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Preparing students to engage with science- and technology-related misinformation: The role of epistemic insight

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Abstract

Helping students to become more resilient to online misinformation is widely recognised as an essential task for education in a rapidly digitalising world. Students need both scientific knowledge and epistemic insight to navigate online spaces containing sensationalised reports of scientific and technological developments. Epistemic insight involves epistemic curiosity and the ability to think critically about the nature, application and communication of knowledge. This includes developing an understanding of the power and limitations of science and a curiosity regarding its relationship with other disciplines. We present a workshop designed for school students aged 16–18 titled 'Can science and technology cure loneliness?', designed to develop students' epistemic insight through investigating loneliness through a multidisciplinary perspective. We discuss how the design and pedagogy of this workshop might help students to build epistemic humility—the recognition that no single disciplinary perspective can complete our knowledge about a given topic. As part of a broader programme, epistemic insight-based pedagogies have the potential to develop students' resistance to science- and technology-related misinformation and prepare them for their potential role in shaping our scientific and technological future.

KEYWORDS

digital literacy, interdisciplinary learning, epistemic insight, misinformation, science education

INTRODUCTION

It is now widely accepted that the transformations afforded by digitalisation require a major rethink of educational priorities (Choi, 2016; Richardson et al., 2021). In an 'Information Age' (Castells, 1996) we have easy access to technologies that can constantly supply us with new knowledge. Following the movement of nearly all formal education online during the COVID-19 pandemic, there is an expectation that the digitalisation of education will accelerate in the period following the pandemic (Iivari et al., 2020). It is widely acknowledged that the ongoing digital transformation of many social systems requires an epistemological shift in the way that we conceptualise knowledge in education (Craft, 2010; Frolova et al., 2020; Kennedy et al., 2009). This has been brought into sharp relief during the COVID-19 pandemic. The World Health Organisation (WHO) recently referred to the concept of an 'infodemic', which they defined as "an overabundance of information—some accurate and some not—that occurs during an epidemic" (Tangcharoensathien et al., 2020, p. 2). Misinformation regarding COVID-19 vaccines has been identified as a major threat to global public health.

In parallel, global organisations with influence on education policy are noticing the strengths and weaknesses of national education systems for preparing students to navigate information-rich online spaces. A recent major international study by PISA, found that 1 in 10 students in Organisation for Economic Co-operation and Development (OECD) countries were unable to distinguish 'fact' from 'opinion' (Schleicher, 2018). Smaller-scale studies flesh out the problem in greater detail, exploring, for example, the tendency of students not to follow up on dubious news stories even where there are clear opportunities to evaluate claims for themselves (McGrew et al., 2019). Other research has shown that students struggle to distinguish news from advertising (Nygren et al., 2020) and use a range of online information-seeking practices that limit their ability to think critically (Hargittai et al., 2010). Research attempting to explain ways young people share misinformation online has advanced conceptual frameworks such as 'motivated circulation' (Bowyer & Kahne, 2019) in which sharing misinformation reinforces alignment with political values. A recent report from the OECD on literacy entitled "21st Century Readers" (2020) identifies the challenge of helping students navigate information-rich online contexts, proposing reforms to the teaching and assessment of reading as a key solution.

In this paper, we focus specifically on science- and technology-related misinformation, which we define in greater detail below. We note that many students in school today will go on to significantly shape the place that science and technology will have in our future lives. This raises the question as to whether schools are well placed to prepare young people for living and working in a scientific and technological age. In this paper, we develop a perspective on these concerns by drawing on the concept of epistemic insight (Billingsley et al., 2018) to construct an educational response to science- and technology-related sensationalism—a form of misinformation. First we characterise the problem of science- and technology-related sensationalism in the context of our study. We then consider existing approaches to developing student resilience to misinformation more generally and describe the distinctive contribution of epistemic insight as an educational aim. We will then describe a workshop titled 'Can science and technology cure loneliness?' aimed at 16–18 year olds, showing how an epistemically insightful approach can help students to become more epistemically curious and critical when they encounter science- and technology-related sensationalism.

FRAMING THE PROBLEM

Our focus in this study is on the circulation of claims that have a scientific, science-related or apparently scientific basis. In this context, there are several forms of content that could

amount to misinformation. One is to build a case around a 'false fact' such as the assertion that the moon has no gravity or that a tenth of a gram is smaller than a hundredth of a gram. Another is to be deliberately selective about which scientific stories to tell about a product or advance—focusing either only on those that are beneficial or on those that are disadvantageous. A related form is where content presents a scientific finding or a technological advance in a sensationalised way designed to mislead the reader into supposing that it has more significance than it does. We are particularly interested in this form of misinformation—sensationalism or 'hype'.

Sensationalism is one of a range of discursive techniques employed by a range of news media sources. Scholarship on news media sensationalism is largely condemnatory, with wide agreement that the aim of sensationalism is to trigger emotion for readers (Vettehen et al., 2008). Kligo and Sinta (2016) found highest proportions of sensationalised reporting in news categories 'lifestyle & society' (21.5%), 'crime' (17%) and 'government affairs' (16.8%), with 8.8% of 'science & technology' news categorised as sensationalised. While science and technology stories are less likely to be sensationalised than these other categories, where they are sensationalised we can observe similar discursive techniques, geared towards the arousal of emotions. For example, 'hyping' scientific and/or technological breakthroughs attempts to arouse excitement and interest through exaggerating the significance of a scientific or technological breakthrough. Science and technology media 'hype' has been noted in fields such as biomedicine (Bubela & Caulfield, 2004), paleopathology (Snoddy et al., 2020) and epidemiology (Van Scoy et al., 2021). While the role of journalists is to simplify complex issues to communicate clearly and effectively, sensationalising involves the deliberate distortion of information to gain interest rather than to explain accurately (Ransohoff & Ransohoff, 2001). In sensationalising misinformation, the significance of scientific or technological innovations for addressing a question or problem of public interest is exaggerated. Sensationalism can also involve misapplication, where scientific discoveries are wrongly claimed to have purchase on a particular question or problem.

Why might the sensationalising of scientific and technological advances be an issue of concern to educationalists? Weingart (2017, p. 111) argues that science 'hype' can "undermine public perceptions of science's commitment to factual evidence". The reporting of science using the same language and approach as, for example, political news can obscure the empirical nature of scientific practice and place it on the same level as informal and less scholarly processes of knowledge production. Further, the sensationalising of science may reinforce what we call 'uncritical scientism'. Scientism is defined by Stenmark (2013) as a tendency to assume that science will one day provide a complete explanation of the natural world. While some students may hold to scientistic positions, it is the *uncritical* adoption of these positions and their reinforcement through sensationalising misinformation that we identify as problematic.

