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When 'we wish they knew' meets 'I want to know'

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ABSTRACT

The tension between mandated curricula and students' interests is evident throughout the history of science education. Societal expectations for student learning often lead to standards and curricula that leave little room for students to explore their own individual interests. Occasionally, however, an event can capture the interest of so many students that teachers feel compelled to respond. The Ebola outbreak of 2014 was such an event. This article discusses findings from a study of teacher decision-making; specifically, it explores how high school science teachers in the U.S. decided whether and how they should address Ebola during the 2014–2015 school year, when the Ebola outbreak in West Africa was at its peak. Approximately 2500 teachers of science responded to an online questionnaire that addressed their Ebola-specific instruction. In comparing the decisions of those who taught about Ebola and those who did not, the study found that teachers weighed various factors, in particular student interest but also curriculum standards, time, and availability of resources for teaching about Ebola. The article concludes with implications for future urgent health-related issues.

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Introduction

Within science education, there is a long-standing tension between the mandated science curriculum and students' personal interests. Those who advocate for more emphasis on student interest stress that without this focus, students see school learning and life learning as separate (Bouillion & Gomez, 2001). Researchers also highlight the affordances of focusing on student interest. Koballa and Glynn (2007), for example, argued that 'a student who is interested or curious about a science topic has a readiness to pursue it' (p. 88). Multiple ideas for generating student interest have been offered from research – from providing analogies that are relevant to the students (e.g. Koballa & Glynn, 2007) to including technology that helps students to construct their own problems in addition to solving them (Bransford, Brown, & Cocking, 2001). Basu and Barton (2007) described multiple examples of structuring learning around students' interest in science and how the approach advances students' future careers. One student became motivated to learn about science when he saw how it could further his dream of becoming an artist. Another

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student from the same study, interested in medicine, engaged her community by connecting with people through science topics, such as teaching her younger cousins about nutrition.

Practitioner-oriented literature is replete with accounts of educators who have attempted to make science relevant to their students by connecting to communities or incorporating current events. For example, Weeks and Stepanek (2001) discussed how they incorporated the community into their classrooms. Through building and maintaining a garden to working with scientists from the community to improve science research in the area, the authors provide examples of ways students interact with their environment. Bentley (1995) argued for seizing opportunities to discuss current events that students ask about, acknowledging both the benefits (student engagement) and challenges (extra demands on teachers). In this vein, Wright (2011) described how one teacher capitalised on his students' curiosity about the tsunami in Japan in 2011 to explain how an earthquake could have caused it, discussing the event and then creating a laboratory activity to demonstrate how the phenomenon occurred.

Theoretical framework

Aikenhead (2006) offered a framework for thinking about relevance to students' lives from a curriculum-design standpoint, defining seven types of relevance based on who is deciding what is relevant (Table 1). This same framework is useful for interpreting the results of our study.

Wish-they-knew science, the perspective most common in national standards and curricula, is decided by scientists, science educators, education officials, and often, practising science teachers. Three prominent science standards documents in the U.S. illustrate this perspective: *Benchmarks for Science Literacy* (American Association for the Advancement of Science, 1993), the *National Science Education Standards* (National Research Council, 1996), and the *Next Generation Science Standards* (Next Generation Science Standards [NGSS] Lead States, 2013) more recently. In each case, committees of scientists and educators met to form consensus about the content of the standards, that is, what students should know in science. In the case of the NGSS, the committee published a framework document (National Research Council, 2012), which subcommittees then drew upon to generate the standards.

Table 1. Perspectives on curriculum relevance.

Type of relevance	Who decides what is relevant?
Wish-they-knew science	Academic scientists, education officials, many science teachers
Need-to-know science	The general public who have faced and resolved real-life problems/decisions related to science and technology
Functional science	People in science-based occupations
Enticed-to-know science	The media and internet sites
Have-cause-to-know science	Experts who have interacted with the general public on real-life issues
Personal-curiosity science	Students themselves
Science-as-culture	Interpreters of culture who can determine what aspects of science comprise features of local, national, and global culture

Source: Aikenhead (2006, p. 32).

Perhaps the sharpest contrast to the *wish-they-knew* perspective is *personal-curiosity* science (or, as we refer to it in this article, *I-want-to-know* science). From this perspective, students decide what to study based on science content that is relevant to them. *I-want-to-know* science is, of course, shaped by other influences, including the *enticed-to-know* perspective, through which the media and Internet shape what is relevant for students to know.

