example of a coherent curriculum. The website includes nine inquiry lessons on technological topics, such as the electric lighting and the refrigerated railcar, modeled on the Inquiry Design Model (IDM) framework that substantively attends to technical dimensions in ways uncommon to social studies. Also, Krutka et al. (2022b) offers five critical questions for teaching about technology and advances them through curricular resources at the Civics of Technology project that include a historical IDM lesson built around the compelling question, "Should we be more like the Luddites?"[7]

While there are worthwhile efforts at technology education in social studies, they are largely scattered and seemingly implemented based on the whims of curriculum developers and classroom teachers. Social studies instruction is still criticized as being dominated by traditional approaches that tend to uncritically treat technological advancements as equivalent to social progress. In the case of history, the disciplinary approach has the potential to encourage deeper, technoskeptical investigations of primary and secondary sources concerning technology and its effects, but such lessons are uncommon. The social problems approach shows similar promise, but there is still little evidence that technoskeptical inquiries are common or well executed.

Technology in English Language Arts

The role of technology may not be as transparent in ELA as it is in science or social studies, but it is nevertheless present. After all, written language—be it in a novel, poem, essay, personal reflection, or grocery list—is a technology for communication. It involves an invented symbol system that aids writers and readers in remembering, ordering, sharing, and critiquing ideas, from rote information to rich aesthetic experiences. In this sense, there is no study of literacy or literature that does not engage with technology (Haas, 1996; Selfe, 1999). While some pedagogical lineages in ELA have approached the subject through its communication technologies (Bruce & Hogan, 1998; Myers, 1996; Postman, 1963), most are organized around language, literature, and composition rather than their technological underpinnings. When technology surfaces, it is most often associated with changes in how we communicate, thus initiating new demands for reading and writing education. Technological advancements in paperback publishing and television, for instance, inspired a "paperback movement" (Cohen, 1964) and "critical viewing" (Thornton, 1954) in the mid-twentieth-century ELA curriculum. Recent developments in digital technologies, likewise, have led to a constellation of "new literacies" (Lankshear & Knobel, 2003), "twenty-first-century literacies" (Morrell, 2012), and "digital literacies" (Gilster, 1997). These views recognize the impacts that new communication technologies have, but the pedagogical approach centers technical practices for navigating an evolving set of tools.

ELA's dominant approach to technology stems from the fact that literacy—what has emerged as the foundational focus of the field—is a moving target. Scholars demonstrate that the dramatic rise in US literacy rates during the twentieth century did little to preempt the periodic panics about national reading crises, partly because the goalposts for what counts as "literacy" constantly shifted (Tierney & Pearson, 2021). Myers (1996) argued that notions of literacy are shaped by ever-escalating demands for citizens to be familiar with new communication technologies and participate in the industrialized and globalized working conditions those developments shape (Kaestle, 1985). The goals of ELA have evolved in relation to those shifting literacy standards (Myers, 1996, 89–91), emphasizing one of several strands: (1) functional skills needed to navigate a moment's textual landscape; (2) cultural heritage, or appreciation of particular aesthetic objects; (3) personal growth, or the nurturing of personal connections to texts; and (4) meta-awareness about the structures that mediate the aforementioned skills, appreciation, and growth.

The cultural heritage strand is arguably the least systematic in its engagement with technology. Educators, for instance, might introduce technology as a topic for consideration via literary study of Western canonical texts, such as *Frankenstein, Brave New World,* or young adult literature like *Feed* (Wilkinson, 2010). Investigations like these can be fruitful and can even lead to technoskeptical discussions. However, they are also largely done on an ad-hoc basis and are ancillary to the primary curricular goal of reading or analyzing an assigned book.