We make a similar case around the reporting of technological advances. Research on 'technology hype' has shown the tendency for inflated expectations and subsequent disappointments around new technologies can be counterproductive to mobilising their actual potential (e.g., quantum computing, Smith, 2020). This form of misinformation about technology can undermine public trust in technological developments by over-stating the nature or significance of a piece of technology, creating public backlash (e.g., nanotechnology—see Williams-Jones, 2004).

Responses to sensationalism in schools

As the motivation of our project is to provide educators with tools and pedagogies to help them to increase student resilience to sensationalism, we widen the scope to 'misinformation'

in order to discuss some strategies in schools today that have similar and overlapping aims. Educational research dealing with the challenge of misinformation has put forth arguments for the development of education systems that foster 'media' 'information' and 'digital' literacies (Korona, 2012; Rosenzweig, 2017; Smith, 2017). While some variation exists between the conceptual framing of these educational aims, they all encourage some form of critical thinking about the rhetorical and algorithmic techniques employed across digital news media platforms. For example, one highly cited study draws on psychological theory of 'inoculation' against misinformation, reporting the success of a 'fake news game' for 'prebunking' fake news claims (Roozenbeek & Van der Linden, 2019). Other approaches develop students' ability to sense where a headline might be emotionally manipulating their attention with highly charged language. Other approaches focus on evaluating the credibility of a source by examining its origins, including who funds the site and how the 'feed' of news sites might be algorithmically generated (Cook et al., 2015). Taken together, these discourse-focused approaches potentially provide students with valuable skills and insight into science- and technology-related misinformation. Students might learn, for example, to employ their rhetorical faculties in suspicion of stories that tout a particular 'exciting-sounding' breakthrough as decisive or world-changing in its implications.

In the early stages of developing the workshop described below, we found it useful to question how students' understanding of discursive practices, as emphasised by media information and digital literacies, might be mutually enhanced by their understanding of how different disciplines construct, communicate and apply knowledge. In our previous work, we have argued that students need the space and preparation to think within and across disciplinary perspectives to be well-prepared for engaging with different forms of information online, including those invoking science and technology (Billingsley et al., 2021). Fact-checking, source reliability evaluation and awareness of algorithmic techniques can be usefully supplemented by the development of epistemic curiosity and critical thinking about the nature, application and communication of knowledge (we define these terms in more detail below). A student with an understanding of how scientific knowledge is constructed, communicated and applied *and* how discursive techniques might distort these processes would be very well-prepared to engage with science- and technology-related misinformation. However, as we will now show, the entrenched compartmentalisation of educational practices effectively prevents this epistemically insightful approach to education.

The challenge of science-related misinformation in a compartmentalised curriculum

In England and many other countries, the curriculum is divided into subjects many of which are associated with a scholarly discipline; geography, history, mathematics, science, music are examples. As highlighted by literature showing the lack of space for students to develop critical and discursive skills through media, information and digital literacies, the issue of online misinformation and sensationalism in any disciplinary field, let alone that of science and technology, falls into a gap between curriculum subjects.

In England, the context for our study, a cross-parliamentary Digital, Culture, Media and Sport (DCMS) Committee's report on misinformation and fake news has highlighted the potential of misinformation to "distort, to disrupt, and to destabilise" (2018, p. 5). In response, they argue that digital literacy "should be a fourth pillar of education, alongside reading, writing and maths" (p. 86). Opportunities to teach about misinformation were identified in three subjects—Computer Science, English and Citizenship. For example, the National Curriculum for Key Stage 4 English programmes of study specifies students should be "distinguishing between statements that are supported by evidence and those that are not, and identifying bias and misuse of evidence" (Department for Education, 2014, p. 5).

There are thus clear opportunities within the National Curriculum in England for schools to engage with misinformation. However, these are contained within single subject areas with little capacity for cross-curricular connections (Polizzi, 2020). In our previous work, we have defined this 'entrenched compartmentalisation', as "the organisational, social and pedagogical practices [that] have become habits and now dictate students' and teachers' expectations about what should happen in the classroom" (Billingsley et al., 2017, p. 27). Entrenched compartmentalisation means that children learn to use each discipline one-at-a-time—answering 'hand-picked' questions designed by specialist teachers which are typically focused on establishing an understanding of the knowledge produced by the discipline, rather than on understanding the nature of the discipline itself (cf. Sadler & Zeidler, 2009). Compartmentalisation seems likely to prevent an effective response to science and technology-related misinformation because raising students' critical faculties regarding sensationalism requires discussion about how science relates to other disciplines. We now consider how an interdisciplinary approach might provide these opportunities and how epistemic insight provides a distinctive space within this field.

INTERDISCIPLINARY LEARNING AND EPISTEMIC INSIGHT

'Interdisciplinary learning' (IDL) denotes a broad area of educational research and development that responds both to the problems created by a compartmentalised curriculum and the calls issued by global education policy-makers for systems that prepare citizens for an increasingly digitally connected future of work (Barrett, 2012). Because the borders between terms 'interdisciplinary', 'multidisciplinary' and 'transdisciplinary' are rather loosely defined, IDL is conceptualised in a range of ways across a large body of literature. One highly-cited, simple and instructive definition of interdisciplinary learning is given by Rowntree (1982), where "two or more disciplines are brought together, preferably in such a way that the disciplines interact with one another and have some effect on one another's perspectives" (p. 135, cited in Ivanitskaya et al., 2002).

Epistemic insight pedagogies occupy a distinctive space within the 'family' of approaches covered by IDL. Most approaches to interdisciplinary learning have as their goal an improved approach to a topic or answer to a question or solution to a problem by combining two or more disciplinary perspectives. However, epistemic insight is less concerned with the advancement of understanding into a topic and more with critical thinking about the nature of knowledge itself. In epistemically insightful pedagogies, the topic, question or problem is 'engineered' to serve the primary goal of developing understanding of the characteristics of disciplines and the relationships between them.