Osborne and Collins (2001) studied how students in the UK responded to a *wish-they--knew* curriculum. Unlike the U.S., where states have the latitude to adopt their own curriculum standards,[1] the UK has a national science curriculum. Osborne and Collins interviewed 16-year-old students in schools across the UK to gather perspectives about the curriculum. Overall, the researchers found that students thought learning science was important and that science was an aspect of their daily lives. However, many factors contributed to students describing themselves as uninterested in the subject. Students emphasised that the curriculum was rushed – too fast to fully absorb the material they were learning. Students also reported that the aspects of science they found most interesting were the topics they perceived as relevant to them. For example, students expressed interest in biology because they easily made connections to their lives. Further supporting Osborne and Collins' findings, the most recent Programme for International Student Assessment study found that students' scores were higher when their science teachers changed their lessons based on the needs and knowledge of their students (OECD, 2016).

The vast majority of science teachers in the U.S. teach in a standards-driven, *wish-they-knew* context, often with high-stakes end-of-grade or end-of-course tests. Only about one-third of high school science teachers report having strong control over deciding what topics to teach (Banilower et al., 2013). In contrast, almost three-fourths report strong control over teaching techniques. In our study, conducted in the U.S., we explored what happens when an event captures students' interest to the extent that they bring it into the science classroom and essentially ask for instruction. We were curious about how science teachers charged with teaching a *wish-they-knew* curriculum would respond when their students expressed a want, or even a need, to know about a topic that does not necessarily fit within that curriculum – or as the title of the article states, what happens when *we-wish-they-knew* meets *I-want-to-know*.

Study context and research questions

In 2014, the West Africa Ebola outbreak captured the attention of adults and students alike in the U.S. Even though the virus was unlikely to spread in the U.S., media reports at the time documented widespread misunderstanding and even fear about the virus. School districts in Maine, Ohio, and Texas either put teachers on leave or closed schools temporarily due to fears about the virus spreading (Blad, 2014). In one case, a teacher had simply travelled to Dallas, Texas, where two infected nurses lived. Two districts temporarily shut schools when they learned that students, parents, or staff had been on the same airplane (not the same flight, just the same airplane) as one of the infected nurses. In a poll conducted at the time, roughly 4 in 10 Americans said that they were worried that either they or an acquaintance would be exposed to the virus (Pew Research Center, 2014). Another poll found that almost one in five Americans saw Ebola as the nation's most

urgent health-related problem, a proportion that was higher than that for heart disease, cancer, and obesity (Saad, 2014).

In March 2015, we launched a study of how U.S. K–12 science teachers responded to Ebola in their teaching and what factors influenced their response. The following research questions guided the study:

(1) In what ways did K–12 science teachers adapt their teaching in responding to the Ebola outbreak, regardless of whether the issue was part of their curriculum or not?
(2) What factors shaped teachers' response to the Ebola outbreak?
(3) What did K–12 science teachers know about Ebola?
(4) What were K–12 science teachers' sources of information about Ebola, and how did teachers perceive the usefulness of these resources?

We developed and administered a survey to K–12 science teachers nationally. We also interviewed a sample of teacher respondents to explore in greater depth the issues addressed by the survey and to illustrate how individual teachers responded to Ebola.

In the following, we describe the study methodology and then detail the study findings, organised by research question.

Methodology

The study entailed constructing the survey and interview protocol, recruiting participants, collecting data, reducing the sample, and analysing the data. The teacher questionnaire, included in the supplementary materials, was developed largely to query teachers about their Ebola-related instruction (or lack thereof) and the factors that influenced their decisions. Other survey items were designed to measure teachers' knowledge of the Ebola virus. Cognitive interviews (Desimone & Le Floch, 2004) were conducted with teachers on all questionnaire items to make sure that respondents' interpretation aligned with the researchers' intent. The final survey questions were loaded in an online survey platform for administration.

The interview protocol (also included in the supplementary materials) was designed to elaborate on teachers' questionnaire responses.

Using an email list of K–12 teachers of science in the U.S., we registered approximately 3500 teachers for the study. Some registrants were not eligible to participate (e.g. teachers from countries other than the U.S.). After removing these, the web-based survey was administered to just over 3400 K–12 teachers in May 2015. As an incentive to respond, completers had a chance to win 1 of 10 $100 cash prizes. The survey was closed at the end of June, having achieved a 70% response rate.

Because of the study budget and timeline, we were unable to draw a nationally representative sample for the survey. Rather, we surveyed enough teachers so that we could construct a representative group from respondents for the analysis. Target sample characteristics were identified using the 2012 National Survey of Science and Mathematics Education (Banilower et al., 2013). For example, we removed survey respondents from the sample until it closely matched population characteristics for race/ethnicity (sample demographics are included in supplementary materials). Through this process, approximately half of the respondents were excluded from the analysis. We also divided the

respondent sample into elementary (grades K–5), middle (grades 6–8), and high school (grades 9–12), allowing us to generate findings and make claims about these categories separately. The final analysis sample sizes are: 244 elementary school teachers, 445 middle school teachers, and 566 high school teachers.[2] In this article, we focus primarily on results for high school teachers due to word limits.

We also conducted in-depth telephone interviews with a purposive sample of 30 survey respondents. We assembled a diverse pool to invite for interviews based on responses to several survey items (e.g. content area taught, time dedicated to Ebola instruction, whether students asked about Ebola, sources of Ebola information).

