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Socioscientific Issues-Based Instruction: The Messier Side of (Leading) Science Teaching

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Case

Socioscientific Issues-Based Instruction: The Messier Side of (Leading) Science Teaching

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Abstract

The present case centers on a socioscientific issues-based lesson taught by a preservice teacher (PST) in an AP Biology class. The PST designed and delivered a lesson on disease transmission and ways to avoid infection with connections to the COVID-19 pandemic mask mandates and vaccine reticence. The Principal received several emails from parents (positive and negative), citing the incorporation of political issues and critical race theory into the science lesson. With this framing, the case depicts how the Principal, PST, university supervisor, and cooperating teacher navigate the situation. The case highlights the role of school leader as instructional leader. In particular, to interact with teachers and other stakeholders about content and pedagogy, leaders must develop leadership content knowledge (LCK). The present case offers school leaders an opportunity to build LCK around the Nature of Science and socioscientific issues, while exploring how they might address challenges to curriculum and pedagogy.

Keywords

instructional leadership; leadership content knowledge; socioscientific issues; nature of science

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Introduction

This case unfolds at Marshall High School (MHS), which serves approximately 1,500 students in grades 9-12 about 40 miles from a major metropolitan area in the southwest United States. While a decade ago MHS would have been considered rural, as it served students in three smaller towns within the county, the quickly growing metro area has meant simultaneous growth for MHS and the geographic area it serves. Population and economic growth in and around the area have attracted a diversifying population along multiple lines (e.g., age, marital status, race, religion, and political affiliation).

Characters

Melissa Elliott is a preservice teacher (PST), in her final semester at Jayne State University (JSU). A Science Education major, she grew up close to the area served by MHS and is excited to have been placed there.

James Jackson is a science teacher at MHS and Ms. Elliott's cooperating teacher. This is his fifth year at MHS, and his third year teaching AP courses. Mr. Jackson has his M.Ed. in Science Education, serves as department chair, and was campus teacher of the year two years ago. Though he has wanted to work with PSTs, this is the first year he has had the opportunity to supervise and mentor a PST. He works diligently to review Ms. Elliott's lesson plans and to collaborate with her, but also tries to stay in the background as much as possible so she gets a fuller experience of being "the teacher" and so that students see her as the classroom teacher.

Dr. Mark Mathers is an Associate Professor in Science Education at JSU and, among other duties, serves as the university supervisor for several PSTs each semester. He reviews lesson plans and has a weekly virtual chat with each PST, during which he asks them probing questions about their lessons and how they think students will engage with the material. He presses PSTs to consider what misconceptions students might bring to the lessons that the PSTs will need to address.

Principal Calvin Young is in his third year at MHS, having previously served as principal of a middle school that feeds MHS. Prior to working in administration, Principal Young taught Speech, English, and Theatre in another district for eight years. Principal Young has maintained a focus on instruction in his work at MHS and takes time each day to conduct walkthroughs of two to three classrooms in order to model this focus for other leaders on campus. He is happy to host PSTs, though this is the first year MHS has hosted anyone in science.

Compliments and Complaints

Principal Young arrived as the sun began to rise over MHS campus, grabbed some coffee, and opened his email. He typically tried to respond to emails early, so he could be present to greet as many arriving students as possible and walk through halls to wish teachers a good morning. As he worked through emails, three in particular suggested a pressing issue he would have to address as soon as possible, or he feared it would become a bigger problem. He felt a knot form in his stomach.

He had been excited to work with PSTs from JSU, and he thought Melissa Elliott would have a great experience with Mr. Jackson. Yet, here was a cluster of emails, all focused on a science lesson that – according to at least two of the corresponding parents – had somehow strayed into politics and race, two issues he thought disconnected from any science standards he had encountered (Figure 1).

Figure 1

Three Parent Emails that Principal Young Received

Mr. Young:

I am writing to express some concern about an incident that occurred in my son Blake's AP Biology class yesterday. The class is supposed to be about science, but evidently the student teacher decided to talk about racism in science and medicine instead. I don't know if she got input or guidance from Mr. Jackson—all I can say is we had no issues with him or the class prior to this. Blake also said that Ms. Elliott also went off on churchgoers, saying they don't follow science, which seems very biased. I've read several articles recently about how universities like to push CRT into our K-12 system, but I must say I never expected this to happen at MHS! I would like you to look into this issue immediately, and I expect an update on what will be done to ensure that the teachers at MHS stick to the curriculum they are supposed to teach and stop wading into politics and religion instead. Those things are our family's business, not the school's. We want Blake to learn about science, not be forced to sit in a class and listen to someone preach about CRT. Blake is there for education, not indoctrination.

Janine Driscoll

CC: Charles Jackson; Superintendent Trejo

Mr. Young,

We met at last year's parent night. My son Gary came home yesterday talking about the lesson in his AP Biology class. I know he has a student teacher, which we were nervous about at first, but I want you to know she seems to have done a good job staying balanced, because evidently there were some pointed and political questions asked, and from what Gary said she apparently responded well and kept the lesson focus. I'm not sure what all was said, but Gary said she "didn't take the bait!" I don't know that I mentioned it when we met, but I'm a physician working with the regional hospital system, and I'm so glad MHS is providing accurate science instruction. These last few years have been really hard for healthcare and healthcare workers in general, so it's heartening to see when schools and science teachers are trying to educate appropriately.