In locating the value of epistemic insight within a suite of available interdisciplinary educational approaches, we are drawn to the evidence we have so far from workshops in schools and teacher education where participants' comments indicate gains in academic self-concept (Billingsley & Nassaji, 2019; Billingsley et al., 2021) and their capacities to navigate the complex opportunities and problems of a hyper-connected, globalising and digitalising society. The Epistemic Insight Curriculum Framework provides learning objectives that refer to the nature of knowledge both within disciplines and across them. In doing so it seeks to support and enrich the epistemic knowledge identified as important in the compartmentalised curriculum in England and also the interdisciplinary approaches characteristic of many national curricula, including Norway (Havnes, 2009), and more recently Scotland. Epistemic insight also shares some features of metacognition, an increasingly important educational concept with similar ambitions to support the development of thoughtful citizens (ten Dam & Volman, 2004). The Epistemic Insight Curriculum Framework (Billingsley et al., 2018) sets out a progression of learning objectives commensurate to

different stages of learning. Epistemically insightful approaches have been used effectively to advance students understanding of the relationship between disciplines (Billingsley et al., 2021) including in the contexts of real-world problems and Big Questions that bridge science and religion (Billingsley et al., 2020).

So far, research into epistemic insight has focused on students up to the age of 16. More recent work has explored what the development of epistemic insight might look like for students between the age of 16–18, using a real-world contexts based pedagogy (Billingsley et al., 2021). This has included workshops on science and COVID-19 tested with 16–18-year-olds in England during the pandemic, focusing on developing students' critical thinking about how science informs thinking about complex opportunities and problems that require a multidisciplinary perspective. This work also discussed how epistemic insight might effectively prepare students to engage with sensationalism—for example, the inflation of the extent to which science can inform decision on its own in isolation from other sources of knowledge shaping policy decision making. This work has led us to two additional elements of epistemic insight that overlap, support and buttress other elements of the core Epistemic Insight Curriculum Framework (1) epistemic curiosity and (2) critical thinking about the nature, application and communication of knowledge. The workshop we outline in this paper was developed focused on these two additional elements of epistemic insight as learning objectives (Figure 1).

Epistemic curiosity

Building on Berlyne's (1954) basic definition of epistemic curiosity as the 'desire to know', we define epistemic curiosity as the desire to know how disciplines work and how they can individually and collectively help us to address Big Questions and real-world problems. One way to stimulate epistemic curiosity is to invite students to systematically consider and compare the answers they get to a carefully chosen question (such as, 'Is it true that you are what you eat?') if they examine this question through different disciplinary lenses (science, geography, history, theology, economics and so on). The framing of these questions/problems directs curiosity towards *epistemic* issues by setting the expectation that the question problem will require us to use many different school subjects/disciplines to address a Big Question that does not have a simple agreed-upon answer. An example of epistemically curious questioning we might expect to see from a student would be 'I wonder which disciplines can help me answer this question'?

Critical thinking about the nature, application and communication of knowledge

Epistemically insightful approaches develop students' critical thinking about the *nature* of knowledge by helping students notice the division of knowledge into different forms (disciplines). Through multidisciplinary inquiry, students develop their understanding of the similarities and differences between disciplines, including between different disciplines' preferred questions, methods and norms of thought. Students' critical thinking about the *application* of knowledge is developed as they start to gain the skill of 'matching' questions and problems with appropriate disciplines—for example, through role-play activities forming a decision-making committee required to conduct a multidisciplinary consultation meeting on a complex real-world problem. These activities can help students to consider the role a new technology could play within a wider programme of interventions. Critical thinking about the *communication* of knowledge is developed as students consider how the knowledge

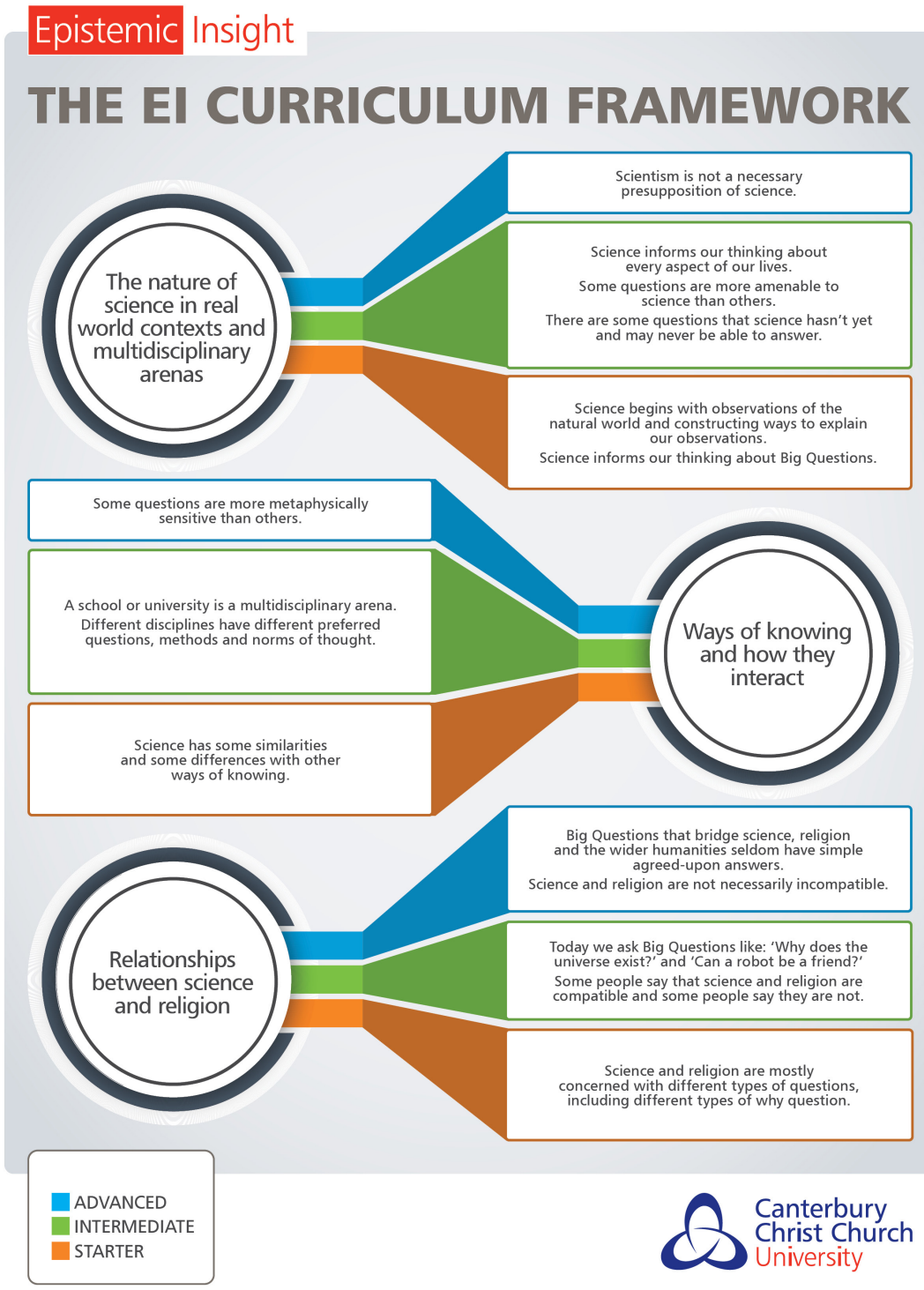

FIGURE 1 Epistemic insight curriculum framework.

produced through the work of disciplinary experts is 'translated' into news media and other public communications—through analysing, for example, headlines which report on scientific studies.