Like the results of any survey based on a sample instead of the population, the results from the present study are subject to variability in sampling, which is reflected in the sampling error (or standard error). In this article, standard errors for the estimates are displayed in parentheses in the tables. When describing the study results, we discuss only differences that are substantial and statistically significant at the 0.05 level.[3]

The article includes vignettes, which are written to illustrate teachers' response to Ebola and how various factors affected their response. The vignettes were constructed from in-depth interviews with teachers and from their survey responses.

Results

The results that follow are organised in the following categories: Teaching about Ebola, Factors in Teachers' Decision-Making (including teachers' knowledge about Ebola), and Teachers' Sources of Information.

Teaching about Ebola

The survey asked teachers whether they had spent class time on Ebola and what influenced their decisions to address Ebola or not. If teachers reported that they addressed Ebola, the survey asked how much class time they devoted to the topic and what instructional activities they used. Overall, 76% of high school science teachers addressed Ebola; 88% of life science teachers and 44% of non-life science teachers took up the topic. It is noteworthy that a substantial proportion of high school non-life science teachers addressed the topic, given that the topic was almost certainly not part of their curriculum.

Roughly three-quarters of high school teachers who taught about Ebola devoted more than one class session but fewer than four. The average lesson on Ebola lasted about 30 minutes, but the standard deviation was large (approximately 20 minutes), suggesting wide variation in lesson length. (Additional detail on which teachers taught about Ebola and how much time they spent on the topic is available in the supplementary materials.)

Most teachers spent one or two class periods discussing Ebola, but some spent considerably more. The vignette that follows is based on an interview with a biology teacher and illustrates substantial attention to Ebola.

Vignette 1: Substantial Emphasis on Ebola in a Life Science Class

Ms Parker[4] teaches several 9th–12th grade biology classes at a semi-rural, public school in North Carolina. Ms Parker's decisions about how to address Ebola occurred in the spring of 2014, early in the outbreak, when she was planning for the next school year with another biology teacher. They were trying to identify a book for their honours class to use in their book project for the semester. Ms Parker had been following the news about Ebola and recalled reading *The Hot Zone*, which the two teachers decided to structure their project around.

The teachers found abundant resources to go along with the text, including over 300 questions to discuss. They quickly winnowed through these and chose the ones they thought were most appropriate for their students. Ms Parker typically assigned the readings and questions as homework and then had discussions during class sessions that followed. Complementing the book project, Ms Parker had students listen to stories from National Public Radio during class, mostly focused on the outbreak's human impact. Students interacted with a virtual virology lab from the Howard Hughes Medical Institute and watched *Outbreak* (the movie). Students also constructed a virus timeline that documented the Ebola's history and compared other viruses to Ebola. Ms Parker used the steady stream of media reports at the time as another source of discussion material. Her students discussed how the outbreak described in *The Hot Zone* compared to the 2014 outbreak, Ebola's viral lifecycle, and several media reports during the semester.

Not surprisingly, high school life science teachers were much more likely than non-life science teachers to address Ebola as part of their curriculum. Interestingly, 90% of life science teachers reported addressing Ebola as part of their curriculum, and almost half as a standalone topic,[5] suggesting that for at least some, part of their treatment of the topic fell within their curriculum while other parts did not. Non-life science teachers, in contrast, tended to treat Ebola as an isolated topic (67%), without apparent connections to their science curriculum.

The most frequently used instructional activities, no matter the focus of the class (life science or not), were whole-class discussion and question-and-answer (see Table 2). It is important to highlight the question-driven nature of instruction and the fact that questions are posed by students. It is also interesting to note how relatively infrequently teachers reported lecturing about Ebola.

The vignette that follows depicts how one teacher's instruction was influenced by students' questions.

Vignette 2: How One Teacher's Instruction Was Influenced by Students' Questions

Mr Johnson teaches in two adjacent schools (one middle and one high school) in rural Texas, not far from Dallas. He teaches 8th grade science and 12th grade Environmental Systems.

Because of his proximity to Dallas, where one of the nurses with Ebola worked, conversations about the virus within and outside of his schools were common. Students were intensely interested, asked frequent questions, and often expressed misconceptions about Ebola. All of these factors influenced Mr Johnson's instruction. He was particularly concerned that students did not understand the conditions necessary for transmission. They thought if they were 'on the same block' as someone with Ebola, they would get it too.

Mr Johnson approached Ebola differently in his classes, which he attributed to a number of factors. In the Environmental Systems class, he was able to connect students' questions about the virus to state standards, in particular population growth and limits, how environmental factors impact interactions between organisms, and how transmission rates varied in rural and urban areas. The Environmental Systems class was not subject to state testing, which Mr Johnson said allowed him more latitude (and time) to take up students questions on Ebola. Mr Johnson also said that the intensity of students' interest gave him justification to diverge from his textbook, which he described as 'weak,' and discuss an issue that had relevance for the students. In contrast, his 8th grade science class was subject to state testing. Consequently, he felt constrained to spend less time discussing questions from students, although he did feel compelled to address Ebola, just in less depth.

