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The Challenge That's BIGGER THAN FAKE NEWS

CIVIC REASONING IN A SOCIAL MEDIA ENVIRONMENT

Private school choice—past and present

RANDI WEINGARTEN, AFT President

RECENTLY, I GAVE A SPEECH about ensuring that all children have access to a powerful, purposeful public education. At the exact same time, Education Secretary Betsy DeVos was addressing the American Legislative Exchange Council—a group of corporate lobbyists and conservative legislators who are working to privatize and defund public education, and cloaking their efforts as school "choice."

It's no surprise. No matter the question, for DeVos, the answer is choice. When schools struggle, privatization advocates invariably propose choice as the solution, with the coda that poor families should have the same educational choices as more affluent families. But that innocuous word belies the record—both the academic results of private school choice and the way it was used historically to continue school segregation after the Supreme Court ruled it was unconstitutional.

After the *Brown v. Board of Education* decision, many school districts, especially in the South, resisted integration. White officials in Prince Edward County, Virginia, for example, closed every public school in the district rather than have white and black children go to school together. They opened taxpayer-funded private schools where only white parents could choose to send their children.

Members of the American Federation of Teachers sent funds and school supplies to set up schools for black students, and some traveled from New York and Philadelphia to help. Their activism was in keeping with the AFT's long history of fighting racism and injustice—a history that includes expelling our local unions that refused to integrate.

And what about the schools DeVos appallingly called "pioneers of school choice"—historically black colleges and universities? HBCUs are vital institutions, but the truth is that they arose from the discriminatory practices that denied black students access to higher education. The real "pioneers" of private school choice were the white politicians who resisted school integration.

DeVos's preferred choices—tuition vouchers and tax credits, and private, for-profit charter schools—actively destabilize our public schools. They can—and many do—discriminate, because private schools do not follow federal civil rights laws. They drain funds from public schools and increase racial and economic segregation. They lack the accountability that public schools have. And, after decades of experiments with voucher programs, the research is clear: they fail most of the children they purportedly are intended to benefit—children who are disproportionately black or brown, and poor.

But President Trump and DeVos are not backing off their support for vouchers, for-profit charters, and other privatization schemes. They have proposed spending billions of tax dollars on vouchers and tuition tax credits, paid for by cutting federal education spending that goes directly to educate children in public schools by $9 billion.

Make no mistake: this use of privatization and this disinvestment are only slightly more polite cousins of segregation. The same forces are keeping the same children from getting the public education they need and deserve. And how better to pave the way to privatize public education than to starve public schools to the breaking point, criticize their deficiencies, and let the market handle the rest—all in the name of choice.

That's how a democracy comes apart. The bigotry and hatred on display in Charlottesville, the president's failure to unequivocally denounce it, and threats to deport young people who have made their lives in the United States remind us of our nation's many unhealed wounds—and of the importance of our public schools in uniting us.

Public schools are not perfect, and every one doesn't always work for every one of its students. But, as far as I am concerned, our only choice is: Do we, as a nation, strengthen and improve our public schools, or don't we?

> **Undermining public education is how a democracy comes apart.**

We know what works to accomplish this: investment in and a focus on the four pillars of powerful, purposeful public education. These pillars are children's well-being, powerful learning, educators' capacity, and collaboration. They are in place in every public school that is working as it should, and they can and should be present in every school.

Defenders of democracy must not only call out what doesn't work and resist injustice, but also fight to reclaim the promise of public schools. That is the objective of the NAACP's Task Force on Quality Education, which recently released a report calling for more equitable and adequate funding for schools serving students of color, investing in low-performing schools and schools with significant opportunity and achievement gaps, mandating a rigorous authorizing and renewal process for charter schools, and eliminating for-profit charter schools.

The NAACP caught flak from some privatizers who have attempted to cast themselves as the new civil rights movement. And, not surprisingly, DeVos went on the attack after my speech. But those who truly want to ensure that all children have access to the great education they need—not by chance, not by choice, but by right—will fight to make every public school a place where parents want to send their children, students are engaged, and teachers want to teach.

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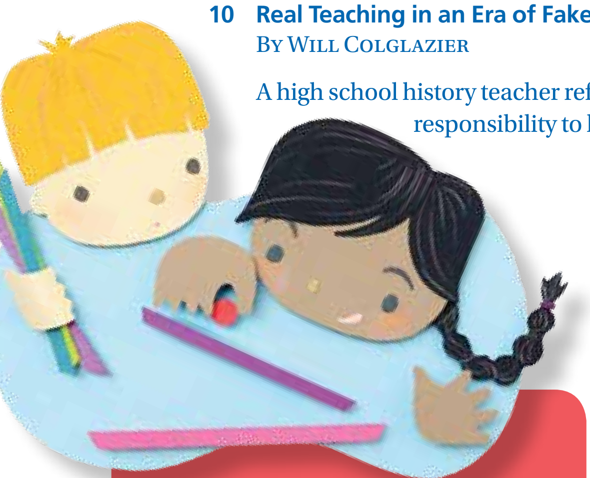

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Current Events in the Classroom

ENSURING OUR CHILDREN BECOME KNOWLEDGEABLE and engaged citizens is critical for their success and our country's future. With "fake news" being broadcast as fact, and with access to vast amounts of information on social media, students face an ever-growing challenge to discern what is true.

Educators must actively cultivate students' curiosity about what's in the news and teach them the critical-thinking skills required to zero in on what is accurate and responsible journalism. To that end, Share My Lesson has partnered with reputable news organizations to bring broadcast and audio stories into the classroom and to provide webinars and lesson plans on how to be a discerning news consumer.

Get Them Hooked

A news story designed for classroom use should capture students' attention, inspire discussion, and ultimately get them hooked on the news. For educators looking to seamlessly fit a discussion of current events into their classrooms, Share My Lesson's "Today's News, Tomorrow's Lesson" collection delivers three- to five-minute news stories, with accompanying text, questions, and short activities, on a daily basis from PBS NewsHour Extra, Listenwise, and Science Friday.

Fact vs. "Fake News"

Media literacy is not something students are born with; assessing various types of media must be learned. Students need instruction and opportunities to practice deciphering fact from fake news. In general, evaluating the veracity of a story requires asking some foundational questions: Who is the source of the information? Does the story have strong evidence? Are other reliable sources sharing similar information? A student may also need to learn how to pose more detail-oriented questions: Is this the most up-to-date and informed report? Does this source offer contact information? What kinds of ads appear on the web page or take place during commercials?

The Newseum, the Stanford History Education Group (whose work is featured on page 4 of this issue), and PBS NewsHour Extra all have prerecorded webinars for teachers on media literacy. PBS NewsHour Extra also offers a lesson plan for students in grades 7 to 12 called "How to Teach Your Students about Fake News." On Share My Lesson, teacher Barbara Tutino's lesson "The Trouble with Reality—Fake News" uses text, video, and Twitter examples to help students separate rhetoric from reality.

Keeping It Civil: Classroom Discussions

Staying up to date on current events empowers students to intelligently discuss what's going on in the world. Within a classroom, watching students share their knowledge can be both exhilarating and nerve-racking—what if things get too heated?

Allowing students to reflect on current events supports their development as responsible citizens. But setting boundaries for discussion is just as important. Doing so can encourage students to express themselves, since they know what is expected of them and their peers. Teaching Tolerance's "Civil Discourse in the Classroom" is an invaluable resource on the subject that includes everything from how the historic role of civil discourse has shaped our country to how to effectively create and defend an argument.

It goes without saying that news events are bound to create emotional situations. And unless we teach students how to express themselves in respectful ways, their voices won't be heard.