We will now introduce the workshop through a discussion of additional intended outcomes and topic choice.

'CAN SCIENCE AND TECHNOLOGY CURE LONELINESS?'

Intended outcomes of the workshop

The Epistemic Insight Curriculum Framework is designed to be adaptable to a wide range of topics and challenges in educational spaces. In this workshop, we apply epistemic insight to the relatively new space of educational engagement with sensationalising misinformation. When thinking about the ways in which epistemic insight might most clearly address the issue, we were led to consider the importance of *epistemic humility*. We build here on Kidd's (2016) discussion of epistemic humility, which focuses on the epistemic limitations of science. In our approach, we broaden the question of whether and where science has power and/or limitations to encompass all disciplinary perspectives. Epistemically insightful approaches develop epistemic humility as students become more familiar with thinking about how a discipline can contribute to different question or problem and the significance of its contribution. Further, a multidisciplinary approach essentially models epistemic humility in its acknowledgement that no single discipline has the capacity to answer all questions or solve all problems. Students become more epistemically humble as they notice that although scientific research informs our thinking about complex social phenomena such as loneliness, even a 'complete' understanding of, for example, the brain chemistry involved in the experience of loneliness, does not complete our understanding of the phenomenon itself. In this way, we expect that a student who learns to be epistemically insightful when encountering sensationalism about a specific topic like loneliness will also develop epistemic humility, which can then be reapplied when encountering sensationalism about a range of other topics.

Workshop topic choice

We chose the topic of loneliness firstly because of its inclusive nature. Loneliness is a common, if not universal aspect of human experience, thus likely to be something that most students would feel they could say something about. We also chose loneliness because it has been studied by scholars in multiple disciplines. As such, the question 'Can science and technology cure loneliness?' is designed to stimulate epistemic curiosity about the power and limitations of science in the context of a real-world problem. Science is a discipline that specialises in discovering and testing patterns in the natural world. The foundations of an epistemically insightful critique of the significance of a scientific advance would recognise that tapping into a range of disciplines will give us better sight of how loneliness works in society. Further, loneliness is experienced differently by different people and some disciplines specialise in helping us to see the individual nature and setting of each person's subjective experiences.

Our assumption that loneliness has attracted interest from a range of disciplinary specialists was supported by a brief literature search. We found that in science, studies of loneliness have looked for biological correlates of loneliness in the brain (Cacioppo et al., 2014). In geography, scholars have sought to find and study regional differences (Buecker, et al., 2020)

and economists have asked whether there are connections to draw between loneliness and varying income levels (Macdonald et al., 2018). Philosophy, Theology and Religious Studies scholars introduce metaphysical questions about loneliness as part of the human condition (Collins, 1989). When considered on a sociological level, scholars studying loneliness have applied statistical methods to test for relationships in data gathered about attitudes, experiences, age and gender. Thirdly we speculated and found that there are a plethora of stories by journalists discussing scientific research on loneliness in news media outlets, including recently stories about or contextualised by the impacts of COVID-19 prevention measures (Groarke et al., 2020).

We will now outline the workshop with explication of the design and intended pedagogy. We also include comments and reflections on initial pilot runs of the workshop with students aged 16–18 in English schools. The outline below thus represents the product of feedback and refinement, both from within the research team and from peer reviewers of this manuscript. Workshops are intended to be delivered by the research team, with the option for CPD allowing teachers to continue to use the approaches in their future practice. The workshop is intended to run for 1–1.5 h.

Activity 1—Introductory discussion

In the introduction to the workshop, we begin with some broad explanation of the epistemic insight initiative and what our aims are. We remind them that in school, the knowledge comes to them in 'boxes' like the boxes on their timetable—this is your history knowledge, this is your maths knowledge, this is your science knowledge. We explain that we are interested in the connections between the different subjects you study at school, because when we look at a complex question or problem, often we need knowledge from different subject areas. This introduction orients students to the activities that they will be doing and prepares students for the challenge of doing something different from the 'normal' work of subject lessons—asking them to think across boundaries of their school subjects.

We then introduce the topic that we will be covering—loneliness. We give students a headline reporting on the ONS study demonstrating increasing loneliness amongst age 16+ in England. We explain that there may be evidence to suggest that more and more people are reporting feeling lonely. We are careful to note that some people may not consider loneliness to be a problem (this will be considered later), but that research shows that over a long period, loneliness can contribute to other health issues.

We then ask students to consider the question "What does loneliness mean to you?". We facilitate a brief discussion that draws out the different possible subjective meanings of loneliness. This section of the workshop is designed to help students notice, before we introduce any sort of disciplinary thinking, that loneliness is at least partially subjective in nature—it is something that is *experienced* as well as something that is empirically observable. We point out to students that this means loneliness is a less suitable area for science to investigate compared with, for example, the boiling point of liquids in science, because people have inner lives as well as material properties we can test through observations.

Activity 2—Engaging with misinformation headlines

We move from the introduction to the next activity by noting that we often see headlines in the news and on social media about complex topics that appear simplistic. We note

that many headlines we see are designed to grab our attention, but we rarely have time to really think about their truthfulness. We then introduce the next activity. We show three 'headlines:

- "Study finds robots just as good as care home nurses"
- "Scientists develop a pill that will cure loneliness"
- "Innovative new app proven to improve your social life"

These headlines were slightly re-worded versions of real headlines (see additional activity below). The 'cures' proposed in each of the three headlines were selected because taken together, they enable a range of disciplinary perspectives to be brought into relation. We did this 'rewording' in order to focus students' attention and discussion on issues and problems of knowledge creation, application and communication—including questionable language such as 'just as good', 'cure' and 'proven'. We gave students 2 questions to ground their discussion of the headlines:

1. What would the authors of these headlines need to *know* to make that claim?
2. How could they gain that knowledge?

As these are challenging questions, we give an example using the first headline. We explain that in order to make a claim that robots are as good as care-home nurses, a journalist would need to know what care a nurse provides and be confident that robots can cover each aspect of care. They would need to have (and share) a definition of what 'just as good' means. This would include the extent to which there is agreement on the description and measurement of care quality, and whether/how it was determined that robots are able to perform these different aspects of care.