Study data indicate that Ebola-related instruction differed from life science instruction more generally. As part of a national study of science education in the U.S. in 2012 (Banilower et al., 2013), high school biology teachers were asked what types of activities occurred in their most recent lesson. Sixty-nine per cent of biology teachers nationally reported engaging in whole-

Table 2. Instructional activities used to address Ebola in high school science classes.[a]

	Per cent of respondents		
		Focus of class	
	All ($N = 429$)	Life science ($N = 303$)	Non-life science ($N = 126$)
I answered questions about Ebola asked by students	86 (1.7)	85 (2.1)	88 (2.9)
I led a whole-class discussion about Ebola	69 (2.2)	70 (2.6)	67 (4.2)
Students read about Ebola	45 (2.4)	50 (2.9)	33 (4.2)
Students watched a video about Ebola	40 (2.4)	48 (2.9)	22 (3.7)
I lectured or gave a presentation about Ebola	36 (2.3)	41 (2.8)	24 (3.8)
Students searched the Internet for information or current events related to Ebola	26 (2.1)	28 (2.6)	21 (3.6)
Small groups discussed Ebola	15 (1.7)	17 (2.2)	8 (2.4)
Students did a worksheet or answered written questions about Ebola	15 (1.7)	16 (2.1)	13 (3.0)
Students did a hands-on activity or laboratory activity	12 (1.6)	14 (2.0)	6 (2.2)
A student (or students) gave a presentation about Ebola	10 (1.5)	11 (1.8)	8 (2.4)
A guest speaker talked about Ebola	2 (0.7)	2 (0.7)	4 (1.7)

[a]Only those who reported that they devoted class time to Ebola are included in this table.

class discussion in their most recent lesson (Lyons, 2013), quite similar to life science teachers' reports of their Ebola instruction. Having students read was also similarly prominent in both studies – 43% for biology teachers nationally and 50% for teachers reporting their Ebola instruction. However, when considering the use of hands-on laboratory activities, sharp contrasts are evident (41% for biology teachers nationally versus 14% for teachers reporting on their Ebola instruction). A difference was also evident in the use of worksheets (54% for biology teachers nationally versus 16% for those describing their Ebola instruction). A likely explanation for both contrasts is the lack of resources available for Ebola instruction, a challenge that may accompany instruction driven by student interest more generally.

The survey provided a list of topics teachers could have addressed during Ebola instruction. Those most commonly addressed were defining Ebola and how the virus is transmitted, including how to prevent transmission (see Table 3). Generally, life science classes took up more topics than classes described as non-life science, a reasonable finding, given that there is more potential for connections to the curriculum in life science. "The following vignette" illustrates how one teacher addressed multiple topics about Ebola.

Vignette 3: Exploring Ebola in Depth in a Biology Class

Mr Terry teaches biology in a large high school in suburban New Jersey. He provided Ebola-related instruction through a multi-day unit in all of his biology classes. His decision to explore Ebola in depth was influenced by several factors: his own understanding of Ebola, his students' interest, the frequency of misconceptions about the disease, access to resources about Ebola (specifically, the CDC website), and his sense that the topic was appropriate for his students' maturity level.

The Ebola unit lasted several days, during which Mr Terry engaged students with several instructional activities. In one, he had students read and respond to questions on an article titled, '*You Can't Catch Ebola From a Giraffe in Tanzania*.' The article related the Ebola outbreak to a lab investigation that modelled how the virus is transmitted. Students also watched YouTube news clips and a PBS documentary that explored the Ebola outbreak in the Democratic Republic of Congo during the 1990s (Zaire at that time). Mr Terry brought in a speaker who worked at the county health department who explained the virus's biology, as well as its history and transmission. Throughout the unit, Mr Terry was alert for misconceptions expressed by students in discussions and adapted his instruction to counter incorrect information with facts. He was able to identify several misconceptions evident in his students' comments. Among them, students thought that the virus was airborne. They thought that Africa was a country rather than a continent, and consequently thought that Ebola was present in every country in Africa. They thought there was an outbreak in their own state (New Jersey). The wide range of misinformation influenced Mr Terry's decision to address multiple aspects of Ebola in his classes. Although it was a bit of a force fit, he tied his Ebola instruction to his unit on cellular biology, stating that he was able to 'throw in viruses' in his discussion of eukaryotes and prokaryotes (specifically bacteria).