–THE SHARE MY LESSON TEAM

Recommended Resources

- "Today's News, Tomorrow's Lesson": **http://go.aft.org/AE317sml1**
- "How to Spot Fake News and Train Students to Be Educated News Consumers": **http://go.aft.org/AE317sml2**
- "Judging Fact, Fiction, and Everything In-Between: Teaching Media Literacy": **http://go.aft.org/AE317sml3**
- "How to Teach Your Students about Fake News": **http://go.aft.org/AE317sml4**
- "The Trouble with Reality—Fake News": **http://go.aft.org/AE317sml5**
- "Civil Discourse in the Classroom": **http://go.aft.org/AE317sml6**

Looking for a particular set of resources? Send an e-mail to **help@sharemylesson.com**.

The Challenge That's

Bigger Than Fake News

Civic Reasoning in a Social Media Environment

ILLUSTRATIONS BY VIKTOR KOEN

BY SARAH MCGREW, TERESA ORTEGA, JOEL BREAKSTONE, AND SAM WINEBURG

Since the November 2016 presidential election, coverage of "fake news" has been everywhere. It's hard to turn on the TV without hearing the term. Google and Facebook have pitched plans for fighting the menace.[1] State legislators have even introduced bills to mandate K–12 instruction on the topic.[2]

Fake news is certainly a problem. Sadly, however, it's not our biggest. Fact-checking organizations like Snopes and PolitiFact can help us detect canards invented by enterprising Macedonian teenagers,[3] but the Internet is filled with content that defies labels like "fake" or "real." Determining who's behind information and whether it's worthy of our trust is more complex than a true/false dichotomy.

For every social issue, there are websites that blast half-true headlines, manipulate data, and advance partisan agendas. Some of these sites are transparent about who runs them and whom they represent. Others conceal their backing, portraying themselves as grassroots efforts

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when, in reality, they're front groups for commercial or political interests. This doesn't necessarily mean their information is false. But citizens trying to make decisions about, say, genetically modified foods should know whether a biotechnology company is behind the information they're reading. Understanding where information comes from and who's responsible for it are essential in making judgments of credibility.

The Internet dominates young people's lives. According to one study, teenagers spend nearly nine hours a day online.[4] With optimism, trepidation, and, at times, annoyance, we've witnessed young people's digital dexterity and astonishing screen stamina. Today's students are more likely to learn about the world through social media than through traditional sources like print newspapers.[5] It's critical that students know how to evaluate the content that flashes on their screens.

Unfortunately, our research at the Stanford History Education Group demonstrates they don't.* Between January 2015 and June 2016, we administered 56 tasks to students across 12 states. (To see sample items, go to http://sheg.stanford.edu.) We collected and analyzed 7,804 student responses. Our sites for field-testing included middle and high schools in inner-city Los Angeles and suburban schools outside of Minneapolis. We also administered tasks to college-level students at six different universities that ranged from Stanford University, a school that rejects 94 percent of its applicants, to large state universities that admit the majority of students who apply.

When thousands of students respond to dozens of tasks, we can expect many variations. That was certainly the case in our experience. However, at each level—middle school, high school, and college—these variations paled in comparison to a stunning and dismaying consistency. Overall, young people's ability to reason about information on the Internet can be summed up in two words: *needs improvement*.

Our "digital natives"† may be able to flit between Facebook and Twitter while simultaneously uploading a selfie to Instagram and texting a friend. But when it comes to evaluating information that flows through social media channels, they're easily duped. Our exercises were not designed to assign letter grades or make hairsplitting distinctions between "good" and "better." Rather, at each level, we sought to establish a reasonable bar that was within reach of middle school, high school, or college students. At each level, students fell far below the bar.

Determining who's behind information and whether it's worthy of our trust is more complex than a true/false dichotomy.

In what follows, we describe three of our assessments.[6] Our findings are troubling. Yet we believe that gauging students' ability to evaluate online content is the first step in figuring out how best to support them.

Assessments of Civic Online Reasoning

Our tasks measured three competencies of civic online reasoning—the ability to evaluate digital content and reach warranted conclusions about social and political issues: (1) identifying who's behind the information presented, (2) evaluating the evidence presented, and (3) investigating what other sources say. Some of our assessments were paper-and-pencil tasks; others were administered online. For our paper-and-pencil assessments, we used screenshots of tweets, Facebook posts, websites, and other content that students encounter online. For our online tasks, we asked students to search for information on the web.

Who's Behind the Information?

One high school task presented students with screenshots of two articles on global climate change from a national news magazine's website. One screenshot was a traditional news story from the magazine's "Science" section. The other was a post sponsored by an oil company, which was labeled "sponsored content" and prominently displayed the company's logo. Students had to explain which of the two sources was more reliable.

Native advertisements—or ads craftily designed to mimic editorial content—are a relatively new source of revenue for news outlets.[7] Native ads are intended to resemble the look of news stories, complete with eye-catching visuals and data displays. But, as with all advertisements, their purpose is to promote, not inform. Our task assessed whether students could identify who was behind an article and consider how that source might influence the article's content. Successful students recognized that the oil company's post was an advertisement for the company itself and reasoned that, because the company had a vested interest in fossil fuels, it was less likely to be an objective source than a news item on the same topic.

We administered this task to more than 200 high school students. Nearly 70 percent selected the sponsored content (which contained a chart with data) posted by the oil company as the more reliable source. Responses showed that rather than considering the source and purpose of each item, students were often taken in by the eye-catching pie chart in the oil company's post. Although there was no evidence that the chart represented reliable data, students concluded that the post was fact-based. One student wrote that the oil company's article was more reliable because "it's easier to understand with the graph and seems

*The Stanford History Education Group offers free curriculum materials to teachers at http://sheg.stanford.edu. Our curriculum and assessments have more than 4 million downloads. We initiated a research program about students' civic online reasoning when we became distressed by students' inability to make the most basic judgments of credibility.

†For more about the myth of "digital natives," see "Technology in Education" in the Spring 2016 issue of *American Educator*, available at www.aft.org/ae/spring2016/debruyckere-kirschner-and-hulshof.

more reliable because the chart shows facts right in front of you." Only 15 percent of students concluded that the news article was the more trustworthy source of the two. A similar task designed for middle school students yielded even more depressing results: 82 percent of students failed to identify an item clearly marked "sponsored content" as an advertisement. Together, findings from these exercises show us that many students have no idea what sponsored content means. Until they do, they are at risk of being deceived by interests seeking to influence them.

Evaluating Evidence

A task for middle school students tapped their ability to evaluate evidence. The Internet is filled with all kinds of claims—some backed by solid evidence and others as flimsy as air. Such claims abound in the comment sections of news articles. As online news sites have proliferated, their accompanying comment sections have become, as it were, virtual town halls, where users not only read, but debate, challenge, react, and engage publicly with fellow commenters. Our exercise assessed students' ability to reason about the factors that make an online comment more or less trustworthy (see Sample Item below).

Students examined a comment posted on a news article about healthcare. We asked if they would use the information in a research paper. To be successful, students needed to recognize that they knew nothing about the commenter, "Joe Smith," and his motivations for writing. Was he an expert on healthcare policy? Did he work for the Department of Health and Human Services? Adding to the dubiousness of Joe Smith's comment was the fact that he provided no citation or links to support his claims. Without a sense of his credentials or the source for his statistics, the information he provided was virtually worthless.

Despite the many reasons to be skeptical, more than 40 percent of 201 middle school students said they would use Joe Smith's information in a research paper. Instead of asking themselves whether the evidence he provided was sound, students saw a match between the information he presented and the topic at hand. They credulously took the numbers he provided at face value. Other students were entranced by the semblance of data in the comment and argued that the many statistics made the information credible. One student wrote that she would use the comment's information "because the person included statistics that make me think this source is reliable." Many middle school students, it seems, have an unflinching belief in the value of statistics—regardless of where the numbers come from.