We ask students to imagine someone coming to them and making the claim being made in the headline. They would naturally want to ask 'how do you know'? This helps students begin to think critically about knowledge—in this instance, its production and application. We found that in earlier pilots of the session students were tending to critique the practices that the headlines are discussing—e.g., they focused on arguing why nurses will always be better than robots. We clarify that we are not asking them to question the *idea* of installing robots in care homes. Rather, we are asking them to question the processes of knowledge production and application underpinning the claim being made. This engages students' epistemic curiosity, as they consider these 'hidden' processes of knowledge application and communication underlying the kind of media material they likely consume regularly.

In pilots of the session, we found that students were able to identify that although a survey of nursing home residents could access their opinions, the residents may not be best placed to evaluate, e.g., whether the robots were performing duties to a high enough standard. In our guidance of the students' group discussions, we aim to encourage students to consider, for example, what the headlines might mean by the terms 'as good as', 'cure' and 'proven'. We found that, once guided into this way of thinking, students were able to notice by themselves that 'cure' might imply something short term—we might be able to make some of the feelings of loneliness away, but this does not solve the problems in the person's life that may be related to their loneliness.

This section of the workshop is designed to develop students' critical thinking about knowledge. They are beginning to notice that there are multiple stages taking place between the production of knowledge within particular disciplines and its communication through news media. With regard to the underlying epistemic insight framework, they are building on their understanding of the *application* and the *communication* of knowledge by realising the difference between these two processes. We direct students' focus to key words like 'as

good as' and 'cure' to help them see that these words do a lot of 'heavy lifting' for the claim being made and give them tools they can use to question any future piece of misinformation that uses these words in the same questionable manner. Epistemic curiosity builds as students notice these thinking tools can be applied to the kinds of media 'feeds' they engage with in day-to-day life.

Activity 3—'Real' headline comparison

We then show the students the 'real' headlines, which are all drawn from the United Kingdom newspaper 'The Guardian'. We note that although we did make up those particular headlines, we did not make up all of the content—there are indeed robots in nursing homes (Booth, 2020), pills being developed for loneliness (Entis, 2019) and apps for befriending (Stevens, 2016).

Students are then asked to look at the real headlines and compare the different wording of the headlines. For example, the Guardian headline states that robots 'have been found to improve mental health'. We are able to notice with students that the wording 'have been found to' moderates the scope of the claim being made. This begins to introduce students to the thinking underpinning epistemic humility—care must be taken with the language we use to not overstep the boundaries of what we can know. We also make space at this point for students to continue to critique the real headlines. For example, students may ask what the headline means by 'have been found to improve mental health'? Is an improvement in mental health something that can be evaluated just by asking patients? If we ask the staff as well—how does that strengthen the claim? This helps students continue to engage with the idea that even 'proper' newspaper headlines can communicate knowledge in a way that could be misleading, even if they are not deliberately misinforming.

Interlude—Noting the power and limitations of science

We continue the session with a brief explanatory interlude. We note that these headlines all suggest that it is science and/or technology that will help us in addressing the problem of loneliness. We note that science has a lot of power and influence in our society because it has helped us understand and address many important questions that have helped enrich our society and make us healthier. We then ask the question "Can science and technology cure loneliness on their own"? This is a deliberately leading questions which helps us emphasise one of our main learning objectives—that science and technology should inform our thinking about a problem, but that they also have inherent limitations.

We then present a news story, reporting research at University College London (UCL) claiming discovery of 'the neurobiological basis for loneliness' (UCL, 2012). Researchers scanned the brains of people claiming to be lonely and compared them to those who claimed they were not lonely, finding differences in 'the amount of grey matter in the part of brain involved in basic social perception'. We explain this to the students and then ask them to have a short discussion on their reactions to the research. We ask them as we circulate the groups whether they think this research has now told them everything they need to know about loneliness. If they say no, then we ask them what they think it has contributed and how this contribution might help us in our thinking about loneliness. Again, the idea behind these leading questions is to help students notice that scientific research such as neurobiology has an important contribution to make, but that even a complete understanding of the brain chemistry involved in the experience of loneliness does not complete our understanding of loneliness. Students are continuing to notice that scientific practice requires epistemic

humility—'the neurobiological basis for loneliness' may be interpreted to imply that we have 'completed' our understanding of loneliness, but this is not necessarily how we should interpret such findings. Additionally, this task builds epistemic curiosity by challenging those students who may have held the view that loneliness is entirely subjective, not knowable objectively through scientific methods.

Activity 4—Multidisciplinary team task 1

We transition to the next activity by noting that in the real world, important decisions are often made by teams consisting of people trained in a variety of different disciplinary perspectives, including science. In this activity, students are asked to imagine their group as a team of doctors who are working in a community where there are many lonely people. However, before they consider solutions to the problem of loneliness, we ask them to 'mind-map' what might be all the different causes of loneliness amongst their patients (Figure 2).

We display the discipline wheel and ask students to use the wheel to make their 'mind-map' of possible causes of loneliness amongst their patients. We give some examples to help students understand our expectations here, e.g., a geographer might help us understand whether the place a person lives might play a role in their loneliness. The discipline wheel has been used extensively in other epistemic insight interventions and workshops to support multidisciplinary enquiry. The disciplines in this wheel have been chosen as those with greatest potential to apply to the topic of loneliness. One useful supplementary exercise is to ask students to consider 'are there any disciplines missing from the wheel?' that might also apply to the topic. In pilots we found this task engaged students' epistemic curiosity as they encountered the challenge of thinking about how the less 'obvious' disciplines might apply to the topic.