Table 3. Topics addressed in high school classes during Ebola instruction.[a]

	Per cent of respondents		
		Focus of class	
	All ($N = 427$)	Life science ($N = 301$)	Non-life science ($N = 126$)
What Ebola is (e.g. Ebola is a virus)	94 (1.2)	96 (1.1)	89 (2.8)
How Ebola is transmitted among humans	93 (1.3)	94 (1.4)	90 (2.7)
Ways to prevent Ebola transmission	79 (2.0)	84 (2.1)	68 (4.2)
Symptoms of Ebola in humans	77 (2.0)	83 (2.2)	63 (4.3)
Likelihood of a widespread Ebola outbreak in the United States	77 (2.0)	79 (2.3)	73 (4.0)
Where Ebola originated (i.e. what part of the world)	74 (2.1)	79 (2.4)	64 (4.3)
How Ebola is transmitted to humans from other animals	72 (2.2)	73 (2.6)	70 (4.1)
Survival rates of Ebola victims	70 (2.2)	78 (2.4)	53 (4.5)
Factors that place people at risk for contracting Ebola	69 (2.2)	71 (2.6)	63 (4.3)
Common misconceptions about Ebola	67 (2.4)	67 (2.9)	66 (4.5)
How Ebola is treated	58 (2.4)	65 (2.8)	42 (4.4)
History of Ebola (e.g. first discovered in the 1970s)	54 (2.4)	60 (2.8)	39 (4.4)
How Ebola is diagnosed	38 (2.4)	45 (2.9)	22 (3.7)

[a]Only those who reported that they devoted class time to Ebola are included in this table.

A large majority of respondents (79%) who reported addressing Ebola in class also reported that their students asked about it first. There was no difference between classes of life science and those of non-life science. The data suggest that students' questions motivated teachers' decisions to address the topic and are supported by other data discussed later. Interestingly, 82% of high school science teachers indicated that they would have addressed the topic even if students had not asked. Life science teachers were substantially more likely than teachers of non-life science classes to report that they would have addressed Ebola whether students asked or not (89% of life science teachers versus 64% of non-life science teachers).

Factors in teachers' decision-making

A major objective of the study was to identify the factors that shaped teachers' decisions about addressing Ebola in their instruction. Respondents rated a list of potential factors on a three-point scale: 1, 'discouraged me from addressing Ebola with my students'; 2, 'not a factor'; and 3, 'encouraged me to address Ebola with my students.' For reporting purposes, the items were grouped into three categories: Likelihood of Lesson Success, Policy, and Influence of Others. Figure 1 shows the items in each category.

The Likelihood of Lesson Success category includes factors that are important for teaching about Ebola effectively. For example, without knowledge of Ebola, teachers are unlikely to provide effective instruction. The same is true for availability of resources and even student interest. Within this group of factors, the ones most frequently rated as encouraging, whether teachers taught the topic or not, were the students' interest (95% of those who taught about Ebola, 46% of those who did not) and the age appropriateness of the topic (90% and 33%, respectively; see Table 4). Among those who did not devote class time to Ebola, teachers' knowledge of how to teach about Ebola, availability of resources for Ebola instruction, and their own knowledge of Ebola were most likely to be rated as discouraging factors (44%, 40%, and 36%, respectively). Each factor suggests the need for Ebola-specific resources targeted to teachers.

Grouping of Factors that Influenced Decision Making about Ebola

Likelihood of Lesson Success
- Your knowledge of Ebola
- Your knowledge of how to teach about Ebola
- Availability of resources for teaching about Ebola
- Appropriateness of the topic of Ebola for the age group I teach
- Student interest in Ebola

Policy
- District/state-administered tests in science
- School/district pacing guides for science
- District/state-administered tests in other subjects (e g , mathematics, English/Language arts)
- District/state standards for science instruction
- School/district pacing guides for other subjects (e g , mathematics, English/Language arts)
- Availability of time for science instruction in general

Influence of Others
- Other teachers in your school or district
- Your school administration
- Parent/guardian beliefs or opinions about Ebola
- Your district administration

Figure 1. Grouping of factors that influenced decision-making about Ebola.

Table 4. Respondents rating factors that affected their decision to address Ebola: Likelihood of Lesson Success.

	Per cent of respondents ($N = 562$)[a]		
	Discouraged	Not a factor	Encouraged
Likelihood of Lesson Success			
Student interest in Ebola			
Did teach about Ebola	0 –[b]	5 (1.0)	95 (1.0)
Did not teach about Ebola	9 (2.5)	45 (4.3)	46 (4.3)
Appropriateness of the topic of Ebola for the age group I teach			
Did teach about Ebola	0 (0.2)	10 (1.4)	90 (1.4)
Did not teach about Ebola	10 (2.5)	58 (4.3)	33 (4.0)
Your knowledge of Ebola			
Did teach about Ebola	6 (1.1)	29 (2.2)	66 (2.3)
Did not teach about Ebola	36 (4.2)	50 (4.3)	14 (3.0)
Your knowledge of how to teach about Ebola			
Did teach about Ebola	7 (1.2)	45 (2.4)	48 (2.4)
Did not teach about Ebola	44 (4.3)	49 (4.3)	7 (2.3)
Availability of resources for teaching about Ebola			
Did teach about Ebola	11 (1.5)	61 (2.4)	28 (2.2)
Did not teach about Ebola	40 (4.2)	56 (4.3)	4 (1.6)

[a]For all factors: Did teach about Ebola, $N = 427$; Did not teach about Ebola, $N = 135$.
[b]Standard error not calculated.