Seeking Additional Sources

Another task tapped students' ability to investigate multiple sources to verify a claim. Administered online, this task directed college students (as well as a group of Advanced Placement high school students) to an article on minimumwage.com about wages in the Danish and American fast-food industries. The article claimed that paying American workers more would result in increased food prices and unemployment. Students could consult any online source to determine whether the website was a reliable source of information on minimum wage policy.

The article bears all the trappings of credibility. It links to reports by the *New York Times* and the *Columbia Journalism Review*. It is published on a professional-looking website that features "Research" and "Media" pages that link to reports and news articles. The "About" page says it is a project of the Employment Policies Institute, "a non-profit research organization dedicated to studying public policy issues surrounding employment growth." If students follow the link to the institute's website (www.epionline.org), they encounter an even sleeker site with more research reports.

Indeed, if students never leave minimumwage.com or epionline.org, they are almost guaranteed to remain ignorant of the true authors of the sites' content. To evaluate the article and the website on which it appears, students needed to leave those two sites and investigate what other sources had to say. If they did so, they likely learned that the institute is "run by a public relations firm

Sample Item
Evaluating Online Comments

This post appeared in the comments section of a news article about the U.S. healthcare system:

Joe Smith

Percentage of men and women who survived cancer five years after diagnosis:

U.S. 65%
England 46%
Canada 42%

Percentage of patients diagnosed with diabetes who received treatment within six months:

U.S. 93%
England 15%
Canada 43%

Percentage of seniors needing hip replacement who received it within six months:

U.S. 90%
England 15%
Canada 43%

You come across this comment while researching the U.S. healthcare system for a research paper. Would you use this information in your paper? Why or why not? ____

that also represents the restaurant industry," and that the owner of that firm has a record of creating "official-sounding nonprofit groups" to promote information on behalf of corporate clients.[8]

Fifty-eight college students and 95 Advanced Placement U.S. history students completed this task. A mere 6 percent of college students and 9 percent of high school students identified the true backers of this article. The vast majority—college and high school students alike—accepted the website as trustworthy, citing its links, research, and parent group as reasons to trust it. As one student wrote: "I read the 'About Us' page for MinimumWage.com and also for the Employment Policies Institute. The Institute sponsors MinimumWage.com and is a non-profit research organization dedicated to studying policy issues surrounding employment, and it funds nonpartisan studies by economists around the nation. The fact that the organization is a non-profit, that it sponsors nonpartisan studies, and that it contains both pros and cons of raising the minimum wage on its website, makes me trust this source."

Cloaked sites like epionline.org abound on the web. These professional-looking sites with neutral descriptions advocate on behalf of their parent organizations while actively concealing their true identities and funding. Our task shows how easily students are duped by these techniques.

Where to Go from Here?

Our findings show that many young people lack the skills to distinguish reliable from misleading information. If they fall victim to misinformation, the consequences may be dire. Credible information is to civic engagement what clean air and water are to public health. If students cannot determine what is trustworthy—if they take all information at face value without considering where it comes from—democratic decision-making is imperiled. The quality of our decisions is directly affected by the quality of information on which they are based.

What should we do? A quick survey of resources available on the web shows a surfeit of materials, all of which claim to help students evaluate digital information.

Many of these resources share something in common: they provide checklists to help students decide whether information should be trusted. These checklists range in length from 10 questions to sometimes as many as 30.[9] Short or long, checklist approaches tend to focus students on the most easily manipulated surface features of websites: Is a contact person provided for the article? Are sources of information identified? Are there spelling or grammatical errors? Are there banner ads? Does the domain name contain the suffix ".org" (supposedly more reliable than ".com")?

Even if we set aside the concern that students (and the rest of us) lack the time and patience to spend 15 minutes answering lists of questions before diving into a website, a larger problem looms. Providing an author, throwing up a reference list, and ensuring a site is free of typos hardly establishes it as a credible source. One could contend that in years past, the designation ".org" (for a mission-driven organization) could be trusted more than ".com" (for a profit-driven company), but that's no longer the case. Practically any organization, legitimate or not, can obtain a ".org" domain name. In an Internet characterized by polished web design, search-engine optimization, and organizations vying to appear trustworthy, such guidelines create a false sense of confidence. In fact, checklists may make students *more* vulnerable to scams, not less.

The checklist approach falls short because it underestimates just how sophisticated the web has become. Worse, the approach trains students' attention on the website itself, thus cutting them off from the most efficient route to learning more about a site:

Our findings show that many young people lack the skills to distinguish reliable from misleading information.

finding out what the rest of the web has to say (after all, that's why we call it a *web*). In other words, students need to harness the power of the web to evaluate a single node in it. This was the biggest lesson we learned by watching expert fact checkers as they evaluated unfamiliar web content.

We interviewed journalists and fact checkers at some of the nation's most prestigious news and fact-checking organizations as they vetted online content in real time.[10] In parallel, we observed undergraduates at the nation's most selective university, Stanford, and college professors at four-year institutions in California and Washington state as they completed the same set of online tasks. There were dramatic differences between the fact checkers and the other two groups.

Below, we describe some of the most powerful strategies employed by fact checkers and how educators can adapt them to help our students become savvy web users. (For examples of classroom activities that incorporate these strategies, see the box on page 9.)

1. ***Teach students to read laterally.*** College students and even professors approached websites using checklist-like behaviors: they scanned up and down pages, they commented on site design and fancy logos, they noted ".org" domain names, and they examined references at the bottom of a web article. They often spent a great deal of time reading the article, evaluating the information presented, checking its internal logic, or comparing what they read to what they already knew. But the "close reading" of a digital source, the slow, careful, methodical review of text online—when one doesn't even know if the source can be trusted (or is what it says it is)—proves to be a *colossal* waste of time.

   Fact checkers approached unfamiliar content in a completely different way. They read *laterally*, hopping off an unfamiliar site almost immediately, opening new tabs, and investigating outside the site itself. They left a site in order to learn more about it. This may seem paradoxical, but it allowed fact checkers to leverage the strength of the entire Internet to get a fix on one node in its expansive web. A site like epionline.org stands up quite well to a close internal inspection: it's well designed, clearly and convincingly written (if a bit short on details), and links to respected journalistic outlets. But a bit of lateral reading paints a different picture. Multiple stories come up in a search for the Employment Policies Institute that reveal the organization (and its creation, minimumwage.com) as the work of a Washington, D.C., public relations firm that represents the hotel and restaurant industries.
2. ***Help students make smarter selections from search results.*** In an open search, the first site we click matters. Our first impulse might send us down a road of further links, or, if we're in a hurry, it might be the only venue we consult. Like the rest of us, fact checkers relied on Google. But instead of equating placement in search results with trustworthiness (the mistaken belief that the higher up a result, the more reliable), as college students tend to do,[11] fact checkers understood how easily Google results can be gamed. Instead of mindlessly clicking on the first or second result, they exhibited *click restraint*, taking their time on search results, scrutinizing URLs and snippets (the short sentence accompanying each result) for clues. They regularly scrolled down to the bottom of the results page, sometimes even to the second or third page, before clicking on a result.
3. ***Teach students to use Wikipedia wisely.*** You read right: Wikipedia. Fact checkers' first stop was often a site many educators tell students to avoid. What we should be doing instead is teaching students what fact checkers know about Wikipedia and helping them take advantage of the resources of the fifth-most trafficked site on the web.[12]

   Students should learn about Wikipedia's standards of verifiability and how to harvest entries for links to reliable sources. They should investigate Wikipedia's "Talk" pages (the tab hiding in plain sight next to the "Article" tab), which, on contentious issues like gun control, the status of Kashmir, waterboarding, or climate change, are gold mines where students can see knowledge-making in action. And they should practice using Wikipedia as a resource for lateral reading. Fact checkers, short on time, often skipped the main article and headed straight to the references, clicking on a link to a more established venue. Why spend 15 minutes having students, armed with a checklist, evaluate a website on a tree octopus (www.zapatopi.net/treeoctopus) when a few seconds on Wikipedia shows it to be "an Internet hoax created in 1998"?