Dr. Roberta Harris

> Dear Mr. Young,
>
> I just wanted to drop you a quick note of appreciation. As you know, Rachel has an interest in a career in science, but had such a horrible year last year in her science class. We were excited to have her in Mr. Jackson's class, and Ms. Elliott seems just as wonderful so far. Rachel came home yesterday and could not stop talking about the lesson on diseases. Ms. Elliott evidently incorporated some content on masking and viruses, which Rachel said included a discussion related to COVID and even some connections to race and politics. I don't really see how those are connected, but I'm glad Rachel was excited about the class. She just kept saying this was the kind of work she wants to explore. Anyway, thank you for putting her in Mr. Jackson's/Ms. Elliott's class–it's turned her year around.
>
> James Peterson

He never had any complaints about Mr. Jackson and was perplexed at how a lesson Mr. Jackson had helped a PST structure could seemingly go off the rails. Perhaps there was a misunderstanding of some sort. Whatever the case, something out of the ordinary had occurred. After rereading the emails, Principal Young copied each into a new email to Mr. Jackson with a brief note (Figure 2).

Figure 2

Principal Young's Email to Mr. Jackson

> Mr. Jackson,
>
> I just wanted you to see these emails – I'm not sure what happened in the lesson referenced, but will need to follow up with you on this – how about you and I and Ms. Elliott talk tomorrow afternoon during your conference period? I'm hoping to start by just learning more about the lesson's objectives, how Ms. Elliott delivered the lesson, and what happened. I'll also plan to drop by during one of my walkthroughs tomorrow, just so I can get a firsthand sense of how she is engaging with students. That will help as I talk with Mrs. Driscoll or any other parents moving forward.
>
> Thanks,
> Calvin Young
> Principal
> Marshall High School

Supervising through Curricular Controversy: Reacting to Challenge

Sitting in his first period class, observing Ms. Elliott lead a lesson, Mr. Jackson read the email from Principal Young and sighed. He had worried that the lesson could generate pushback, but did not anticipate some of the issues raised, nor how vehement Blake's mother sounded. He certainly had not anticipated a parent cc-ing the superintendent. He crafted a separate email to Ms. Elliott, not wanting to worry her too much by forwarding the email directly from Principal Young.

Figure 3

Mr. Jackson's Email to Ms. Elliott

Melissa,

Principal Young got a few emails related to yesterday's lesson. A couple were really complimentary, but one (from Blake's mother) took serious issue with some of the content. That one concerned the inclusion of political issues and 'critical race theory' in a science lesson as well as perceived disconnect in the issues discussed and the science curriculum. I'm not quite sure how they got to CRT or any attack on religion (two of the things she mentioned) from what I saw you teach, but let's visit about the lesson before we chat with Principal Young. Don't worry – I'll help you navigate this – parent concerns are part of the job. Principal Young suggested that we all talk tomorrow afternoon during our conference period, and he mentioned he will try to drop in for a walkthrough in the AP Bio class tomorrow morning as well. But you and I can talk more at lunch today.

Talk soon,
Mr. Jackson

Melissa Elliott felt her heartbeat increase as she read the email a second time. It took her by surprise as she felt that her lesson in a junior-level AP Biology class had gone very well. The class was starting a unit on the immune system and infectious disease prevention. With that in mind, she had planned an introductory lesson with the objectives of distinguishing viruses and bacteria and introducing ways we combat diseases caused by them. She decided to use the COVID-19 pandemic as a way of launching the lesson and initiating student discussion. She engaged the students with a discussion about why the school was mandating students, teachers, and staff wear a face mask while on campus. Students shared multiple perspectives that presented lines of inquiry to follow as the lesson unfolded. Ms. Elliott left with a sense of satisfaction and looked forward to continuing the unit. She grabbed her lesson notes and post-lesson self-evaluation, and emailed Dr. Mathers to request a virtual conversation.

Supervising through Curricular Controversy: Planning for Response

"I know this can be anxiety-producing," Dr. Mathers began, "but the first thing we should do is reflect on what occurred during the lesson. Run through it for me."

Ms. Elliott took a breath, "I started out with an engagement question: 'Why is the school requiring face masks?' Students offered various responses. Some were simple like, 'Because of COVID.' Others were more scientifically-based, referencing new COVID variants and increased cases over the holidays.

"Once students were engaged, in small groups, I had half of the class investigate viruses and identify notable viral diseases from the past. The other half did the same with bacteria. After twenty minutes, the groups shared out. I helped clarify a few misunderstandings and then explained how medical science had developed treatments, like vaccines, to deal with such diseases and that we would look closer at them as we move through the unit. I wrapped up with a short quiz."

As Ms. Elliott spoke, Dr. Mathers reviewed her lesson plan, Mr. Jackson's email, and took notes. He probed deeper, "Mr. Jackson's email mentioned CRT. How did race come into the lesson?"

"It wasn't part of my lesson," Ms. Elliott began, "but when I mentioned vaccines, a student said that his grandmother wasn't about to get the vaccine for COVID. He said that she just didn't trust that it was safe and that she had plenty of reasons to doubt what the news was sharing. Mark, the student who raised the issue, is Black and I thought about how some people trust science more than others. I pointed out that historically some groups, like Black Americans, have been mistreated by the medical community and that some might still be reluctant to just accept what a doctor tells them. I said similar doubts could be found in other groups due to politics or religion." Ms. Elliott paused, "Was I wrong to go there?"