The functional and personal growth strands tend to be more systematized in their approach to technology but still foreground technical practices over social and political inquiry. The Common Core (CCSSO, 2022) standards for ELA, for example, acknowledge that "new technologies have broadened and expanded the role that speaking and listening play in acquiring and sharing knowledge and have tightened their link to other forms of communication" (22). They suggest that English education ought to systematically teach and assess students on their capacities to access, create, and interpret "words, graphics, images, hyperlinks, and embedded video and audio" (22). The personal growth strand shares some similarities with this functional view. However, rather than justifying the inclusion of digital media production and analysis on the grounds that it prepares students for future career demands, it highlights how such methods allow students to bring their out-of-school interests and abilities into the school day (NCTE, 2019). Across both the functional and personal growth strands, ELA educators are encouraged to teach students how to *use* technologies. However, there is no parallel imperative for them to equip students to interrogate the social and political currents that shape the use of such devices.

Several efforts in ELA education have centered the fourth strand, meta-awareness. These approaches extend the purview of the field beyond students' technical capacities for personal and professional communication to include reflexive attention to literacy (and literature) as a technology. One cluster of such efforts might be termed the "structuralist tradition" in English education. Emerging in the 1960s as an educational analog to other disciplinary engagements with structuralism (e.g., in anthropology, linguistics, literary theory, and psychology) (Olson, 1974), this tradition approached the subject of ELA by attending to the underlying patterns ("structures") that allowed it to cohere as a body of disciplinary knowledge. In this view, if all communication—reading, writing, speaking, and listening—is underpinned by combinations of symbols (e.g., words, images, gestures, tone) mediated through different forms (e.g., conversations, notes, poems, videos), then ELA education ought to focus on these structures as much as, if not more than, particular works of literature or genres of writing.

At the time, this was not a marginal position. It was the basis for *Project 69* (McLuhan, 1960), a federal initiative led by Marshall McLuhan to develop a comprehensive media curriculum for secondary ELA classrooms in the US.

It also was the foundation of Postman's *The New English* (1963), a middle and high school textbook series. It was even the subject of several invited papers at the 1966 Dartmouth Seminar, a pivotal event in the shaping of modern English education (Dixon, 1967; Parker, 1966). These programs shared an understanding that it wasn't just the content of communication that gave language, literacy, or literature meaning, but its *form.* As such, they advocated for student inquiry on the properties and the wider social and political effects of these forms as individuals and groups used them to communicate.

Despite investments from federal agencies, publishers, and professional organizations, the structuralist tradition in English education never gained the traction its supporters hoped it would. McLuhan's *Project 69* proved too idiosyncratic for adoption in secondary schools and was ultimately published as *Understanding Media* (1964)—a work of media theory, not pedagogy. Postman's textbook series was short-lived, and his subsequent efforts to organize English education around the study of media technologies did not find systematic uptake in institutions or curricula. His attempt to rebrand New York University's English education program into one focused on "media ecology"—the study of media environments and their social implications—led to a split and the formation of a new department that found closer synergies with media studies than with education (Maness, 2009). There were, however, other inheritors of this structuralist orientation that found sizable, if fragmentary, purchase in English classrooms. For instance, "multimodality," a concept derived from structural linguistics and semiotics that denotes how meaning is produced through the combination of multiple communicative modes (e.g., image, sound, gesture, genre), inspired a turn in English education toward the teaching of "multiliteracies" (New London Group, 1996, 80). In the years since, there have been mixed attempts to incorporate multiliteracies into ELA education (Jewitt, 2008). At times, these efforts have even been explicit about interrogating the ideologies and imperatives that are embedded in, and extend from, media technologies (Bruce & Hogan, 1998; Prior et al., 2019)—a view close to the vision we outline.