This activity is designed to build on the previous exercise noting the subjectivity of loneliness. This primes students to begin engaging with the complexity of loneliness, which might otherwise be viewed only through the lens of medical science. Students build on that understanding of complexity to begin seeing that loneliness is 'knowable' in a variety of different ways, including and beyond science. The discipline wheel provides prompts for students

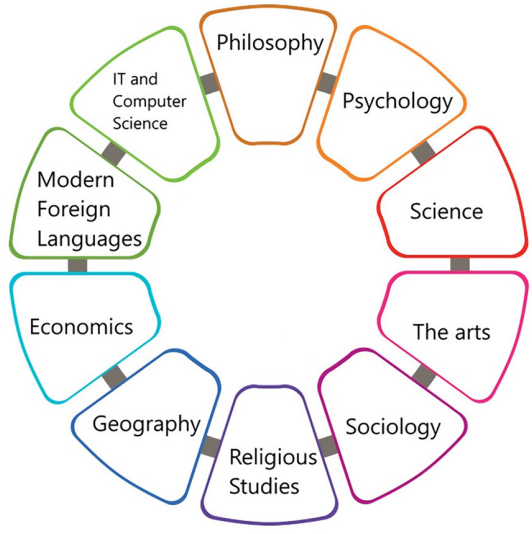

FIGURE 2 Discipline wheel.

to recall the different content and approaches taken in different disciplines. In pilots, we found students observing, for example, that geographical location may have an impact—some people may live in remote or rural areas or in built-up areas with limited green space in which to conduct sociable leisure activities. Other examples of disciplinary applications which aided in our discussion with students (besides those mentioned above) included sociological perspectives on social exclusion (Byrne, 2005) and how language barriers might create loneliness for non-native speakers (Slagter & Pyper, 2019). This task builds on the directly misinformation-focused task to develop students' critical thinking about knowledge, with the intention of linking the two activities back together in a plenary discussion.

Additionally, as students work through different disciplinary perspectives, they encounter first-hand the inherent strengths and limitations of disciplines as they seek to apply different kinds of knowledge, exercising epistemic humility. The first activity helps students to see that some topics are dependent on subjectivity and thus an 'objective' definition or understanding (for example that loneliness is always negative and needs to be 'cured') might not be possible. This activity helps students notice that topics they might see framed simplistically in news media in fact require many different kinds of knowledge to understand.

Activity 5—Multidisciplinary team task 2

Students are then asked to use both their 'mind-map' of causes and the discipline wheel again to consider possible ways that they could help their patients with loneliness.

In the discussion we encourage students to work slowly through the different disciplines rather than 'jumping around'. We found that this helps prevent students using the discipline wheel as a 'word association' tool and encourages them to think of the distinctive ways that each discipline works. For example, one student suggested that an economic approach might try and assess the comparative value of investing in different kinds of social programmes to address loneliness to find out which one provided the best 'value for money'. We also encouraged students to think about joining up two or more disciplines in their answer. Along these lines, one student suggested joining 'arts', 'IT' and 'psychology' by designing a series of adverts promoting an online forum for the lonely, then doing a psychological study to evaluate the effects of participating in the forum.

This activity is intended to take students skills and capacities to engage with online knowledge claims a step further. By becoming familiar with how a more integrated response to an issue might look like, students are further prepared to recognise where misinformation simplifies a topic that requires a multidisciplinary approach. By understanding the depth and extent of the range of knowledge needed to address a complex problem, students are better prepared when misinformation suggests one or a few ideas, developments or technologies that will 'solve' a big issue. This means that misinformation becomes not just something to be insulated against, but, with epistemic insight, an opportunity to be epistemically curious and think critically about a question or problem that is recognised as attention-attracting by the media.

Plenary

The workshop ends with a plenary session in two parts. First students are encouraged to bring together insights acquired from the headline analysis activity and the multidisciplinary team activity. We ask students to consider 'what have you learned from this activity that might help us think about the sorts of news headlines we looked at before?' The aim of this discussion is to help students see that developing a plan to help lonely patients required a significant

breadth of knowledge. As a result, when encountering media headlines and reports on similar social issues, students are now better prepared to notice the insufficiency of superficial or sensationalised applications of science and technology. Finally, students are given the opportunity to ask any questions about anything covered in the workshop. We also ask the students the question "What did you find most surprising about the workshop?", stimulating students to reflect on an approach that is likely to stood out in their single-discipline-focused timetable.

CONCLUSIONS AND FURTHER RESEARCH

The proliferation of science and technology-related misinformation, particularly 'hype' that sensationalises the contribution of scientific and technological solutions, demands an educational response. An expanding body of educational research endorses a multidisciplinary approach to addressing misinformation that is embedded across the curriculum (Cook et al., 2015; Polizzi, 2020). Understanding the nature of science, including its power and limitations for addressing complex social problems like loneliness, can be an effective insulation against science and technology-related misinformation (Sadler & Zeidler, 2009). In the school context, this requires science teachers to work with teachers of other subjects to create a coherent approach. Our creation of the workshop described in this paper began with the perceived need for activities and pedagogies that engage misinformation by creating connections across a compartmentalised curriculum.

The workshop we created, titled 'Can science and technology cure loneliness?', is based on the Epistemic Insight curriculum framework and builds on 10 years of research and development into epistemically insightful pedagogies. The workshop uses tools such as media headline analysis and the 'discipline wheel' to help students notice the value and importance of a multidisciplinary approach to real-world problems and how science and technology can inform our thinking. We showed how an epistemically insightful approach can foster both the capacity to recognise science and technology 'hype' *and* an understanding the nature of the problem that is being hyped (i.e., loneliness). In this sense, our work resonates with Ecker et al.'s (2014) recognition of the 'educational potential' of misinformation. We propose that workshops designed in this way can create greater understanding of the nature of science *and* greater epistemic insight into the problem of loneliness itself. Additionally, the workshop design demonstrates how a discursive approach to the critical analysis of news media can work together with an epistemic approach. The workshop asks students to engage critically with obscurantist media discourse such as "as good as" and "proven" while also engaging with processes of knowledge production and application. While the workshop is designed to help students notice that science cannot solve complex problems like loneliness by itself, the aim is not to undermine the value and contribution of science to society. Rather, the aim is to undermine the *uncritical* scientism (Stenmark, 2013) that science 'hype' exploits and reinforces, by giving students access to the possibility of asking questions regarding how science informs our thinking about real-world problems. The overall approach and ethos of the work outlined in this article resonates with recent work emerging from the United Nations Educational, Scientific and Cultural Organisation (UNESCO), on what they call a 'new social contract for education'. This includes, for example, arguments that "curricula should emphasise ecological, intercultural and interdisciplinary learning that supports students to access and produce knowledge while also developing their capacity to critique and apply it" and that "the spread of misinformation should be countered through scientific, digital and humanistic literacies that develop the ability to distinguish falsehoods from truth" (UNESCO, 2021, p. 4).