Dr. Mathers thought for a moment and then responded, "Sometimes, especially when teaching socioscientific issues, what parents end up hearing about what we teach can differ quite a bit from what we actually say … like a game of telephone. Also, with regard to Mark's grandmother's concerns, it's important to remember while it is true that historically the scientific and medical communities have mistreated Black and other marginalized populations, there are various reasons she may hold her opinion apart from her racial identity, which we do not actually know."

Ms. Elliott paused, "You're right – I assumed Mark's grandmother probably didn't trust the vaccines because she is Black, but I don't actually know her, or what her rationale is. I was anxious and wanted to defend Mark's family, and to acknowledge there might be deeper reasons for her opinion. But I jumped to my own conclusions." She sighed, showing frustration, "I was just trying to provide some historical perspective and keep the lesson moving. I don't think I even understand what CRT is."

"I doubt many parents do either." Dr. Mathers responded. "CRT is highly politicized right now; I have some resources I can share to help you understand it better. Right now, let's think about how your next lesson might help address sensitive aspects of the content. You know, sometimes questions will surprise you in class and you are not expected to have all the answers. The important thing is to consider what may come up, and prepare as thoughtfully as you can, but there will be moments in every teacher's career when we just don't have the answer in the moment.

"This could be a great opportunity to incorporate a short lesson on nature of science; establishing NOS makes teaching sensitive issues much easier. You can point out how social and cultural values influence how we interpret and accept science – you can lay a strong foundation for the rest of the unit by discussing how science is theory laden, based on empirical evidence, and tested by peer-review. Let's work together to come up with a NOS lesson."

Supervising through Curricular Controversy: Implementing SSI and NOS

The next day Ms. Elliott was preparing for the NOS lesson (Appendix), nervously thinking about the emails and upcoming meeting, when Principal Young entered the classroom. Ms. Elliott knew he would likely stop by but seeing him take a seat at the back of the room still raised her anxiety. She really wanted today's lesson to proceed smoothly.

Once the class started, discussion about NOS flowed and Ms. Elliott began feeling better. The beginning activities introduced students to NOS concepts in a fun and engaging way. Even Principal Young got into the topic and asked if he could try the puzzle activity. After explaining and discussing tenets of NOS, students worked in groups to read articles related to some of the tenets. On alert for tension, Ms. Elliott circulated, listening to groups as they worked, but detected no negativity.

Towards the end of class, after working through discussion guides, one student posed a question, "We've been reading about reliable and trustworthy experiments, but why has science in the past not been as trustworthy, like when you said Mark's family probably doesn't trust science because of things scientists did?"

Ms. Elliott was impressed with the connection the student drew but paused as she considered how students might see science as untrustworthy because of her comments in the prior lesson. She saw this as an opportunity for clarification.

"Let's differentiate between NOS, which includes the tenet of tentativeness, and ethical breaches here. Scientists sometimes committed errors and ethical failures, and sometimes these were rooted in racist beliefs or stereotypes," Ms. Elliott began. "It takes time to rebuild trust with marginalized communities when these breaches occur. Another part of science involves being reliable and trustworthy, and holding scientific findings up to scrutiny and replication. One part of that is adjusting practice when we discover new knowledge – that is, when we get better scientific information, we adjust our practices to align with that better, fuller information. Peer review – asking other informed people to weigh in on methods and processes to minimize errors – is one way scientists hold each other accountable.

"That process is actually similar to what you are doing today with questions about these articles. You are building your knowledge, so you can be appropriately critical and make the best decisions with the information you obtain. That's what we want you to do as critical thinkers – to assess whether information is credible, and if so, to weigh that information against other data and facts and act on it responsibly. That may mean changing your mind at times, or it may end up strengthening existing beliefs."

As class concluded, Ms. Elliott felt a mix of relief and anxiety. On one hand, she felt Principal Young had witnessed her deal with potentially sensitive subject matter in a respectful way. On the other hand, she still had to talk about the issues raised in the parent emails with Principal Young, Mr. Jackson, and Dr. Mathers.

Supervising through Curricular Controversy: Listening, Learning, Coaching

At day's end, Ms. Elliott, Mr. Jackson, Principal Young, and Dr. Mathers sat around a table in Principal Young's office to discuss the parent concerns. "First," Principal Young started, speaking to Ms. Elliott, "the majority of feedback I have received about your teaching has been positive. At the same time, I do have to address this concern from a parent who felt CRT and politics were being pushed on her child and did not understand why this was needed in a science course. Unfortunately, she copied the superintendent, so I'll have to also explain my course of action to my supervisors. I just need to better understand what happened, so I can respond appropriately. Start by telling me what you recall about the lesson in question."

Ms. Elliott provided her explanation of the initial lesson, just as she had with Dr. Mathers. Mr. Jackson chimed in, "I previewed the lesson with Melissa, and honestly, I think she responded pretty well to Mark's comment in the moment, though with more reflection, I realize I don't know Mark's grandmother either – I made the same assumptions Melissa did. I worried we might get an email or two, just because some parents think any mention of race is out of bounds."

"Okay," Principal Young responded. "But I do have a question about …" he paused to consult his notes, "the nature of science content you talked about today. The email makes it sound like the prior class discussed what we do and don't know about COVID and vaccines, and how that should drive the decisions people make about vaccines, but then today I heard, 'All science is tentative.'" He looked at the others, "Doesn't saying that just make them question everything you taught? How do I respond to a parent who complains, 'When it fits with what the teacher believes we should trust science, but when it fits with my belief – but not the teacher's – we should just wait and collect more information, because science changes?' That seems subjective and the opposite of what I thought instruction in science was about. Help me understand this better."