While we're on the subject of octopi: a popular approach to teaching students to evaluate online information is to expose them to hoax websites like the Pacific Northwest Tree Octopus. The logic behind this activity is that if students can see how easily they're duped, they'll become more savvy consumers. But hoaxes constitute a miniscule fraction of what exists on the web. If we limit our digital literacy lessons to such sites, we create the false impression that establishing credibility is an either-or decision—if it's real, I can trust it; if it's not, I can't.

Instead, most of our online time is spent in a blurry gray zone where sites are real (and have real agendas) and decisions about whether to trust them are complex. Spend five minutes exploring any issue—from private prisons to a tax on sugary drinks—and you'll find sites that mask their agendas alongside those that are forthcoming. We should devote our time to helping students evaluate such sites instead of limiting them to hoaxes.

The senior fact checker at a national publication told us what she tells her staff: "The greatest enemy of fact checking is hubris"—that is, having excessive trust in one's ability to accurately pass judgment on an unfamiliar website. Even on seemingly innocuous topics, the fact checker says to herself, "This seems official; it may be or may not be. I'd better check."

The strategies we recommend here are ways to fend off hubris. They remind us that our eyes deceive, and that we, too, can fall prey to professional-looking graphics, strings of academic references, and the allure of ".org" domains. Our approach does not turn students into cynics. It does the opposite: it provides them with a dose of humility. It helps them understand that they are fallible.

> Our eyes deceive, and we can fall prey to professional-looking graphics, strings of academic references, and the allure of ".org" domains.

The web is a sophisticated place, and all of us are susceptible to being taken in. Like hikers using a compass to make their way through the wilderness, we need a few powerful and flexible strategies for getting our bearings, gaining a sense of where we've landed, and deciding how to move forward through treacherous online terrain. Rather than having students slog through strings of questions about easily manipulated features, we should be teaching them that the World Wide Web is, in the words of web-literacy expert Mike Caulfield, "a web, and the way to establish authority and truth on the web is to use the web-like properties of it."[13] This is what professional fact checkers do.

It's what we should be teaching our students to do as well. ☐

(Endnotes on page 39)

Activities to Try in Your Classroom:

Model Lateral Reading

Show students an article on minimumwage.com (we recommend "Denmark's Dollar Forty-One Menu"). Ask them to spend a few minutes deciding whether it is a reliable source of information on the minimum wage, and tell them they can use any online resources to help them. Then, model how you would approach the site by demonstrating lateral reading. Based on our experience, students will be surprised at what you find—and at how their favored methods of evaluation fail them.

Compare Search Results

Begin by asking students how they decide which search results to click (some students may admit to always clicking on the first one!). Tell students that many people erroneously think search results are ranked entirely on the reliability of the websites. Explain that a better strategy is to quickly scan the URLs and snippets of search results to decide where to click first. Then, ask students to work in groups to analyze the results of different searches: they should investigate both the website that comes up first and another site using the strategy you taught them. Have them compare the sites and share what they learned with the rest of the class.

Analyze Wikipedia

Pick a topic that you've covered in class—something that you're confident students have knowledge about. Ask students to read both the Wikipedia entry (or part of it) and an encyclopedia's description of the same topic. Then, lead a class discussion to compare the texts. Support students in considering multiple factors, including the depth and quality of coverage, authority of the authors, references, and opportunities provided by the texts to learn more. Finish by asking students to reflect on what they learned about Wikipedia and whether anything about the comparisons surprised them. Share with students the results of a study that appeared in the prestigious journal *Nature*, which found that the average Wikipedia scientific entry contained four errors. Let them know that the same study showed that *Encyclopedia Britannica*, considered the world's top reference authority, contained, on average, three errors per entry.

–S.M., T.O., J.B., and S.W.

Real Teaching *in an Era of* Fake News

BY WILL COLGLAZIER

Against the backdrop of our country's current political climate, I sometimes wonder if I'm doing my job as a high school history teacher to the best of my ability. I don't see my role as simply covering what's in the textbook or helping students analyze current events. Rather, I believe it's my professional responsibility—my civic duty—to teach students the democratic ideals necessary for an enlightened citizenry.

This statement may sound dramatic, but it's something that has often come to mind since I saw the play *Hamilton* last spring. Wowed by the grand themes of grit, democracy, identity, and agency, I experienced a moment of self-doubt common to many caring educators: Am I doing enough to prepare my students for life after school? As the education writer Denise Clark Pope claims, many students are merely "doing school," so am I only "doing teaching"?

I'd like to think my focus on explicitly teaching the elements of argumentation is one way I can keep students and myself from merely "doing school." By helping them learn to make a valid claim, marshal evidence in support of it, and critique others' views, I'm imparting to students some of the real-world knowledge and skills they will need to succeed not only in college and in career but also in an increasingly uncertain world.

* * *

"How do you know what you know?" The question intrigued me when I took Sam Wineburg's social studies methods class in the summer of 2005, while I was enrolled in the Stanford Teacher Education Program. It wasn't until Wineburg's class that I realized I had never before been asked to explicitly discern reliable evidence from suspect evidence, even as a history major at the University of Virginia.

Wineburg took the class through a series of investigations—Where did Rosa Parks sit? Who fired the first shot at Lexington? Why were Japanese Americans interned?—and, in so doing, opened up a whole new way to teach. Instead of straight lectures about the facts or how one should interpret a historical event or modern-day policy issue, I learned to teach through inquiries. Questions would soon anchor my lessons instead of content memorization before regurgitation.

Hired to teach U.S. history at Aragon High School in the San Francisco Bay Area, I introduced my students to this approach. My hope was that I could share my passion and knowledge of history through questions that students would begin to recognize as vital for historical analysis and crucial for navigating present-day controversies that affected their day-to-day lives. If they asked whether Pocahontas saved Captain John Smith's life and thoroughly researched that question, I assumed they would be able to take the same approach to deciphering whether vaccines would save their future children. My assumption, however, proved a bit misguided.

I found that some of my highly skilled students were able to decipher credible information but other students were not. Why? To some degree, I was to blame. I had spent countless hours creating documents that allowed my students to access and wrestle with a historical controversy. But for the sake of brevity and clarity, I kept excerpts of documents to only a few hundred words, provided header notes that explained sourcing information and relevant historical context, and included guiding questions. My scaffolds, though, did not mimic the real-world scenario my students experienced when they went online. Was President Obama really born in Kenya? Websites that perpetuated the myth that he was did not acknowledge on their "about us" page that they were created by partisan snake-oil salesmen allergic to credible evidence.

If I were going to help my students decipher fact from fiction online, I would need to explicitly teach them how to discern who is behind information online, analyze the evidence presented, and cross-check information with other sites. While this approach might seem obvious, it took a decade of teaching since I had taken Wineburg's class to figure out.

Ten years into the development of my craft, I began the difficult but necessary process of retooling my curriculum. With the support of Sarah McGrew (the lead author of the article on page 4 of this issue) as well as one-to-one computing support from my school district, which gave me computers for my class, I got to work.

"Fudge-nuggets!" Two years ago, that was the response from one of my most successful students. Why the outburst? I had given him, along with my more than 90 Advanced Placement (AP) U.S. history students, the minimum-wage task referenced in McGrew's article. Essentially, I had directed students to "Denmark's Dollar Forty-One Menu," an article on minimumwage.com, and asked them if it was a reliable source for information about the minimum wage. And it wasn't easy for them to tell if it was.