However, the integration of multiliteracies in ELA education has often centered the interpretation and creation of media *content* (technical practices) over inquiry into social and political work of media *forms* as communicative technologies (Nichols & Stornaiuolo, 2019). Even countries like Australia that explicitly integrate multimodality into their national ELA curriculum offer limited guidance for teachers to move students beyond analysis of textual features and meanings (Mills & Exley, 2014). Perhaps the most recognizable example of this tendency is the role of "media literacy" education in US ELA classrooms. While the term comes from diverse, overlapping lineages (Nichols & LeBlanc, 2021), its inclusion in state curricula (California Department of Education, 2022) and advocacy from professional organizations (NAMLE, 2020; NCTE, 2019) stresses students' capacities to access, critique, and produce media *messages* rather than to understand or intervene in the technical systems that condition them. One explanation for this tendency is that such content-oriented skills can accommodate competing goals for literacy education. They are consistent with the functional demand for students to communicate effectively in a technological society; they can promote cultural heritage by equipping students to appreciate nonprint aesthetic objects like plays and films; and they can support personal growth by ascribing cultural capital to communicative forms that students might use in their out-of-school experiences. These alignments reinforce a vision of technology in ELA education as something to adapt to or use for personal or professional enrichment rather than as something to question.

Common Possibilities and Barriers Across the Subject Areas

Reading across these accounts, we can see both profound possibilities and obstacles for the technology education we advocate. It is telling that over time and across subject areas, there have been similar efforts to extend the purview of technological inquiry to attend to the values and social relations that are bound up with certain tools and technical systems. This suggests that the technoskeptical stance we outline is not a radical departure from historical concerns and interests in each content area but an amplification of existing impulses. We can also see, however, that these impulses have often been short-lived, fragmentary, or marginal. Despite the ambitions of their backers, technoskeptical perspectives have been secondary to those that view technology as a vehicle for meeting more conventional disciplinary goals: applying science ideas, exploring historical episodes, or developing literacy skills. A significant obstacle for technology education, then, is how technoskeptical orientations might be sustained within and across subject areas.

Our disciplinary vignettes offer several insights into this question. The first pertains to what Schneider (2014) calls "occupational realism," the degree to which promising research or practices align with the everyday realities and demands of the classroom. Many of the past efforts to expand the study of technology in science, social studies, and ELA have been rich, engaging, and ambitious. However, they have not always taken seriously the institutional and pragmatic pressures that teachers face when they plan and teach lessons. Postman's (1963) call to remake ELA education into a study of symbolic environments, for instance, attempted to align secondary literacy curricula with modern developments in sociolinguistics, semiotics, and communication theory. But, crucially, it also ignored the experience and training of ELA teachers, the expectations of students and families for ELA learning, and the demands of disciplinary institutions (e.g., curriculum offices, professional organizations, higher education). His project, like others, largely eschewed the work of harmonizing an alternate vision of technology with occupational realism. It is not surprising that it failed to gain widespread adoption.

By contrast, the most successful efforts are those that have been attuned to occupational pressures. The STS movement in social studies education, for instance, managed to be institutionalized as one of the field's ten guiding themes partly because it extended existing practices rather than demanding wholesale reconfiguration of the field. This pattern suggests that a first step toward sustaining technology education in schools is by building it on disciplinary content and practices already in place. However, our vignettes also suggest that there can be limitations if technology education becomes too tethered to the idiosyncrasies of individual subject areas. In our analysis, we were struck by how frequently the writings of advocates in one subject area echoed those in another, often without common references or citations between them. While independence allowed these reforms to stay rooted in the concerns of their respective disciplines, it also left them fragmented and, therefore, vulnerable to being crowded out of the curriculum by other subject area demands. This suggests that an additional step in sustaining technology education is developing shared language and objectives so that efforts in one discipline can help reinforce those in another—and perhaps even lead to cross-disciplinary collaborations.

Moving Technology Education Forward

There is great potential for technology education to occur across subject areas with technoskepticism as a common aim. Achieving that potential and sustaining it over time, however, is unlikely without some shared conceptual and pedagogical tools. Thus, in addition to laying out a guiding vision for technology education, we have developed a framework for promoting technoskepticism both within and across subject areas.