Mr. Jackson spoke first, "It does seem complicated, and I wish it were less messy, but tentativeness is at the foundation of science. Information should be questioned and tested – this process helps build more evidence for or against scientific information being distributed. This is part of the scientific inquiry process that we don't always do a great job of teaching in science courses."

"Melissa was giving students insight into how scientists carry out investigations," added Dr. Mathers. "Theories are constantly being questioned and tested. This actually is the opposite of indoctrination – it's holding students up as critical thinkers and equipping them with knowledge and tools they need to assess and reassess evidence. Once they do that, they aren't beholden to my beliefs, or Melissa's beliefs, or your beliefs, or even their parents' beliefs, which may add to this parent's consternation – but students are able to collect, assess, and act on the most accurate information available. From a scientist's perspective, it is good for students to see that scientific information is composed of well supported ideas and theories, as opposed to seeing science as a set of loosely connected or never-tested set of facts and figures."

Principal Young mulled the conversation. He actually felt comfortable with the description of the previous lesson and with what he observed. However, he was still unsure how to address the parent complaints. "So, what does this have to do with CRT and politics?" he asked.
"I can respond to the politics part," Ms. Elliott started, "and Dr. Mathers can correct me if I'm wrong. Today, we read articles relating to NOS, one of which was about the sociocultural influences of science on society and vice versa. There are social and cultural factors that influenced science in the past, and today, that led to certain populations being skeptical of science and scientists. NOS can help alleviate the uncertainty of why scientific information changes over time or why some populations or cultures view science differently. But there are often social and cultural implications of how science is conducted, discussed, and received. We made some of those connections in class today, just like we did in the prior lesson."

"Okay," Principal Young said. "I see those kinds of political connections, which are, to be honest, simpler to address than 'big P politics' like political party platforms. I don't know where this parent is coming from exactly, but what you just spoke about is something I can wrap my head around enough to have a conversation. But, what about CRT? I don't know a lot about CRT, but what little I do know I don't see in any of this lesson plan or what you talked about in class."

"I don't think it's there," Mr. Jackson responded. "I read about CRT in my graduate work, and yes, it does help me consider structural inequities when I'm thinking about socioscientific issues, but this lesson wasn't CRT. This lesson just happened to mention race, and unfortunately, I think CRT is a charge being levied anytime race or racial injustice is mentioned. But when we talk about science and history, we have to address racial injustice like Tuskegee or the Henrietta Lacks case, for example. And that likely does lead to conversations about the intersection of science and race at some point, including current inequities. But that's just talking about science as it applies to the world around us."

"CRT is not at the center of my work either," Dr. Mathers noted. "I don't envy you the conversation you're probably going to have with a parent or two over this or other curricular challenges. I do have a good resource I can recommend as an introduction that may be helpful- I'll email you the link[1]. But I concur with Mr. Jackson – this lesson addressed some issues of race as it relates to science and history, but that's not CRT – that's just timely and culturally relevant science instruction."

"I guess it would be too easy if one meeting could provide all the answers!" Principal Young sighed. "I'm glad I came to observe today. I really enjoyed seeing kids so engaged in learning, and I feel I can now better address parents' concerns with the information and understanding I gained today." As the office emptied, Principal Young started to consider how he would respond to the parents who emailed, and what he would communicate to the superintendent.

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[1]EdWeek published an article in May 2021 entitled "What is Critical Race Theory, and Why is it Under Attack?" The article is embedded with other pieces that can serve as a useful introduction to CRT for school leaders. Access the article and related pieces at https://www.edweek.org/leadership/what-is-critical-race-theory-and-why-is-it-underattack/2021/05

Teaching Notes

This teaching case includes fictionalized elements that are amalgamations of the authors' experiences in light of research and current events that impact K-12 schools, teachers, and leaders. The focus of the case is how school leaders learn and lead when they encounter challenges to the school curriculum. Specifically, Principal Young must respond to parent concerns about a science lesson that incorporates socio-scientific issues (SSI). As the case unfolds, readers witness how Principal Young seeks clarification about the lesson and learns about important facets of research-based, effective practices in science instruction, namely the integration of SSI into science lessons and how nature of science (NOS) can be used to address questions and concerns about SSI.

The remaining sections of the Teaching Notes elaborate on the educational leadership and science content and pedagogy foci of the case. Further, the following pre-case activities and questions will help readers be prepared to engage with the case.

1. Watch the following two videos:
   - "The Nature of Science" on the NCAR & UCAR Education and Outreach channel on YouTube (https://www.youtube.com/watch?v=ui8X)
   - Naomi Oreskes' TED Talk, "Why we should trust scientists" (https://www.youtube.com/watch?v=RxyQNEVOElU)

   Reflect on the content of the videos, then ask your science department chair or an instructional expert how the tenets of NOS are integrated in the science curriculum at your school or in your district.

2. Read Bloom et al. (2021). After reading, consider your own beliefs around an SSI (e.g., climate change, vaccines, evolution). From where do those beliefs come, and what evidence, if presented, would prompt you to adjust your thinking?