I wanted to see if they could, with the World Wide Web at their fingertips, figure out that a hotel and restaurant lobbyist had created the "nonprofit" website that conveniently claimed an increase in the

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ILLUSTRATION BY VIKTOR KOEN

minimum wage would lead to higher prices and unemployment. Needless to say, the student who shouted "Fudge-nuggets!" was duped, along with a majority of my AP students. When I showed them who was behind the website and how I went about finding out, they were surprised and somewhat embarrassed they had initially considered the site credible.

I realized then and there that I can't lament my students' inability to decipher fake news if I haven't given them a chance to practice doing it.

So I continued to experiment. In the next unit, on the 1920s through World War II, I deleted the multiple-choice question on my summative test on why Italian immigrants Nicola Sacco and Bartolomeo Vanzetti were executed in 1927. The answer: contextual prejudice against radicals and immigrants during the Red Scare post–World War I. But in place of circling a bubble on a Scantron sheet, I created a Google form. I sent my students to an article online (available at www.nodeathpenalty.org/new_abolitionist/august-2002-issue-25/sacco-and-vanzetti) and asked them if this is or is not a reliable source to determine if Sacco and Vanzetti were guilty. I told them they could search anywhere online for their answer.

As with many historical events, there are multiple perspectives on the Sacco and Vanzetti case. Successful students recognized the controversy and questioned the objectivity and expertise of nodeathpenalty.org, while at the same time finding different, more scholarly sites to support both a guilty and an innocent verdict.

With my new approach, my students performed admirably. While by no means perfect, they did show significant improvement from the minimumwage.com assessment, as they were practicing the three explicit strategies I modeled. First, I showed them how to read *laterally* by leaving the website and seeing what other sites say about the site they found themselves on. Professional fact checkers use this tactic rather than reading vertically, which is essentially reading the article before finding their bearings about the site they were on.

Second, I encouraged them to move beyond the "about us" page, to recognize the inherent bias in a description of an organization written by the very organization one is trying to vet. Third, when searching for information about an organization, I emphasized the importance of scrolling through the search results, using even the second or—*gasp!*—third page of search results before clicking on a site. When I did this, my students were incredulous at first; they seemed to fear I would break the Internet! But their reaction made sense, because no one had modeled for them why such an approach was necessary.

In addition to formative assessments like the minimumwage.com one and summative assessments like the Sacco and Vanzetti one, I found that educators like me were lacking curricula that embedded online investigations. Instead of tossing out lessons I've used for years, I found that a better approach was to modify them to include opportunities to teach students how to discern credible content online.

> If I were going to help my students decipher fact from fiction online, I would need to explicitly teach them.

For example, I tweaked an online lesson I had created years before, on whether President Franklin D. Roosevelt allowed the bombing of Pearl Harbor to happen (see www.bit.ly/2wGdEAK). Document #1 was a diary entry that Secretary of War Henry Stimson wrote two weeks before the "day of infamy," alluding to the fact not only that FDR knew a Japanese attack was probable, but that he wanted to "maneuver them into the position of firing the first shot" to convince Americans to support a U.S. entry into World War II. The lesson included other materials: a declassified Japanese telegram, a History Channel documentary clip, and two accounts from noted historians.

But instead of stopping the lesson there, as I had done for years, I was only at the midpoint. Rather than merely asking students, hypothetically, "Which sources do you wish you had to further answer the central question?," I unleashed students onto, as I joke, "the Google machine." The task was to find a site that answered the central question about whether FDR allowed the Pearl Harbor attack to happen. The students had to source the site and information for reliability, using the techniques explicitly modeled after the minimumwage.com assessment.

* * *

By teaching students how to decipher credible information, educators can empower them with what the authors on page 4 call "civic online reasoning" skills. For years, I had inadvertently robbed my students of the chance to practice and develop these skills, when I merely provided them teacher-vetted lists of sites to use in researching various topics.

But these strategies don't just apply to history, and they're not ones that need to wait until students reach high school. They can work in many disciplines where students must learn how to separate fact from fiction. For instance, students in science classrooms could investigate answers to phenomena online and wrestle with divergent opinions on important issues such as GMO (genetically modified organism) food production, stem cell research, or global warming. Because students in English classrooms engage in evidence and analysis with literary and nonfiction texts, it would be natural for teachers to extend lessons to incorporate online research opportunities. And students in math classrooms should have numerous opportunities to go online to examine the misuse and manipulation of numerical data.

While the upsurge of fake news in the past year sadly isn't a new phenomenon in American or human history, the Internet has emboldened its perpetrators and expanded their influence. In May, I came across the *New York Times* article "Climate Science Meets a Stubborn Obstacle: Students." The article recounted the experience of a biology teacher in Ohio who was confronted with skeptical students, a majority of whom thought he was "wasting their time" with evidence of man-made global warming. One parent even went so far as to say the teacher was "brainwashing" his daughter.

As teachers, it's easy to get discouraged with these responses. But the answer isn't to shy away from the controversy—or the additional work that comes with teaching these strategies. I'm sympathetic to the fact that educators must devote much of their time to covering critical content. But to ensure our students become questioning and resourceful citizens, we must also make time for systematically teaching them the sleuthing skills they need to wade through misinformation online.

Where's Spot?

Finding STEM Opportunities for Young Children in Moments of Dramatic Tension

BY ELISABETH MCCLURE, LISA GUERNSEY, AND PEGGY ASHBROOK

It is a Friday morning at Liberty Elementary School in Baltimore, and a group of first-graders are hard at work at a science center on the second floor. Christian, a little boy in a navy sweater and baggy jeans, grabs a bin filled with plastic tracks for building bridges and roadways. "Hey Malaya, come on!" he says to a classmate in a yellow shirt and pigtails. "Let's build a track!" Christian works quickly, laying out each piece, rifling through the bin to find exactly the sizes he's looking for.

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Malaya plops down on her knees next to him to help. Christian talks as he works and describes his growing structure, which now includes a series of inclined tracks. The two students work side by side, until they are finally ready to attach their two sections together.

Once they do so, they step back to admire their work. Christian picks up a little plastic ball and holds it in suspension just above the tallest ramp in their track structure. "Let's test this out!" Malaya looks at Christian, and they smile.

At that moment, both kids are electric with anticipation, nearly holding their breath. What is going to happen? Will the ball make it all the way down the track to the edge of the carpet? Will it get stuck along the way? How fast will it go?

It is a moment of drama among many moments of drama that play out every day at Liberty, where this science center declares itself with a big banner that says "Idea Lab" and the shelves are lined with science books, jars of beads and balls, cartons of colored pencils, cardboard boxes, and bins filled with interlocking plastic blocks. Four desktop computers are open for playing Mine-

ILLUSTRATIONS BY LIZA FLORES

craft, rugs are spread out on the floor for building with blocks, and tables offer laptops for drawing shapes and diagrams using computer graphics.

This school has embraced a truth that is difficult for many people to see: the potential for integrated science, technology, engineering, and math (STEM) learning really is all around us. And the moments of intense drama these children experience when they test out a new design are the engines that drive STEM practices; it's what keeps scientists, programmers, engineers, and mathematicians up at night, wanting to try *just one more* possible solution to a problem. STEM is full to the brim with drama.

The converse is also true: dramatic storytelling is full to the brim with STEM. While we rarely recognize it, STEM processes are at the heart of the narratives we love. Stop for a moment and consider your favorite novel or movie. What's at the heart of the story? What makes you turn the page or keep watching? At their core, narratives are almost always about the dramatic tension created when someone faces a challenge or barrier and attempts some strategy to overcome it. A great mystery hangs in this implicit question, "Will it work?"—whether it's asked about a social interaction or a physical experiment—and this tension is the heart of STEM.

When our team started its research on early STEM learning in 2015, this focus on drama and storytelling was not the expected result. Our project, funded by the National Science Foundation, was designed to help researchers, educators, and policymakers gain more insight into how they could work together to infuse STEM experiences into early childhood. The outcome was a major report, called *STEM Starts Early*,* that included not only a suite of recommendations for the adults involved in children's learning, but also a new language for communicating about the importance of STEM opportunities for little kids. This rethinking of early STEM learning led us to a few important insights.