For those who did not teach about Ebola, their knowledge about the virus was one of the most prominent discouraging factors. To explore this factor in more detail, respondents were presented with 20 true/false statements regarding Ebola. Specifically, the survey included questions about the nature of the virus, transmission, and how to prevent transmission. In addition to answering the questions, respondents rated their

Table 5. Mean test scores and confidence scores.

	Percentage of true/false statements answered correctly		Confidence in answering true/false statements correctly	
	Mean	Standard deviation	Mean	Standard deviation
Did teach about Ebola ($N = 411$)	83.52	10.20	75.08	16.75
Did not teach about Ebola ($N = 127$)	77.90	13.21	59.47	21.66

confidence in their answer. Teachers who taught about Ebola scored higher on the Ebola quiz than those who did not (see Table 5; independent samples t-test, $p < .001$, effect size of 0.51 standard deviations). In addition, even though the majority of questions were answered correctly, the high school teachers who did not teach about Ebola gave lower confidence ratings when answering the questions (independent samples t-test, $p < .001$, effect size of 0.87 standard deviations). Both of these findings indicate that among those who did not teach about Ebola, knowledge of the virus was a discouraging factor.

In addition to comparing means on the quiz scores and confidence scores, we analysed responses to individual true/false questions (see supplementary materials for item-level results). More than half of respondents answered all questions but two correctly. The statement about availability of a drug for treating Ebola patients was answered correctly by 40% of respondents. The other question, which focused on how the Ebola virus is transmitted, was answered correctly by 33%. Interestingly, transmission was one of the topics most frequently addressed. The high percentage of incorrect answers strongly suggests that some teachers who taught about Ebola conveyed information that was inaccurate.

Overall, policy-related factors tended to discourage high school teachers from teaching about Ebola (see Table 6). The most prominent factor among those who did not discuss the topic was the availability of time for science instruction in general, which reflects school and district policy. For example, in high schools, time for all subjects is prescribed by policies about the number of class periods and the length of the school day. The time factor is related to other policies, including the presence of school or district pacing guides for science (another factor that those who did not teach about Ebola often cited as discouraging). Other prominent discouraging factors were district/state standards for science instruction and district-/state-administered tests in science.

The factors listed in the third group, Influence of Others, appeared to have no influence on high school science teachers whether they taught about Ebola or not. Regardless of the type of 'other,' more than 80% of high school science teachers responded that the group was 'not a factor' in their decision-making. It appears that teachers largely made their instructional decisions about Ebola in the absence of influence from others, whether other teachers, school/district administrators, or parents/guardians.

Finally, an open-ended question asked teachers to identify the single most important factor in their decision-making about Ebola. Teachers could choose from the factors listed in Figure 1 or identify a new one. Among respondents who taught about Ebola, student interest was far and away the most frequently cited 'single most important factor' (65%; see supplementary materials for a list of cited factors); the next most frequently cited factor (age appropriateness of the topic) was identified by only 8% of respondents. Among those who did not devote class time to Ebola, science instructional time (21%) and district and state standards for science instruction (20%) were the most commonly mentioned factors.

Table 6. Respondents rating various factors that affected their decision to address Ebola: policy.

	Per cent of respondents ($N = 562$)[a]		
	Discouraged	Not a factor	Encouraged
POLICY			
Availability of time for science instruction in general			
Did teach about Ebola	22 (2.0)	50 (2.4)	28 (2.2)
Did not teach about Ebola	70 (4.0)	29 (3.9)	1 (1.0)
District/state standards for science instruction			
Did teach about Ebola	2 (0.7)	80 (1.9)	18 (1.9)
Did not teach about Ebola	36 (4.2)	64 (4.2)	0 –[†]
School/district pacing guides for science			
Did teach about Ebola	11 (1.5)	82 (1.9)	7 (1.2)
Did not teach about Ebola	44 (4.3)	54 (4.3)	2 (1.3)
District-/state-administered tests in science			
Did teach about Ebola	4 (1.0)	91 (1.4)	5 (1.0)
Did not teach about Ebola	26 (3.8)	74 (3.8)	0 –[b]
District-/state-administered tests in other subjects (e.g. mathematics, English/Language arts)			
Did teach about Ebola	2 (0.6)	96 (0.9)	2 (0.7)
Did not teach about Ebola	12 (2.8)	88 (2.8)	0 –[b]
School/district pacing guides for other subjects (e.g. mathematics, English/Language arts)			
Did teach about Ebola	3 (0.8)	96 (0.9)	1 (0.6)
Did not teach about Ebola	7 (2.2)	93 (2.2)	0 –[b]

[a]For all factors: Did teach about Ebola, $N = 427$; Did not teach about Ebola, $N = 135$.
[b]Standard error not calculated.