The framework is the product of our cross-disciplinary collaboration. All of us coauthors are former secondary subject area teachers who now work in higher education as teacher educators. Our collaboration on this study came out of a set of critical perspectives on technology and education. At the same time, each of us brings a unique pathway toward developing those critical perspectives. As a STEM educator, Jacob Pleasants uses lenses from the history and philosophy of science, technology, and engineering (Pleasants, 2023; Pleasants et al., 2019). As a social studies educator, Dan Krutka has largely sought to bring critical perspectives of technology into the social studies field by drawing on Benjamin (2019) to problematize social media or media ecologists, such as McLuhan (1964), to broaden media education (Krutka, 2020; Krutka et al., 2022a). As an ELA educator, Phil Nichols draws from a range of disciplines that speak to processes of "mediation" in the cultural production of texts, including media studies (van Dijck, 2013), literary studies (Guillory, 2010), science and technology studies (Bowker & Star, 1999), cultural studies (Hall, 1980), linguistic anthropology (Agha, 2011), and communication studies (Gandy, 1993).

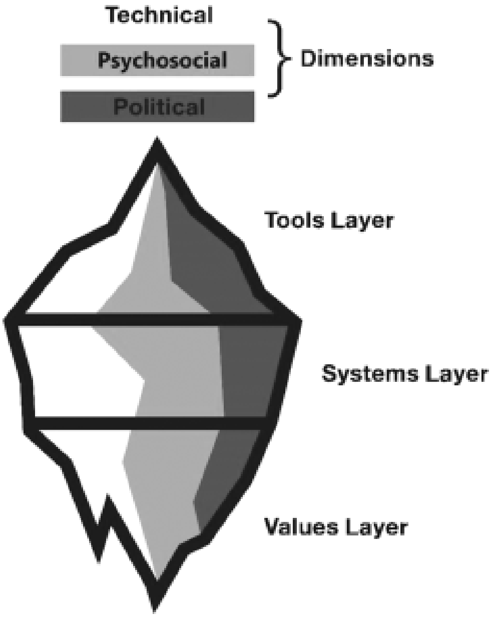
To construct our technoskepticism framework, we began by engaging with current and past examples technology education occurring in our respective subject areas. We then undertook in an iterative process of creating conceptual schemas that could capture overlapping foci of those examples while also incorporating concepts from academic literature that have informed our own technoskeptical thinking (Benjamin, 2019; Borgmann, 1984; Cowan, 1983; Feenberg, 2010; van Dijck, 2013; Verbeek, 2005; Winner, 1978). We leveraged our distinct but overlapping views on technology to develop a framework that honors multiple scholarly traditions while also being practical, intelligible, and applicable across our subject area contexts. We recognize that technoskeptical inquiry will occur differently in the subject areas, both in terms of the specific technologies that are examined and the aspects of the technologies that are foregrounded. For instance, an ELA classroom might focus on communication technologies, whereas a science classroom might focus on energy production, and a science classroom will likely spend more time addressing technical details than would a social studies classroom.

We drew on our different educational and scholarly backgrounds to strengthen our work but were also cognizant of limitations and gaps in our perspectives. All three of us identify as cisgender, able-bodied, white males in academia, and we recognize that our shared identities come with a limited set of life experiences. Most relevant for this study, we recognize that modern technologies tend to be designed by and for individuals with similar identities. Knowing this, we have actively sought out counternarratives about technology from nondominant perspectives (Benjamin, 2019; Brock, 2020; Broussard, 2023; Costanza-Chock, 2020; D'Ignazio & Klein, 2020; Hendren, 2020; Noble, 2018). These perspectives have greatly informed our work, but we acknowledge that we still have much to learn and must continuously work to address our gaps in understanding.

The result of our collaborative work is a novel conceptual framework, the Technoskepticism Iceberg (Figure 1). The categories and dimensions of this framework are particularly useful for mapping out inquiries into technological issues across a wide variety of contexts. It is not a comprehensive guide, but it helps direct attention toward dimensions that often evade notice and that are essential for technoskeptical reasoning across subject areas.