STEM Is Full of Drama

STEM experimentation—when it's conducted without the use of "leading questions" or plot "spoilers" given away beforehand—should draw you to the edge of your seat, like you're watching the last three minutes of your home team's final game. STEM learning should feel like the unfolding drama of a well-told story; it should be near-impossible to walk away. So when you're doing your STEM instruction, highlight that drama and be prepared to support children through the highs and lows of their unfolding STEM stories.

Back at Liberty Elementary, Christian drops the ball gently on the plastic track. It rolls along just as he had hoped. "Look, Malaya! It works!" he squeals. Their relief is tangible. But so is their excitement to try another design. Christian scurries back to the bin, saying, "Let's get the other track so we can keep working!" Malaya springs to action by putting one of the blocks in a new position. "Ooh, let's try this, lay it this way," she says.

In fact, according to recent research, these STEM lessons and habits of mind—habits such as design and systems thinking, reasoning, collaboration and communication, exploration, and persistence—have significant positive effects on other learning domains. For example, it probably comes as no surprise that high-quality, facilitated early science experiences, like the ones kids experience at Liberty, support the development of children's executive function skills, like cognitive control, especially the ability to reflectively revise predictions based on their observations.[1]

High-quality early math education may also have similar benefits for encouraging executive function development, including skills like working memory (the ability to hold something in mind while working on a task), inhibition (the ability to control one's impulses), cognitive flexibility (the ability to adapt one's strategies when encountering new information or situations), and sustained attention.[2] In fact, early math instruction, when done well, is a great example of cross-domain effects more generally: it can lead to higher scores in early language and literacy, including the ability to express one's knowledge and understand others' spoken words;[3] and, remarkably, preschool math skills predict later academic achievement more consistently than early reading or attention skills.[4]

While we rarely recognize it, STEM processes are at the heart of the narratives we love.

That's because the competencies and habits young children form when they experience STEM education are integral to how children learn to learn.[5] As children go through their lives and learn new things, they braid all those individual skills or "strands" together into braided "skills ropes." Then they can use these ropes to do all the complex things they must do to function well in school and in life: solve problems, work with others, formulate and express their ideas, and learn from their mistakes. Children can use STEM skills, which are especially adaptable and strong, in weaving *many* different kinds of skills ropes. When kids have strong STEM strands, they can use them for all kinds of things, both practical and academic, that they will need to be able to do throughout their lives.[6]

In other words, when children become immersed in the unfolding drama of STEM experiences and are supported by their teachers, they learn skills that apply not only to their own understanding of science, technology, engineering, and math concepts, but to many other aspects of their lives. Fostering their engagement in these intense narratives encourages them to persist in their explorations and to embrace challenges—and even failures—as the building of dramatic tension that can propel them forward, both in their current project and in life.

Drama Is Full of STEM

Once you identify the hidden drama in STEM experimentation, it becomes much easier to incorporate it into your existing lessons in the classroom. For example, when you're doing your literacy instruction, highlight the STEM experimentation evident in the narrative.

This takes a little preparation. It is not unusual in Ms. Shaw's class, for example, to hear young children use engineering

*To read the full report, visit www.joanganzcooneycenter.org/publication/stem-starts-early.

words like "troubleshoot" or "test" or "run it" as they go through trial and error, creating new designs and products. They are words the students learned at the beginning of the school year, when Ms. Shaw taught a lesson on "prototypes." She explained that "design thinking" is about flexibility and the openness to use observations and tests to inform how they make improvements over time. Once children have this understanding of flexible design thinking, you can use it to help them identify STEM practices in the dramas that naturally unfold all around them, even in the books you read together.

Show children they are already doing science all the time, and they will begin seeing themselves as scientists.

This is possible even with very young children, because even simple stories rely on experimentation for dramatic tension. For example, in the lift-the-flap book *Where's Spot?*, a mother dog is looking for her hiding puppy, Spot. As we turn the pages, the children are invited to search for him by lifting one flap per page:

> *Is he in the box? No!* (Turn the page.)
>
> *Is he in the closet? No! Where could he be? Let's keep looking!* (Turn the page.)

You might not have realized it before, but this story, at its core, is a beautiful enactment of STEM practices. Each time the children turn the page and discover a new place to look…

- …the tension builds as they **form a prediction** *(Maybe Spot is in the closet!)*,
- …they lift the flap (the closet door) to **test their prediction**,
- …they are surprised to **observe** that their prediction is not supported *(A monkey in the closet?! Silly monkey!)*, and
- …they **troubleshoot and revise** their prediction as they turn the page *(Maybe Spot is in the cupboard!)*.

Pausing during reading and asking open-ended questions or prompts opens the door for children's comments, claims, and wonderings, and research suggests that giving them this opportunity to exercise their mutually reinforcing STEM, language, and literacy knowledge and skills can lead to improvement across all three areas.[7] These STEM practices are already present all around them; our job is to make those processes explicit for children. Show children they are already doing science all the time, and they will begin seeing themselves as scientists.

In fact, many children's books (picture books too!) even include core ideas that are in the Next Generation Science Standards (NGSS), which were released in 2013 to integrate content with science practices across disciplines and instructional levels.* Consider, for example, the character of Ned in Remy Charlip's classic, *Fortunately*. He receives a letter (paper

*For more on these standards, visit www.bit.ly/2stnt2R.

and writing tools are a form of technology) inviting him to a birthday party that turns out to be so far away (math, and NGSS Practice 5: Using Mathematics and Computational Thinking), he needs to borrow an airplane to get there (technology). His journey has ups and downs, problems to solve, and an element of chance. Every page is an opportunity for children to notice an A-B pattern (math, and NGSS Practice 4: Analyzing and Interpreting Data), make a claim about what might happen next (science and engineering, and NGSS Practice 7: Engaging in Argument from Evidence), and describe what they would do to overcome difficulties such as falling into shark-infested water (math—e.g., How fast would they have to swim to escape?—and NGSS Practice 5: Using Mathematics and Computational Thinking) or digging a tunnel through the earth to escape tigers (engineering and technology—e.g., using a miner's pickaxe—and NGSS Practice 6: Constructing Explanations and Designing Solutions).

These more dramatic challenges mirror children's challenges with riding a trike with a broken wheel, running away from a friend, and digging holes in the sandbox, and they demonstrate that scientific inquiry is a messy, creative endeavor (not a series of ordered steps we follow) when it's experienced in the world. These STEM-infused dramas appear routinely in works of fiction and nonfiction. Some additional book examples are included in the sidebar to the right, involving "characters" as diverse as a chicken and a young library patron.

Highlighting STEM in books like these demonstrates for children the opportunities for STEM learning they can experience outside of school, whether that's on the way to a birthday party, at a library, or at the grocery store. In fact, books (and newer technologies too) play an important role in bridging school learning with other learning spaces, like homes, local libraries, recreation centers, churches, and museums. Developmental experts like to call these out-of-school learning spaces "charging stations," where children can power up their learning to keep their STEM batteries active at all times.[8]

Strengthening these charging networks is especially important for students like those at Liberty, a high-poverty public school in northwest Baltimore, where more than 85 percent of the students qualify for free or reduced-price lunch. Children in these neighborhoods tend to live where there are few, if any, charging stations outside of school. So when an educator gives a child a book to take home, when a class takes a field trip into nature or to a science museum, and when a teacher uses or suggests well-designed apps (like Bedtime Math[†]) to engage parents in their children's learning, they are actively strengthening the network of charging stations for children. And, just like with learning a language, the immersion children experience with a strong charging network leads to STEM fluency, both in and out of school.