3. Reflect on how you respond to others in moments of conflict in the workplace. What are your strengths and weaknesses, and how does your approach shift when the conflict focuses on issues of teaching, learning, and curriculum? When it involves teachers, parents, students, or supervisors/persons in governance?

Building Leadership Content Knowledge (LCK)

When leaders lack understanding about content standards and discipline-specific pedagogy, they may struggle to engage as instructional leaders (Quebec Fuentes & Jimerson, 2020). Faced with political challenges, these leaders may fall back on strategies that placate complainants, but do not result in robust instruction. To interact with teachers and other stakeholders about content and pedagogy, leaders must develop leadership content knowledge (LCK), or "knowledge of academic subjects that is used by administrators when they function as instructional leaders" (Stein & Nelson, 2003, p. 423). Stein and Nelson explain that:

> All administrators have solid mastery of at least one subject (and the learning and teaching of it) and that they develop expertise in other subjects by postholing, that is, conducting in-depth explorations of an important but bounded slice of the subject, how it is learned and how it is taught. (p. 423)

This teaching case offers school leaders an opportunity to build knowledge around NOS and SSI, while exploring how they might learn and lead in situations that involve curricular challenges. Prior to becoming a school leader, Principal Young taught English, Speech, and Theatre. To be an effective instructional leader who can engage in conversations about content and pedagogy across the school curriculum, he must develop LCK in other content areas. In this case, he encounters a situation in which he needs to understand foundational aspects of science instruction in order to respond to parents.

School leaders can identify content areas in which they lack LCK, yet do not commonly make targeted efforts to address these gaps (Quebec Fuentes & Jimerson, 2020). How do school leaders, like Principal Young, posthole? School leaders can develop LCK by incorporating individually-driven practices and existing district structures (Jimerson & Quebec Fuentes, 2021a, 2021b; Quebec Fuentes & Jimerson, 2019).

School leaders can engage in purposefully-structured and individualized learning plans, such as the LCK Challenge (Quebec Fuentes, 2019). In alignment with the LCK Challenge, Principal Young could commit to learning about science instruction over the course of a year. He would start by speaking with science education experts, like Dr. Mathers and Mr. Jackson, to establish learning goals and make an action plan aligning with these goals. He could join the National Science Teaching Association (NSTA) and regularly read the practitioner-focused journal, The Science Teacher. He could also identify books to read that address his learning goals, such as Crosscutting Concepts: Strengthening Science and Engineering Learning (Nordine & Lee, 2021) and Science Denial: Why It Happens and What To Do About It (Sinatra & Hofer, 2021). Lastly, he could attend one of NSTA's national conferences. Bolstered by regular reflection and engagement with the science teachers at MHS, this process will strengthen Principal Young's ability to engage with parents and teachers around science instruction.

Schools also have existing structures that leaders can leverage to enhance their LCK (e.g., Ford et al., 2020; Jimerson & Quebec Fuentes, 2021a, 2021b). Principal Young leveraged one of these structures before responding to parent emails by observing a science lesson and debriefing with Dr. Mathers, Mr. Jackson, and Ms. Elliott. Principal Young could also choose to attend district-provided, science-focused professional development designed for teachers. As part of a Professional Learning Network, Principal Young could incorporate activities focused on building LCK for science teaching and learning. Participating in these kinds of intentional postholing cycles enables any school leader to build LCK across content areas over time.

SSI-Based Instruction

SSI are issues rooted in science that are of particular interest to society (e.g., cloning, global warming, stem cell research, alternative fuels, and captive breeding in zoos). SSI can be used in the classroom to help students learn about science that affects their current and future lives

(Sadler, 2004). SSI-based instruction roots science content in real-world problems to motivate student learning, resulting in increased scientific literacy skills. SSI are open-ended problems with no single scientific solution and with complex political, economic, moral, or ethical components.

SSI-based instruction can enhance student engagement, but teachers and leaders should understand how SSI can also highlight sensitive topics in the classroom. In this case, Ms. Elliott prepared the basic lesson, but had not anticipated the student responses. Her attempt at responding in the moment inadvertently seeded misunderstandings and the parent complaint. Values, beliefs, and political perspectives are factors that influence how citizens view science issues, but they can also make high-quality science instruction tricky. Science does not occur in a vacuum, and educators should be transparent in addressing and emphasizing these intersections in the classroom. Researchers are working to produce SSI-based instruction materials for the classroom due to many teachers reporting lack of time or resources to teach with SSI (Zeidler & Kahn, 2014); such resources will be helpful to teachers, but careful preparation and consideration of potential student responses will still be essential if teachers are going to successfully implement SSIbased instruction.

Leaders should not dissuade teachers from engaging students with timely, culturally-relevant, and evidence-based lessons. Engagement is key to learning (Marzano, 2017), and students will learn more when they connect content to their own experiences and feel their beliefs and cultures are respected in the context of instruction (Hammond, 2015). Robust science instruction may well invite challenges. But, hewing closely to standards and crafting evidence-based, engaging lessons that equip students as critical thinkers – rather than unquestioningly agreeing with their teachers or others – is a concept school leaders should stand behind as instructional leaders and supporters of teachers under their supervision.