The Technoskepticism Iceberg guides technological inquiry with respect to three dimensions and three layers. Attending to the *technical* dimension means understanding how technologies function in material terms, how they are constructed and maintained, and their interactions with other technological systems. The *psychosocial* dimension involves the ways that technologies affect how humans think, act, and live individually and collectively; it includes moral reasoning about how technologies impact people (as well as nonhumans) and how people create technologies. Attending to the *political* dimension requires thinking about who makes decisions about how technologies are designed, deployed, used, and regulated, as well as how those decisions are and ought to be made. While distinct, the dimensions also interact in many ways. Regulations about a technology, for instance, take into account their technical structure as well as their social effects.

FIGURE 1 *The Technoskepticism Iceberg framework*



The Iceberg is layered to capture how technology's characteristics across the three dimensions are not always visible. At the surface and most visible level, technologies are thought of as *tools* that are created for well-defined purposes that bring about intended outcomes. That perspective might allow people to complete everyday tasks, but it offers a limited view of technology's unintended or unanticipated effects (Benjamin, 2019; Feenberg, 2010; Mitcham, 1994; Postman, 1992; Verbeek, 2005; Winner, 1978). One of the hidden layers of technology is its interactions with multiple technical, political, social, cultural, and economic *systems,* which shape how technologies can and will be used and the disproportionate effects they have on individuals and society (Benjamin, 2019; Broussard, 2023; Chun, 2021; Cowan, 1983; Noble, 2018). The other hidden layer is the way technologies intersect human *values.* Technological choices and judgments can never be made from a "rational" or "value- neutral" perspective. Values influence how technologies are designed and used, in turn affecting the values of those who use them (Borgmann, 1984; Feenberg, 2010; Pinch & Bijker, 1987; Postman, 1992; Van de Poel & Kroes, 2014; Yadav & Heath, 2022).

The task for teachers across the subject areas is to help students expand their capacities to think about technology along multiple dimensions and to levels of depth beyond their typical experience and technical know-how. In short, teachers must help students see more of the Iceberg. In table 1 we provide descriptions and questions that align with different parts of the framework that illustrate how teachers might accomplish this task. We do not argue

TABLE 1 *The Technoskepticism Iceberg layers and dimensions*

		Technical dimension	*Psychosocial dimension*	*Political dimension*
		Focus on the ways that technologies are structured in material terms and how they function.	Focus on the ways that technologies affect and are affected by how people think, act, and relate to one another.	Focus on who makes decisions about how technologies are designed and deployed and how those decisions are made.
Tools layer	Focus on the visible, immediate, and obvious uses and effects of technology. Technologies are regarded as *tools* with well-defined uses and outcomes.	What is it intended to do? How does it carry out its function? How well does it accomplish what it is designed to do?	What does using it allow people to do, and why might people want to do that?	Who made and designed it? What rules exist for how it is used or who can use it?
Systems layer	Focus on the ways that technologies are embedded in and interact with *systems.* The properties of those systems, including their biases, influence how technologies are created and used. Technologies in turn affect those systems in unanticipated and often subtle ways.	What infrastructure needs to exist for it to work as intended? What is required for it to be maintained? What impacts might it have on systems like industry, the environment, or human health?	If it were introduced into a culture that was not your own, how might it be used differently (if at all)? How might using it cause people to reorganize how they live and work?	What allows certain people (but not others) to make decisions about how it is designed and used? How are rules made about how it can or ought to be used? What happens if those rules are broken?
Values layer	Focus on the *values* that are embedded in systems and that interact with technology. The way we use, design, think about, and make decisions about technology are never value neutral or "purely rational" but reflect ideas about what constitutes a good life and the common good.	How does its structure reflect certain goals and values? How would it be different if it prioritized different goals and values?	What kinds of social and cultural practices and values will it reinforce? Which might it erode? How desirable are the social and societal changes that it brings?	Which and whose concerns does it prioritize? How does it reflect power relationships in our society, and how might it reinforce or challenge them?