Teachers' sources of information

Because the science of Ebola was developing rapidly at the same time teachers were deciding whether to address the topic, it was important to explore where they were getting their information. The survey asked *how* teachers searched for Ebola-related information and *where* they ultimately got their information. The survey also asked how useful respondents thought the information was.

Compared to respondents who did not teach about Ebola, those who did were about twice as likely to report that they searched for information about the virus (92% versus 50%). Respondents were also asked to indicate the media sources they used for information about Ebola. (The supplementary materials include a table showing the sources respondents reported using a moderate amount or to a great extent.) Survey responses suggest that websites from health organisations (e.g. the National Institutes of Health, the Centers for Disease Control) were by far the most frequently used sources of information among teachers who taught the topic (91%). Teachers who taught about Ebola also indicated popular science magazines (e.g. *Discover, Scientific American*) as a common source of information (65%), similar to TV news programs (61%), online news sites (59%), and newspapers (print or online; 59%).

Teachers most frequently rated websites from health organisations (e.g. the Centers for Disease Control, National Institutes of Health) as 'very useful' in planning Ebola instruction (61%) (see supplementary materials for a table on respondents' perceptions of usefulness of sources of information about Ebola). Several sources were rated as 'minimally useful' or 'not at all useful' by approximately half or more high school teachers, including local news stations, 24-hour TV news, national broadcast TV news programmes, TV talk

shows, online-only sources (e.g. Yahoo News), social media (e.g. Facebook), resources provided by their school districts, and conversations with other teachers.

The clear picture that emerges from these data is that teachers used the Internet to search for information about Ebola, relied on websites of national or international health organisations, and were more likely to find resources from these websites useful than those from other sources. Another important aspect of this picture is that teachers found most other resources not helpful.

Discussion and implications

The Ebola outbreak of 2014 captured the interest of students nationwide, despite the low probability of the virus spreading in the U.S. No doubt, the media played a role in fostering interest. The symptoms of Ebola virus disease and the high mortality rate were horrific, and U.S. media seized on these aspects much more than the factors that mitigated spread in the U.S. The outbreak was unusual but not unique in the extent to which it garnered student interest. At the writing of this article, the U.S. is on the downswing of a much more likely threat to public health than Ebola, namely the recent Zika outbreak in South America. At one point, models suggested almost half of U.S. states might be affected by Zika.

Events like Ebola and Zika will continue to occur. They tend to be acute, health-related events that command extraordinary attention from the media. Whether truly relevant to students' lives or not, students perceive them as relevant and thus these topics, and others like them, become *I-want-to-know* science (Aikenhead, 2006). And as long as teachers are charged with teaching a *wish-they-knew* curriculum, such events will likely be seen as an intrusion. Teachers will have to decide whether to diverge from the curriculum they are obligated to teach and attend to student interests. Our study suggests that science teachers will create space in their standards and respond to students' questions. This finding is especially true of high school life science teachers but also of a substantial proportion of non-life science teachers.

Addressing health-related events like Ebola and Zika has clear benefits for students' learning of science. In addition to their potential to capture students' interest and the affordances offered in the learning process (Bentley, 1995; Osborne & Collins, 2001; Weeks & Stepanek, 2001; Wright, 2011), these types of events can present an opportunity to engage students authentically with particular aspects of science, including the evidence-based nature of scientific claims and the way scientific knowledge accumulates. Much of the fear surrounding Ebola in the U.S. was based on misinformation, and many of the claims made by government officials at the time (in justifying school closures, for example) were not based on scientific evidence. In addition, events such as Ebola and Zika demonstrate the tentative nature of scientific knowledge and how rapidly it can change, especially as knowledge accumulates across multiple studies in different settings. These events highlight the fact that the scientific enterprise is a global one and that accumulation of scientific knowledge requires communication and cooperation across borders. Opportunities for students to experience these aspects of science 'in real time' are unusual.

At the same time, these events place science teachers in a precarious position, apart from having to decide whether to diverge from their curriculum. We found that teachers were left to their own devices to collect and assemble knowledge about Ebola for

instruction. Resources designed specifically for teachers were scarce or non-existent. Teachers already have very busy schedules, and they may not have time to do the research, vet resources, and plan instruction on a topic outside of their curriculum. Our data suggest that Ebola instruction often took the form of question-and-answer, with students asking the questions. The predominance of this form of instruction may reflect both the lack of instructional materials and teachers' lack of time to prepare.