No Special Equipment Necessary

Some might think that giving young children rich STEM experiences will require schools to buy a bunch of new equipment and materials. And others might think that only some young children will be receptive to engaging in STEM explorations. But once educators begin to recognize the drama and narrative of STEM, doors can open to new possibilities, even in low-income schools such as Liberty, whose students are doing better than most Baltimore students on the state's tests of mathematics and English language arts.[9]

That success is not a result of programs targeted toward a select few; instead, it's the result of a shared investment and belief in the capacity of young learners, and an unspoken understanding about the power of drama. In treating explicit STEM lessons like dramatically unfolding stories, and by using moments of drama, trial and error, and other science practices in non-STEM subjects, educators can help students think like engineers and scientists. Such approaches can then give children the confidence and skills they need to redefine "failure" as the plot twist that inspires the next chapter of their story. There are few better life skills we can give them.

As Ms. Shaw reflected while watching Malaya and Christian work diligently to fix their track: "This is so much easier as a learning experience than having them come in and sit at the carpet having to be still," she says. "I think 21st-century learning looks like this." ☐

(Endnotes on page 39)

[†] To learn more about Bedtime Math, visit www.bedtimemath.org/apps.

Highlighting STEM during Storytime

The children's book *Rosie's Walk*, by Pat Hutchins, is a story full of STEM, as tension rises each time a fox sneakily approaches Rosie, a hen. For example, the title page picture of the entire farm introduces the concepts of mapping and viewing landscapes from different perspectives (math, and NGSS Practice 2: Developing and Using Models), and positional words ("across," "over," "under") in the text guide readers through the landscape.

Questions involving science and math concepts arise as the drama of Rosie's walk unfolds: When they jump onto the haystack, why does the fox sink down into the hay but Rosie the hen does not? How does loosening the rope holding the flour sack make it fall on the fox? Why does the wagon begin to roll when the fox jumps into it? Why do the bees fly after the fox and not after Rosie? This book can inspire hands-on classroom investigations into mapping a familiar area, building structures, using pulleys, rolling objects, and understanding the behavior of insects. The plot of the story gives children an anchor for their questions and increases the drama in the classroom experiments they can conduct as they explore these new learning areas.

Even books about everyday activities children experience, like going to the corner store or to the library, include important STEM elements. For example, while reading the book *Lola at the Library*, by Anna McQuinn and Rosalind Beardshaw, students engage with concepts of calendars, time, and distance, and see how the use of technology and engineering design apply in ordinary situations. By asking open-ended questions and highlighting inferences in the book, teachers can help children apply the information they gather to help make predictions and find solutions as Lola goes through her day.

At the beginning, we learn that Tuesdays are library days—Will Lola go to the library today? (math, and NGSS Practice 1: Asking Questions)—and that the library opens at 9 o'clock (math). Then, Lola uses an engineered design solution for transport (her backpack) as she gathers all the materials needed for a trip to the library and walks there (engineering, and NGSS Practice 6: Designing Solutions). Another familiar engineered design solution for transport, a stroller, is also pictured. Children can describe what kind of technology their library uses after reading that the librarian "buzzes" books through "the machine." Lola sings as part of the library's program for children (adding art to STEM). And drama? Which books will Lola choose to check out? Children can point to evidence for what kind of books they think Lola might pick out.

–E.M., L.G., and P.A.

From Students to Scientists

An Online Journal Inspires the Next Generation to Research, Write, and Publish

By Olivia Ho-Shing

What does it mean to be a scientist? In the most basic of terms, a scientist is someone who does scientific research. But what personal qualities does it take to do scientific research?

In his book *Letters to a Young Scientist*, renowned biologist Edward O. Wilson recounts his own coming-of-age story as a scientist, and distills the motivating qualities of science down to curiosity and creativity. Individuals become scientists when they are curious about a phenomenon in the world around them and ask about the real nature of that phenomenon: What are its origins, its causes, or its consequences? Scientists then employ some creativity to answer their questions through a systematic testing of hypotheses (the scientific method), and form some conclusion based on their findings.

This explanation of how scientists approach research highlights something very powerful: anybody with curiosity and creativity, by subscribing to the scientific method, can do science and discover something new about our natural world. From an early age, children brim with questions and sometimes come up with overly creative methods to test a hypothesis (say, using a magnifying glass to start a fire). It becomes incumbent upon teachers, then, to continually help foster students' curiosity and creativity as critical aspects of their learning, particularly in science.

Wilson describes the broad field of science as a "culture of illuminations dedicated to the most effective way ever conceived of acquiring factual knowledge." His description points to another critical aspect in becoming a scientist: not only acquiring some knowledge but contributing that knowledge to a shared culture and community. Scientists engage with others in their field through collaborations, presentations, and publication,

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ILLUSTRATIONS BY GABY D'ALESSANDRO

thereby strengthening their own findings and assessing information within a broader context of knowledge. While public school students should receive more resources and guidance to do science in schools, motivated students have typically had very limited avenues to experience being a scientist—that is, by sharing their research with the larger scientific community.

The *Journal of Emerging Investigators* (*JEI*) was established to address this challenge. A nonprofit online science publication exclusively for middle and high school students, *JEI* (www.emerginginvestigators.org) gives students an opportunity to submit original research, receive feedback on their work from expert scientists, and have their work published. Through this process, students grow their scientific knowledge and skills, helping them become the next generation of scientists.

> THE *JOURNAL OF EMERGING INVESTIGATORS* GIVES STUDENTS AN OPPORTUNITY TO SUBMIT ORIGINAL RESEARCH, RECEIVE EXPERT FEEDBACK, AND HAVE THEIR WORK PUBLISHED.

One such student is Suvir Mirchandani. As a sixth-grader at Dorseyville Middle School in Pittsburgh, Mirchandani was curious whether he could reduce the amount of ink used to print handouts at his school. To test his hypothesis that changing the font could decrease the amount of ink used, he had a clever idea. He first calculated the five most frequent letters used in teachers' handouts, and he printed enlarged copies of these letters onto heavy cardstock in four different fonts: Century Gothic, Comic Sans MS, Garamond, and Times New Roman. He cut out the letters, compared the masses of each font type, and found that Garamond was the winner.

Mirchandani calculated that his school could save 13 to 24 percent on ink costs, or nearly $24,000 for the school district, by switching from Times New Roman to Garamond 12-point font. After presenting his project at a science fair, Mirchandani's teacher encouraged him to submit a manuscript to *JEI*. Impressed with his results, *JEI* accepted and published his manuscript in 2013.

JEI editors suggested Mirchandani apply his experiment to a much larger scale of printing than his school: the entire U.S. government. Redoing his experiment with a sample of publicly available documents from federal agencies, he found that by switching to Garamond in federal documents, the government could save, on average, an astounding $234 million in printing costs. *JEI* published these results in 2014.

Mirchandani's publications garnered attention from major news outlets like CNN, giving him a greater platform to share his ideas. While it's not clear if the government will indeed follow Mirchandani's advice and transition to a more ink-efficient font, what is certain is that even young investigators, thanks to the support of fellow scientists and the opportunity to publish, can meaningfully contribute to society.

Beyond the Science Fair

Sarah Fankhauser founded the *Journal of Emerging Investigators* in 2011 during her early years of pursuing doctoral work in microbiology at Harvard Medical School. By volunteering at science fairs, afterschool science programs, and other K–12 outreach programs, she saw that middle and high school students were capable of conducting independent and creative research.

While students were often very proud of their projects and excited to show them at science fairs, there were often no avenues for students to continue discussing their results or expand on their projects after the fairs. Moreover, anyone who did not attend that particular science fair would miss out on the research students had done. So Fankhauser considered how experienced scientists share their work with the public—through peer-reviewed publication.