Using NOS to Teach Sensitive Science Content

SSI-based instruction provides opportunities for students to explore NOS. NOS is “a critical component of scientific literacy that enhances students’ understandings of science concepts and enables them to make informed decisions about scientifically-based personal and societal issues” (NSTA, 2022, para. 1). Basic tenets of NOS include (McComas et al., 1998):

- **Empirical Evidence** - Scientific knowledge is based on empirical evidence (observable or measurable). Ways of knowing that lack empirical evidence may be religious (based on faith) or philosophical (based on laws of logic). However, NOS requires that scientific claims be rooted in empirical evidence.
- **Observations and Inferences** - Empirical evidence (observations), that forms the basis of scientific knowledge, help scientists form questions. Scientists use prior knowledge, experimental design, and further exploration to seek explanations (inferences). Observations are measurable, physical evidence (facts), while inferences are theoretical explanations of them.
- **Tentative** - Scientific knowledge can change with the acquisition of new evidence. Sometimes new discoveries require older scientific ideas to be discarded and replaced.

Other times, new evidence leads to improved understanding that alters and improves previous scientific claims.

- **Subjective or Theory Laden** - While many may consider science purely objective, in actuality, scientific claims are made in context of previously held scientific ideas and theories. Established understanding of the natural world influences how scientists interpret novel phenomena.
- **Creative** - Scientists draw upon their creativity to identify questions about the natural world, design experiments, form hypotheses, build explanatory theories, and solve scientifically-based problems.
- **Socially and Culturally Embedded** - Questions asked by scientists and ways in which answers are sought are guided by the cultural and socially accepted norms of communities in which scientists work. Social and cultural values dictate what scientifically-based problems ought to be solved.
- **Laws and Theories** - Scientists use observations of the natural world to develop laws, which describe or predict a range of phenomena (e.g., law of gravity). In contrast, theories are statements, based upon observations and experiments, that explain an aspect of the natural world (e.g., cell theory).

When leaders evaluate science teachers, especially when teachers are using SSI, they should be aware of the important role NOS plays. For example, one tenet of NOS is that scientific claims are tentative and subject to revision with new evidence (Lederman et al., 2002), but citizens can also have confidence in science because it continues to improve over time. Scientific claims are checked by peer review and tested by other scientists until a consensus is formed among the scientific community. This process leads to growing confidence in the consensus of the collective community of scientists around the world (Oreskes, 2014).

Teachers have to balance the need to present science as tentative without undermining students' confidence in scientific discoveries. To this end, research suggests that a blend of decontextualized instruction (e.g., the black box and puzzle activities included in the lesson plan) and contextualized instruction (e.g., grounding a lesson in SSI as Ms. Elliott attempted) would be helpful in developing NOS understanding in learners (e.g., Abd-El-Khalick, 2001; Clough 2006).

Courageous Curriculum Leadership

Though many yearn for education to be apolitical, schools exist in political contexts (Hallinger, 2018; Kaplan & Owings, 2021) and are influenced by those who engage in and with schools (students, educators, families, community members, and politicians), all of whom bring their own identities (including political and faith beliefs). In this case, Principal Young is caught up in a situation that is as much political as it is instructional, as one email includes charges of "indoctrination" and "pushing CRT." Even the positive emails note that the lesson in question was "political." School leaders may encounter anxiety in working through conflicts that are rooted in sociopolitical issues.

Heifetz and Linsky (2002) assert that leadership is dangerous, noting that leaders necessarily effect change, and with change comes a sense of loss among those who perceive their values, structures, or beliefs are being challenged. Where leaders press toward equity, inclusion, and culturally responsive curriculum, some perceive loss of control over the curriculum as they wish it to be taught. This sense of loss can elicit civil or even vitriolic pushback. Indeed, "who controls the curriculum" has been a source of enduring conflict in education, long predating the current spike in stories regarding book bans, censorship, and aspects of history highlighted, backgrounded, or ignored (Nelson et al., 2021).

The school leader's job is to ensure that doors of opportunity are opened for every child. This means that "educational leaders must be morally responsible, not only in preventing and alleviating harm" (Starratt, 2004, p. 49) but also in ensuring that all students experience standards-based, engaging, relevant instruction (Hammond, 2015; Marzano, 2017); are afforded equitable access to high-quality teaching (Khalifa et al., 2016; Theoharis, 2009; Theoharis & Brooks, 2012); experience evidence-based, discipline-appropriate pedagogy (Quebec Fuentes & Jimerson, 2019; Theoharis & Brooks, 2012); and are not marginalized or dissuaded from the fullness of participating in a classroom or school community (e.g., Khalifa et al., 2016; Theoharis, 2009; Theoharis & Brooks, 2012).

Starratt (2004) contends, "the leader is an educated person who continues to learn more about the human condition, about the social, political, cultural, and natural worlds that make up the curriculum the school intends to teach" (p. 50).

Culturally responsive leaders "create school contexts and curriculum that respond effectively to the educational, social, political, and cultural needs of students" (Khalifa et al., 2016, p. 1278). School leaders must be intentional in developing understanding about culturally responsive pedagogy (e.g., Hammond, 2015; Khalifa et al., 2016; Khalifa, 2018) and knowledge of content-area standards and approaches. This will not preclude conflict but will position leaders to engage as courageous and informed advocates for rigorous, standards-based curriculum and robust pedagogy in coaching conversations with teachers, dialogues with leadership teams, and discussions with parents and other stakeholders.

Suggested Application/Activities

1. If you were Principal Young, how would you respond to each parent email – by email, phone, invitation to in-person conference, etc.? What are the pros and cons of each approach? Once you have decided on an approach, enact that communication (i.e., draft the email and get feedback from a colleague, or role play the phone call or in-person conference). Did your choices achieve what you expected? What would change? Why?