Overarching question: What kind of relationship do we want to have with this technology, both as individuals and as a society?

that every part of the Iceberg needs to be addressed every time technology is made an object of inquiry in the classroom. Educators should make judgments about which aspects to emphasize depending on the issue, subject-area context, and students. We also emphasize that, although we provide exemplar questions that occupy specific "cells" of the Iceberg framework, many, if not most, inquiries will span multiple dimensions and layers. Quality questions need not be focused on a specific dimension/layer; wide-reaching inquiries are also important.

Putting the Technoskepticism Iceberg to Work

We developed the Iceberg to provide common terms and goals for technological inquiry, keeping it flexible enough to be adopted and adapted to different disciplinary spaces. Though not a panacea, it serves a vital purpose in terms of making technology more coherent, intentional, and sustained throughout the subject areas. To illustrate how the Iceberg can be put to practical use, we provide examples of technology education in each of our subject areas that are aligned with our vision. Importantly, these are instances in which the Iceberg framework is used to capitalize on opportunities within existing curricula. The examples show how teachers across subject areas can work as allies to cultivate the technoskeptical thinking students need to navigate our rapidly changing technological environment.

— Science

The Next Generation Science Standards (National Research Council, 2013) include technological design as a key part of science instruction. An example life sciences standard indicates that students "design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity" (HS-LS2-7). To address this standard, students could be presented with the issue of agricultural fertilizer runoff and its impacts on streams, ponds, and lakes. They might then be tasked with designing a technology that would mitigate runoff and therefore address the problem. This approach is unlikely to develop a technoskeptical stance because the issue is treated as a purely technical problem that can be readily "solved" with a new "tool." There is little engagement with any of the underlying systems or values that support the widespread use of fertilizers and the lack of responsibility for their negative impacts.

Alternatively, this standard can be an invitation to engage with technology in far greater depth. Teachers could ask students to consider the issue of local biodiversity by examining the flora and fauna in the outdoor spaces of our homes (Tallamy, 2020). Students could explore how our built environments are currently not conducive to biodiversity (e.g., an overreliance on grass-covered lawns and nonnative ornamental plants). From this technical point of entry, other parts of the Iceberg could then be examined, such as how outdoor spaces are connected to social and political systems (e.g., Homeowner Associations, laws regarding yard maintenance, lawns as symbols of socioeconomic status) and values (e.g., the social desirability of manicured lawns, beliefs about property values, unsustainable use of water). As students consider possible solutions to the problem, they might consider not only new technological devices but also ways of unraveling the systems and values that give rise to the problem.

In the science classroom, the point of entry into a technological issue is likely to be the technical dimension. But the inquiry need not stop there. The Iceberg framework can help identify fruitful aspects of a problem that transform it from simple technical puzzle solving to an opportunity for technology education.

— Social Studies

While only some state standards documents address automobiles explicitly (Krutka et al., 2022b), they are usually a topic that appears in US history textbooks or other curricular materials. However, the discussion of cars can be limited to addressing only superficial and well-known historical facts. For example, one textbook dedicated two paragraphs to cars in the 1920s that briefly explained the assembly line process and how the increase in more affordable cars "created a need for highways, gas stations, motels, and roadside diners. The oil industry grew rapidly" (Banks et al., 2016, 328). In this story, the rise of automobiles was immediate, obvious, and even inevitable.

A more meaningful technology education approach to teaching about automobiles might attend to the technical question of whether cars actually fulfilled their primary function of moving people and goods better than existing or possible urban transportation options of the 1920s, such as taking streetcars, walking, or bicycling. Teachers could ask whether cars extended racial segregation in neighborhoods schools and whether highways maintained that segregation by dividing neighborhoods. Students might consider whether the increase in automobile ownership and downturn in shared or public transportation frayed community ties (psychosocial dimension) and whether cars are worth the cost of massive public subsidies required for roads and highways or the damage to personal health and animal ecosystems from car-induced sprawl. Students might also examine how car manufacturers destroyed existing streetcar systems or resisted safer car designs and seatbelts. Instead of seeing cars as simply a tool for human movement, students and teachers might skeptically inquire, Are cars taking us where we want to go?