In order to be effective, the workshop outlined here would need to be just one part of a broader systemic change fostering epistemic insight. If this were to happen, we would expect

that students would become better prepared to evaluate the claims they see in the media made on behalf of science and the technologies that scientific advancements enable. For the purposes of this paper, we have characterised epistemic insight as requiring the development of (1) epistemic curiosity and (2) critical thinking about the nature, application and communication of knowledge. Far from leading to a greater scepticism or uncritical blind trust in science, becoming epistemically insightful in this way should lead to *epistemic humility*—a greater appreciation of what science can and does provide by being able to recognise what it cannot provide. Similarly, having an awareness that technologies may be able to address smaller parts of a bigger issue without solving the issue itself will lead to a greater appreciation of what technology can do and, on a more systemic level, lead to the design of more humane and effective technological solutions. Overall, we anticipate that epistemically humble students who are able to think about problems using a multidisciplinary perspective are both better prepared for engaging critically with attention-grabbing headlines and better prepared for their potential roles shaping the role science and technology in our future lives.

The aim of this paper has been to outline how developing epistemic insight can help students respond effectively to science- and technology-related misinformation. We have also shown that misinformation does indeed carry important educational potential. Epistemically insightful students are not just better 'inoculated' against misinformation, but are also better prepared to actively participate in shaping the expanding role of science and technology in society. However, in this paper we have been limited to outlining an exemplar workshop. Further research is now needed to test the effectiveness of the workshop and other supporting interventions in meeting the aims outlined. We are currently developing an in-depth case study that explores the impact of epistemic insight on a variety of outcomes, including resistance to misinformation, when it is embedded across a school ethos and pedagogy.

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CONFLICTS OF INTEREST
No financial interest or benefit is expected from the application of this research.

DATA AVAILABILITY STATEMENT
Data sharing is not applicable to this article as no new data were created or analyzed in this study.

ETHICS STATEMENT
Approved by Canterbury Christ Church Ethics Committee.

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REFERENCES
Barrett, B. D. (2012). Is interdisciplinarity old news? A disciplined consideration of interdisciplinarity. *British Journal of Sociology of Education*, *33*(1), 97–114.

Berlyne, D. E. (1954). A theory of human curiosity. *British Journal of Psychology*, *45*, 180–191.

Billingsley, B., Abedin, M., & Nassaji, M. (2020). Primary school students' perspectives on questions that bridge science and religion: Findings from a survey study in England. *British Educational Research Journal*, *46*(1), 177–204.

Billingsley, B., Heyes, J. M., & Nassaji, M. (2021). Covid-19 as an opportunity to teach epistemic insight: Findings from exploratory workshops on Covid-19 and science with students aged 15–17 in England. *SN Social Sciences*, *1*(11), 1–24.

Billingsley, B., & Nassaji, M. (2019). Exploring secondary school students' stances on the predictive and explanatory power of science. *Science and Education*, *28*(1), 87–107.
Billingsley, B., Nassaji, M., & Abedin, M. (2017). Entrenched compartmentalisation and students' abilities and levels of interest in science. *School Science Review*, *99*(367), 26–31.
Billingsley, B., Nassaji, M., Fraser, S., & Lawson, F. (2018). A framework for teaching epistemic insight in schools. *Research in Science Education*, *48*(6), 1115–1131.
Booth, R. (2020). Robots to be used in UK care homes to help reduce loneliness. *The Guardian*.
Bowyer, B., & Kahne, J. (2019). Motivated circulation: How misinformation and ideological alignment influence the circulation of political content. *International Journal of Communication*, *13*, 5791–5815.
Bubela, T. M., & Caulfield, T. A. (2004). Do the print media "hype" genetic research? A comparison of newspaper stories and peer-reviewed research papers. *Canadian Medical Association*, *170*(9), 1399–1407.
Buecker, S., Ebert, T., Götz, F. M., Entringer, T. M., & Luhmann, M. (2020). In a lonely place: Investigating regional differences in loneliness. *Social Psychological and Personality Science*, *12*(2), 147–155.
Byrne, D. (2005). *Social exclusion*. Open University Press.
Cacioppo, S., Capitanio, J. P., & Cacioppo, J. T. (2014). Toward a neurology of loneliness. *Psychological Bulletin*, *140*(6), 1464–1504.
Castells, M. (1996). *The rise of the network society, the information age: Economy, society and culture Vol. I*. Blackwell.
Choi, M. (2016). A concept analysis of digital citizenship for democratic citizenship education in the internet age. *Theory & Research in Social Education*, *44*(4), 565–607.
Collins, W. E. (1989). A sermon from hell: Toward a theology of loneliness. *Journal of Religion and Health*, *28*, 70–79.
Cook, J., Ecker, U., & Lewandowsky, S. (2015). Misinformation and how to correct it. In R. Scott & S. Kosslyn (Eds.), *Emerging trends in the social and behavioral sciences* (pp. 1–17). John Wiley & Sons Inc.
Craft, A. (2010). *Creativity and education futures: Learning in a digital age*. Trentham Books.
Department for Education. (2014). National curriculum in England: English programmes of study. https://www.gov.uk/government/publications/national-curriculum-in-england-english-programmes-of-study/national-curriculum-in-england-english-programmes-of-study
Digital, Culture, Media and Sport Committee. (2018). *Disinformation and 'fake news': Interim Report: Government Response to the Committee's Fifth Report of Session 2017–19*. (HC 1630). The Stationery Office.
Ecker, U. K. H., Swire, B., & Lewandowsky, S. (2014). Correcting misinformation—A challenge for education and cognitive science. In D. N. Rapp & J. L. G. Braasch (Eds.), *Processing inaccurate information: Theoretical and applied perspectives from cognitive science and the educational sciences* (pp. 13–37). Boston Review.
Entis, L. (2019). Scientists are working on a pill for loneliness. *The Guardian*.
Frolova, E. V., Rogach, O. V., & Ryabova, T. M. (2020). Digitalization of education in modern scientific discourse: New trends and risks analysis. *European Journal of Contemporary Education*, *9*(2), 313–336.
Groarke, J. M., Berry, E., Graham-Wisener, L., McKenna-Plumley, P. E., McGlinchey, E., & Armour, C. (2020). Loneliness in the UK during the COVID-19 pandemic: Cross-sectional results from the COVID-19 Psychological Wellbeing Study. *PLoS One*, *15*(9), 1–18.
Hargittai, E., Fullerton, L., Menchen-Trevino, E., & Thomas, K. Y. (2010). Trust online: Young adults' evaluation of web content. *International Journal of Communication*, *4*, 468–494.
Havnes, A. (2009). Talk, planning and decision-making in interdisciplinary teacher teams: A case study. *Teachers and Teaching*, *15*(1), 155–176.
Iivari, N., Sharma, S., & Ventä-Olkkonen, L. (2020). Digital transformation of everyday life – How COVID-19 pandemic transformed the basic education of the young generation and why information management research should care? *International Journal of Information Management*, *55*(June), 102183.
Ivanitskaya, L., Clark, D., Montgomery, G., & Primeau, R. (2002). Interdisciplinary learning: Process and outcomes. *Innovative Higher Education*, *27*(2), 95–111.
Kennedy, G., Krause, K. L., Maton, K., Bishop, A., Chang, R., Waycott, J., & Dalgarno, B. (2009). *Educating the net generation: Implications for learning and teaching in Australian Universities*. Australian Learning and Teaching Council.
Kidd, I. J. (2016). Inevitability, contingency, and epistemic humility. *Studies in History and Philosophy of Science*, *55*, 12–19.
Kligo, D., & Sinta, V. (2016). Six things you didn't know about headline writing: sensationalistic form in viral news content from traditional and digitally native news organizations. *Research Journal of the International Symposium on Online Journalism*, *6*(1), 111–130.
Korona, M. (2012). Evaluating online information: Attitudes and practices of secondary English Language Arts teachers. *Journal of Media Literacy Education*, *12*(1), 42–56.
Macdonald, S. J., Nixon, J., & Deacon, L. (2018). 'Loneliness in the city': Examining socio-economics, loneliness and poor health in the North East of England. *Public Health*, *165*, 88–94.