Events like Ebola may also place unusual demands on teachers' own content knowledge. (Recall that a substantial proportion of non-life science teachers devoted class time to Ebola.) Our findings suggest that a substantial proportion of teachers passed on inaccurate information, in particular about transmission of the virus, which was perhaps the topic most likely to reassure students who were concerned about, and even afraid of, the spread of Ebola in the U.S.

Our study also points to broader implications for science education, namely how we ensure that students are learning about emerging science issues and what is the role of the science teacher in this process. Almost 20 years ago, international reports characterised the U.S. science curriculum as broad yet shallow, so packed with topics that none could be treated in depth (Schmidt, McKnight, & Raizen, 1997; Stigler & Hiebert, 1999). As described earlier in this article, *wish-they-knew* standards are typically created by committees, and the negotiations required for consensus can result in an 'overstuffed' curriculum. Taken together with the pedagogies that standards documents often recommend, the odds of teachers being able to address all topics in a curriculum are low. (Note: though officially silent on pedagogy, the NGSS (NGSS Lead States, 2013) emphasise interweaving core ideas, science practices, and crosscutting concepts, which takes considerable time.) Perhaps standards efforts should purposefully leave room for events like Ebola. Such an approach may have a side benefit of creating space for teachers to incorporate topics of local interest, making more states see the standards as adoptable.

The case of Ebola also raises questions about the role of science teachers. In the U.S., misinformation about Ebola was rampant, and policy decisions were being made based on that misinformation. What obligation, if any, do science teachers have in such a context? Should they be encouraged to respond? And what about a true imminent danger, like Zika in early 2016? Should public health organisations attempt to leverage science teachers as a potentially effective information dissemination system for public health purposes? Our data suggest that high school life science teachers alone reached over 5 million U.S. students with information about Ebola. Do science teachers have a responsibility in situations like the Ebola outbreak to serve a public health function? Students are much more likely to see a science teacher than a health educator on a daily basis. At the same time, in many U.S. states, teachers are contractually obligated to teach state standards, and some are subject to high-stakes, end-of-course tests. With so much already on their plates, can science teachers be asked to take on a public health function? These are questions without clear answers but worth discussing.

Setting aside the question of what the role of teachers *should* be, our study found that teachers, by and large, *will* respond when students come to class with questions about events like Ebola. How, then, should science teachers be supported and by whom? Science education researchers are uniquely positioned to help by studying what is likely to constitute an Ebola-like event in terms of its impact on science instruction. What was it about Ebola that so captured students' interest across the U.S.? Answering this

question may help predict similar situations and make the field more ready to support science teachers. Also, what is the most effective way for teachers to address the topic, given the constraints of time, standards, and resources? Even the life science teachers we interviewed found that incorporating Ebola was a stretch because viruses are not included in their standards per se. How can science teachers leverage such events to address the standards they are responsible for teaching while still responding to students' interests?

Health organisations also have an important role to play. U.S. teachers overwhelmingly reported visiting CDC and NIH websites to gather information about Ebola, more than any other source. Such sites are respected and have the most up-to-date information. However, these organisations could accommodate teachers better by organising the information in ways that make it more immediately useful for instructional purposes. For example, our study suggests students will be interested in three types of information (at least): what it (e.g. Ebola, Zika) is, how it spreads, and how likely students are to get it?

Teacher professional organisations (e.g. NSTA, NABT) are in a unique position to support science teachers. The timescale in which teachers have to respond to Ebola, Zika, or similar situations may be too compressed for organisations to develop high-quality instructional materials. Teacher organisations can, however, serve as clearinghouses of accurate information resources for teachers – not creating new materials but organising existing resources for teachers to access easily. Teacher organisations can also provide guidance to teachers on how to leverage such events for broader science education goals, in particular authentically engaging students with the practices and aspects of science discussed earlier.

In closing, Ebola seemed to change an important classroom dynamic. Lecture and discussion are still the most frequent forms of instruction in high school science classes (Banilower et al., 2013). In these discussions, teachers typically ask questions and students attempt to answer them, consistent with the initiate–respond–evaluate pattern of discourse prevalent in many classrooms (Mehan, 1979). In describing their Ebola instruction, teachers made it clear that the direction of questions and answers was flipped: students asked the questions and teachers tried to answer them. The teachers we interviewed described feeling compelled to address Ebola because of students' questions about and interest in the topic. Teachers made it clear that when their 'wish-they-knew' curriculum met 'I-want-to-know' questions from students, they responded, and they responded in ways that differed fundamentally from typical science instruction.

Notes

1. In the U.S., 18 states and the District of Columbia have so far adopted the NGSS as their state standards.
2. We acknowledge that despite efforts to create a representative sample, it may be biased by the teachers' interest in Ebola compared to a random sample of teachers.
3. Given the exploratory nature of this study, all tests of significance were conducted without controlling the Type 1 error rate.
4. All teacher names are pseudonyms.
5. The questionnaire allowed respondents to select both responses.

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