2. Read EdWeek's Spotlight on Critical Race Theory (https://www.edweek.org/products/spotlight/spotlight-on-critical-race-theory), and discuss how and why Mrs. Driscoll might have perceived Ms. Elliott's lesson and comments to be "CRT." How do you explain areas of divergence and overlap among CRT, culturally responsive practice, and anti-racist education practices?

3. Role play how you would enact leadership in the following coaching conversation:

   An early career teacher approaches you after he taught a lesson on evolution by natural selection. He thought he presented the content well and that students understood, but several students were quite vocal in their disagreement with evolution. One said evolution was impossible if Earth was only 10,000 years old. The teacher is concerned that he has not heard the last of this. How will you support the teacher if you receive calls from angry parents demanding that students be taught "both sides" of the issue?

4. Choose a content area in which you want to build your LCK. Make and enact a plan for how you will develop your LCK over the next year, guided by the LCK challenge and existing structures in your context.

Discussion Questions

1. Assess the short- and long-term pros and cons of Principal Young supporting Mr. Jackson and Ms. Elliott in this case or directing them to refrain from engaging students around content related to race or other social/cultural/historical conversations. What would you have Mr. Jackson and Ms. Elliott do the next time students ask questions that connect course content to sociopolitical or historical issues? Why?

2. Consider your own beliefs around SSI. Are there any that would prove more difficult for you to address in a situation where a teacher needed support, or you were facing a parent or stakeholder concern? If so, consider the roots of these tensions, and reflect on how you could work to identify and bracket any implicit bias to support responsible, robust instruction? How does consideration of NOS impact your beliefs, tensions, or biases?

3. Identify two or three standards across the school curriculum that you expect could give rise to parent complaints or concerns, regardless of how well a teacher planned and implemented the lesson or learning activities. How might you prepare for and address the anticipated issues?

4. Ms. Elliott attempts to tackle an SSI and provide historical and social context for vaccine hesitancy, but in doing so makes assumptions about race and science. What are possible outcomes of how she initially handled Mark’s comment? Read more about anti-racist teaching in the area of STEM (start with the story and links provided at https://www.nsta.org/blog/building-anti-racist-scienceclassroom). Discuss how Ms. Elliott could have better responded in the moment to Mark’s comment. What approaches could Ms. Elliott and Mr. Jackson implement to enhance equity in the science classroom?

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Appendix A
Nature of Science Lesson Plan

Objective

Use decontextualized (black box and puzzle activities) and contextualized (COVID-19 articles and discussions) to introduce students the general tenets of nature of science: scientific methodology, empirical basis, tentativeness, natural causes, theories and laws, and science as a human endeavor.

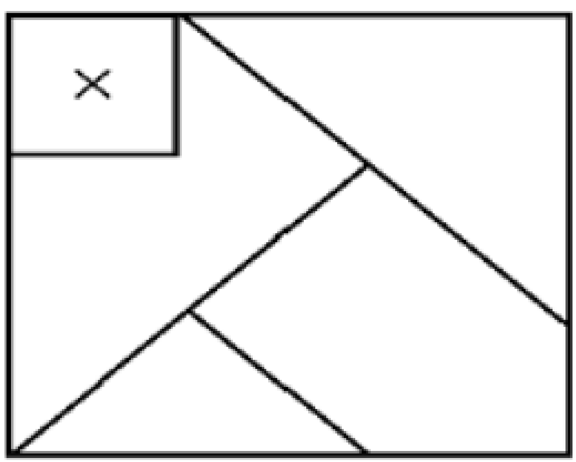
Engage

Open discussion about Nature of Science to the students with the following prompts:

- What is science?
- How do you think science is similar to or different from other subjects or disciplines?
- How do scientists arrive at the results and information they produce?
- Is science influenced by society? any other factors?

Explore

There are two activities to explore nature of science: the black box and the puzzle activities.
Prep: For the black box activity, each group needs a box they cannot see into that is filled with random objects. For the puzzle activity, each person needs the puzzle below printed out and the shapes cut out and placed into an envelope. Leave the square shape with the "X" out of the envelope for now.



Black Box Activity

Each group gets five minutes to figure out what is inside their box. You can smell, touch, hear, or see but not open the box. The group's goal is to figure out how many objects are in the box and what those objects could possibly be. Have groups take notes on their steps of what they do to figure out what is in the box. Discuss each group's notes/processes/objects as a class. Then have a discussion guided by the following questions:

- What steps did you take or what questions did you ask?
- Could you figure out what was in the box based off the questions you asked and the data you gathered?
- What tools could have helped?
- How is this similar to how scientists gather information and draw conclusions?

Puzzle Activity

Give each student an envelope with the four shapes in it (the square with the "X" should not be in the envelope). Each piece represents a piece of scientific information. Students should begin arranging the pieces together individually then they can start to discuss in small groups. Ask students why they made the shape they did and how they arrived at this shape.

Once each student has placed the puzzle together, give each student the small square shape with an "X" on it. Explain to the students a new scientific discovery has been made and this is their new piece of scientific information. Give students the chance to put this puzzle together before opening discussion by asking: How is this activity similar to doing science?