— English Language Arts

The ELA curriculum is already positioned as a site for students to use technologies for communicative purposes—to access, create, and interpret "words, graphics, images, hyperlinks, and embedded video and audio" (CCSSO, 2022). Efforts to integrate such practices into the classroom commonly include instruction on the effective use of digital tools to seek out and vet online information or to combine media types to convey meaning to an audience. These are valuable skills, to be sure. However, viewing these practices through the lens of our Iceberg framework can reveal significant lines of inquiry that are omitted from such forms of digital or media literacy instruction.

While these practices equip students with technical skills related to tool use, and may even encourage some conversation about the psychosocial impacts of communication technologies, the Iceberg model shows how such activities might be extended to include more substantive engagement with the systems and values that underwrite communicative modes. Rather than simply teaching students to effectively use a search engine for research purposes, for instance, English educators might draw attention to the systemic features of such technologies. They could ask: How does predictive text, page ranking, sponsored content, and algorithmic information processing condition the kinds of search results we encounter? What interests and values might drive the development and design of such search engine features? Investigations like these are not dramatic departures from the content area standards, yet they can lead to richer understandings about how and for whom our commonly used technologies work. Even more, they allow students to adopt a technoskeptical stance toward other taken-for-granted tools, asking them to determine for themselves what kind of relationship they want with technology.

Conclusion

We outline a vision for technology education that prepares students to be technoskeptical thinkers who make informed and justice-oriented decisions about technological issues in our world. Given the profound influence that emerging technologies are already having, and will continue to have, on society, providing a coherent, intentional, and sustained technology education should be compelling to students. The most likely way for this to occur, given the way that schools are organized, is by rethinking and expanding how technology is addressed within science, social studies, and English classrooms. The Technoskepticism Iceberg framework provides a useful tool for helping educators in those subject areas achieve the vision for technology education that we put forth.

More than sixty years ago, Jennings (1957) pleaded in a NCSS Yearbook focused on technology, “Will it be necessary, as usual, to wait an entire generation for these new ideas to make their way into classrooms of America’s schools, or can leadership and resources be developed for cutting short the seemingly inevitable lag time?” (245). We do not advocate that teachers take up every technological story in the news but, instead, that they help students navigate a world shaped by technologies both new and old. Inspiring curricular shifts in the subject areas is always difficult, but we believe young people deserve the opportunity to confront technological dilemmas and make informed decisions for their futures. We offer this study to help educators take a proactive approach to technology education in a world in which people—as citizens and consumers—too often react to technological "innovations" on the terms established by designers and capitalists. Classrooms should be where students learn to determine what relationships they choose to have with technology and, consequently, the kind of world they want to live in.

Notes

1. The omission of mathematics is not an oversight; nor is it a slight to that subject area. Based on examinations of mathematics standards and curricula, technology rarely arises as an object of study within typical math instruction. That said, works like O'Neil's (2016) suggest there could very well be generative potential for mathematics education to contribute to the kind of technology education we advocate here.
2. To develop these accounts, we utilized histories of education in our respective subjects (Evans, 2004; Myers, 1996; Rudolph, 2019) as well as curricula, policy and reform documents, and research articles. To ensure that we did not overlook significant efforts to address technology, we sent draft accounts to scholars in our respective fields who are well-acquainted with contemporary and historical reforms. These scholars provided feedback on our claims and suggested additional sources that informed the account we present here.
3. The factor life lesson can be found at https://sheg.stanford.edu/history-lessons/factory-life and the atomic bomb lesson at https://sheg.stanford.edu/history-lessons/atomic-bomb.
4. For a review of STS in social studies education, see Giese et al. (1991).
5. See https://www.socialstudies.org/national-curriculum-standards-social-studies-chapter-2-themes-social-studies.
6. The IEEE REACH materials can be found at https://reach.ieee.org/ and the C3inquiry questions can be found at https://c3teachers.org/.
7. See https://www.civicsoftechnology.org/curriculum.

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