McGrew, S., Breakstone, J., Ortega, T., Smith, M., & Wineburg, S. (2019). How students evaluate digital news sources. In W. Journell (Ed.), *Unpacking fake news* (pp. 60–73). Teachers College Press.
Nygren, T., Wiksten Folkeryd, J., Liberg, C., & Guath, M. (2020). Students assessing digital news and misinformation. In M. Preuss, V. Spaiser, F. Takes, & S. Verberne (Eds.), *Disinformation in open online media* (pp. 63–79). Springer International Publishing.
Organisation for Economic Co-operation and Development (OECD). (2020). *21st century readers: Developing literacy skills in a digital world*. PISA, OECD Publishing.
Polizzi, G. (2020). Digital literacy and the national curriculum for England: Learning from how the experts engage with and evaluate online content. *Computers and Education*, *152*, 103859.
Ransohoff, D. F., & Ransohoff, R. M. (2001). Sensationalism in the media: When scientists and journalists may be complicit collaborators. *Effective Clinical Practice*, *4*, 185–188.
Richardson, J. W., Martin, F., & Sauers, N. (2021). Systematic review of 15 years of research on digital citizenship: 2004–2019. *Learning, Media and Technology*, *46*(4), 498–514.
Roozenbeek, J., & van der Linden, S. (2019). Fake news game confers psychological resistance against online misinformation. *Palgrave Communications*, *5*(1), 1–10.
Rosenzweig, A. (2017). Understanding and undermining fake news from the classroom. *Berkeley Review of Education*, *7*(1), 105–112.
Rowntree, D. (1982). *A dictionary of education*. Barnes & Noble Books.
Sadler, T. D., & Zeidler, D. L. (2009). Scientific literacy, PISA, and socioscientific discourse: Assessment for progressive aims of science education. *Journal of Research in Science Teaching*, *46*(8), 909–921.
Schleicher, A. (2018). *PISA 2018: insights and interpretations*. PISA, OECD Publishing.
Slagter, C., & Pyper, M. J. (2019). Linguistic Loneliness and Study Abroad. *The Interdisciplinary Journal of Study Abroad*, *31*(1), 46–58.
Smith, F. L. (2020). Quantum technology hype and national security. *Security Dialogue*, *51*(5), 499–516.
Smith, M. D. (2017). Arming students against bad information. *Phi Delta Kappan*, *99*(3), 56–58.
Snoddy, A. M. E., Beaumont, J., Buckley, H. R., Colombo, A., Halcrow, S. E., Kinaston, R. L., & Vlok, M. (2020). Sensationalism and speaking to the public: Scientific rigour and interdisciplinary collaborations in palaeopathology. *International Journal of Paleopathology*, *28*, 88–91.
Stenmark, M. (2013). Scientism. In A. Runehov & L. Oviedo (Eds.), *Encyclopedia of sciences and religions* (pp. 2103–2105). Springer.
Stevens, A. (2016). The app to cure your loneliness: Swipe right for your new BFF. *The Guardian*.
Tangcharoensathien, V., Calleja, N., Nguyen, T., Purnat, T., D'Agostino, M., Garcia-Saiso, S., Landry, M., Rashidian, A., Hamilton, C., AbdAllah, A., & Ghiga, I. (2020). Framework for managing the COVID-19 infodemic: Methods and results of an online, crowdsourced WHO technical consultation. *Journal of Medical Internet Research*, *22*(6), 1–8.
ten Dam, G., & Volman, M. (2004). Critical thinking as a citizenship competence: Teaching strategies. *Learning and Instruction*, *14*(4), 359–379.
United Nations Education, Scientific and Cultural Organisation. (2021). *Reimagining our futures together: A new social contract for education*. United Nations Education, Scientific and Cultural Organisation. https://unesdoc.unesco.org/ark:/48223/pf0000379707.locale=en
University College London. (2012). *Loneliness? It's all a state of mind*. UCL News. https://www.ucl.ac.uk/news/2012/oct/loneliness-its-all-state-mind
Van Scoy, L. J., Miller, E. L., Snyder, B., Wasserman, E., Chinchilli, V. M., Zgierska, A. E., Rabago, D., Lennon, C. L., Lipnick, D., Toyobo, O., Ruffin, M. T., & Lennon, R. P. (2021). Knowledge, perceptions, and preferred information sources related to covid-19 among central pennsylvania adults early in the pandemic: A mixed methods cross-sectional survey. *Annals of Family Medicine*, *19*(4), 293–301.
Vettehen, P. H., Nuijten, K., & Peeters, A. (2008). Explaining effects of sensationalism on liking of television news stories: The role of emotional arousal. *Communication Research*, *35*, 319–338.
Weingart, P. (2017). Is there a hype problem in science? If so, how is it addressed? In K. Hall Jamieson, D. M. Kahan, & D. A. Scheufele (Eds.), *The Oxford handbook of the science of science communication* (pp. 111–118). Oxford University Press.
Williams-Jones, B. (2004). A spoonful of trust helps the nanotech go down. *Health Law Review*, *12*(3), 10–13.

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