Explain

Discuss the basic understandings of NOS with students:

(NGSS Appendix H: Understanding the Scientific Enterprise – The Nature of Science)

- Scientific investigations use a variety of methods.
- Scientific knowledge is based on empirical evidence.
- Scientific knowledge is open to revision in light of new evidence.
- Scientific models, laws, mechanisms, and theories explain natural phenomena.
- Science is a way of knowing.
- Scientific knowledge assumes order and consistency in natural systems.
- Science is a human endeavor.
- Science addresses questions about the natural and material world.

Resource to relate the COVID-19 pandemic to some of these NOS understandings:

Shi, W. Z. (2022). Understanding the nature of science through COVID-19 reports. ***Nature Human Behavior***. https://doi.org/10.1038/s41562-022-01303-z

Elaborate (Expand)
Ask the groups to brainstorm about how these characteristics of NOS relate to the COVID-19 pandemic and give specific examples.

Possible examples could be:

- At first scientists did not think kids would get COVID-19 based on other coronaviruses in the past. However, in recent months we have seen it is possible for children to contract COVID-19. (tentativeness)
- At the beginning of the pandemic, the public was told masks were not needed. However, with more investigations and experiments scientists discovered we do need masks and social distancing. (tentativeness and empirical evidence)
- The Johnson and Johnson vaccine stopped production and distribution due to deaths in a specific population of recipients. After further investigation, scientists found it was due to certain medical conditions and suggested those with this condition get a different COVID-19 vaccine. (empirical evidence, human endeavor, and tentativeness)
- We did not have a vaccine for COVID-19 but the vaccine was created quickly within the same year the pandemic began. (creativity and peer review)
- COVID-19 testing was adapted from other PCR testing and rapid tests evolved over time as well. We now have at home tests which were not available throughout the beginning of the pandemic for the public. (creativity and variety of methods)

Evaluate
The following resource gives several examples of media reports about COVID-19 that can be used to help understand NOS and provides discussion questions for each:

Demirdögen, B., & Aydin-Günbatar, S. (2021). Teaching nature of science through the use of media reports on COVID-19. *Science Activities, 58*(3), 98-115.

Each group will be assigned an article about COVID-19 to read and discuss. Ask each group to determine how their article content is related to NOS and if they believe their source is reliable. They should discuss the questions about their article as a group. By the end of their discussion, students should be prepared to explain to the class how their article is related to NOS and provide support for their answers.

Group 1:
Evidence in the practice of science
Warm Weather and COVID-19 Transmission
https://www.sciencenews.org/article/coronavirus-warm-weather-will-not-slow-covid-19-transmission

- Which data did scientists have to claim that warm weather probably would not slow down COVID-19 transmission?
- How did they collect the data?
- Is there any information about the kind of evidence that scientists have: observational and experimental? Explain.

Group 2:
Science is not a solitary pursuit
Collaboration on the Vaccine Development Research
https://thepulse.org.au/2020/02/10/nsw-coronavirus-breakthrough-at-westmead-health-precinct/

- How did scientists conduct scientific inquiries for vaccine development?
- Did scientists conduct their research by themselves? Explain.
- Is there any evidence of collaboration and teamwork between the scientists? Explain.
- What are the areas of expertise of the scientists conducting investigation together for vaccine development?

Group 3:
The role of inference and difference between observation and inference
Retesting for COVID-19
https://edition.cnn.com/2020/04/17/health/south-korea-coronavirus-retesting-positive-intl-hnk/index.html

- What observations have been made about COVID-19?
- What are the corresponding inferences?
- How did scientists conduct observations (i.e., through their senses or the use of instruments)?
- Did the report explicitly use the terms ‘observation’ and ‘inference’? Explain.
- Is the difference between observation and inference clear in the report? Explain.

Group 4:
Tentativeness of scientific knowledge
From Epidemic to Pandemic
https://www.sciencenews.org/article/who-says-coronavirus-wuhan-china-outbreak-not-global-emergency-yet
https://www.sciencenews.org/article/who-declares-coronavirus-outbreak-global-public-health-emergency

- What claims are made or conclusions reached?
- Which data were collected?

https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19—11-march-2020

- Is there any evidence of a change (or possibility of change) in scientific knowledge? Explain.
- How did scientists categorize the outbreak as endemic first and pandemic later?

Group 5:
Evidence in the practice of science
Symptoms of COVID-19
https://www.washingtonpost.com/health/2020/04/27/six-new-coronavirus-symptoms/

- Which data were collected for determining COVID-19's symptoms?
- What is the evidence that supports the claims about COVID-19 and its symptoms?
- Do the data and evidence appear to justify the claims about COVID-19 and its symptoms? Explain.
- What are the limitations of the data and evidence used for COVID-19 and its symptoms?

Group 6:
There are social and cultural impacts on science and vice versa
U.S. Halts WHO Funding
https://www.bbc.com/news/world-us-canada-52289056

- Is there any evidence of scientific knowledge and technology being influenced by the social and cultural environment? Explain.
- Is there information about the social mechanisms through which scientists disseminate and certificate scientific knowledge mentioned in the media report (e.g., peer review systems of journals and conferences)? Explain.
- Is there information about social organizations where scientific investigations are conducted (e.g., universities and research institutes)? Explain.
- Is there information on how financial support is provided to the scientific investigation mentioned in the media report? Explain.

Questions for every group:
Scientific literacy for informed decision making

- To make an informed decision on this issue, what would you like to know and investigate?
- After reading this item, what would you like to know and investigate?
- After reading this article, what would you like to ask its author and the scientists who have done the research?