It may sound daunting for young students to publish their work, but Fankhauser found evidence they could do it. That year, a class of third-grade students published their original research on bumblebee foraging behavior in *Biology Letters*, a journal of the Royal Society publishing group.* The experiments were designed, carried out, and summarized by 25 8- to 10-year-olds in Devon, England, under the supervision of a teacher and a research scientist. Their research is compelling because it gave new insight into color and pattern recognition of the bee. As the authors put it, "No one in history (including adults) has done this experiment before." And it demonstrated that with support from a teacher, even very young students are capable of communicating their research like scientists do.

Beyond that single article, though, Fankhauser could find no science publications for K–12 students that met two criteria she considered basic for a peer-reviewed publication for middle and high school students: it had to be free for students to submit their manuscript, and it had to include an educational aspect through the course of publication. For scientists, that educational aspect comes from scientific review, where peer scientists read manuscripts and offer feedback on the scientific quality and presentation of research. The scientific review process helps scientists understand the strengths and weaknesses of their papers and improve their experiments. Peer review is a key aspect of communication in science that students would never experience before committing to a university-level track in research.

So Fankhauser, now an assistant professor of biology at Emory University, approached a handful of her fellow graduate students with the idea of creating a free way for middle and high school students to publish scientific research and experience

*P. S. Blackawton, S. Airzee, A. Allen, et al., "Blackawton Bees," *Biology Letters* 7 (2011): 168–172.

the peer review process. They responded enthusiastically, and together they founded *JEI*.

Since 2011, *JEI* has received more than 300 submissions from students across the United States and 14 submissions internationally. It has published more than 100 articles on original research in the physical and social sciences. While high school students author the majority of articles, middle school students, like Mirchandani, author about a 10th of *JEI* publications. In addition to science fair projects, students submit manuscripts about original research they conducted during a summer research internship or at home under the guidance of a parent. As *JEI* has grown, more teachers have encouraged groups of students to design and conduct experiments in a classroom setting and submit their research to *JEI*.

Articles adhere to the usual format of a scientific paper: each begins with an introduction to the scientific inquiry and the student's hypothesis. The author then describes the experiment he or she conducted to test the hypothesis and explains the method and results. Finally, the student discusses the implications and potential weaknesses of his or her study. Some students may be familiar with the layout of a primary scientific article, but for many, this is their first experience in communicating science as a scientist would. As a result, the *JEI* experience helps students think critically about their work and prepares them for reading and writing college-level scientific papers.

While biology papers predominate in *JEI* publications, the range of topics students cover in their research is staggering. In *JEI*'s first article, published in 2012, high school student Sarah Geil asked whether the order in which you are born into a family affects your academic success. A pair of sisters in middle school asked which brand of diapers is really the most absorbent—Huggies or Pampers? Students have tested the antimicrobial efficacy of natural supplements like honey and ginger, and whether yogurt containing active cultures affects the growth of a bacteria found in the gut. A sociology study by one high school student investigated how older adults engage during technology training programs. Another high school student, interested in biomimicry, wondered if helicopter blades designed with whale-like tubercles would fly more efficiently.*

Every study begins with a student who is curious about a phenomenon, finds a way to investigate it, and works with a mentor to guide him or her throughout the research and the *JEI* review process. Generally, a teacher, professor, or parent acts as the student's mentor, and becomes the senior coauthor on the final publication.

EVERY STUDY BEGINS WITH A STUDENT WHO IS CURIOUS ABOUT A PHENOMENON, FINDS A WAY TO INVESTIGATE IT, AND WORKS WITH A MENTOR.

The Peer Review and Publication Process

Once students and their mentors submit drafts, the *JEI* editorial team manages their manuscripts through the peer review and publication process. The team began with two editors-in-chief, Lincoln Pasquina and Chris Wells, overseeing four editors, including Fankhauser. "We had tremendous support from the Division of Medical Sciences [at Harvard]," she says, "specifically David Cardozo," associate dean for graduate studies and faculty adviser on the board of *JEI*. "He was a cheerleader from the very beginning." The graduate student editorial team has since blossomed to nearly 60 reviewers, a dozen copyeditors, and three editors-in-chief.

I served as an editor with *JEI* for three years, and I'm now a co-editor-in-chief with Jamilla Akhund-Zade and Michael Marquis. As editors-in-chief, we are the first ones on the editorial team to read a student's manuscript. We check that it has the appropriate structure of a science paper, that the student has clearly explained his or her research question, and that he or she has conducted the experiments to test the hypothesis. The editors also read the manuscript and decide if the student has presented original research that scientific reviewers can understand and comment on. If the manuscript meets these criteria, it is then assigned to a pair of reviewers.

The scientists who serve as *JEI* reviewers are graduate students, postdoctoral fellows, teachers, professors, and other researchers from across the country. After reading a manuscript, reviewers give feedback on the scientific content and writing style. A reviewer may point out a necessary control experiment the student must do to corroborate his or her findings, or suggest a fun additional experiment to try. As early-career scientists with gradu-

*These articles, and many others, can be found at www.emerginginvestigators.org.

WE ENCOURAGE STUDENTS TO SEE THEIR RESEARCH AS A SINGLE CONTRIBUTION TO A MUCH GRANDER SCALE OF SCIENTIFIC INQUIRY.

ate research experience, reviewers have years of research ideas and knowledge of their field to offer to younger scientists.

Student authors often express how thankful they are for the feedback. “I learned a lot from this process about science,” says one student, “and I appreciate the chance to publish!” The primary goal of the editorial team is to accept as many manuscripts for review as possible, so that the students receive educational feedback from scientific reviewers about their work, even if students ultimately decide not to pursue their projects to publication.

Except in serious cases like plagiarism, we accept every submission, pending scientific or written revisions by the authors. The editorial team consolidates the reviewers’ feedback into a one-page summary letter to the authors, followed by several pages of line-by-line comments from reviewers. Receiving this critique of their work can be disheartening for students, so we always note the strengths in students’ work and not only where they need to improve.†

In our scientific review, we try to help students clearly communicate a testable hypothesis that they generate from previous knowledge, data, and observations. We encourage students to search for scientific literature on their topic of interest to learn what other scientists have done and to gain an understanding of how others present and discuss their research. While their hypothesis does not have to be completely novel, we do expect that it is novel to the students; through their experiments, students must have learned something new. We also seek to offer students some guidance on how to perform their experiments and how to analyze their data to attain meaningful answers to their inquiry.

Finally, we help students combine their own data with their background knowledge to deeply discuss the results of their experiment. This final aspect tends to be the most difficult for students, because of the way in which students typically learn science. Both in school and in popular culture, the results of experiments are often explained as proving a certain hypothesis as right or wrong. But this approach leads students to believe there is finality in scientific inquiry, which is not true in reality. Through the editorial process, we try to show students that doing research is not about being right or wrong in the end. Instead, we encourage them to see their research as a single contribution to a much grander scale of scientific inquiry—with always more questions to explore.

After receiving their letter from the editorial team, students can revise their manuscript and conduct any additional experiments that have been suggested. We try to be realistic about how much time and resources students may have to carry out more experiments, so they won’t be discouraged from continuing to work on their project. They then submit their revised manuscript to *JEI*.

All manuscripts require at least one round of revision and resubmission—a markedly different experience for students than presenting their research at a science fair. Once the editorial team is satisfied with the improvements, the accepted manuscript moves on to copyeditors, who proofread the manuscript and help the authors improve the clarity of their writing. Finally, editors generate a proof of the article, review it one final time, and publish it on the *JEI* website. After so much hard work, the authors and the editorial team are thrilled to see the final product.

Working with *JEI* is a rewarding opportunity not only for the student authors but also for the graduate students who comprise the editorial team. It has enabled us to learn about a variety of topics beyond our specific fields, and the opportunity to edit the work of younger peers has allowed us to improve our own science communication skills.

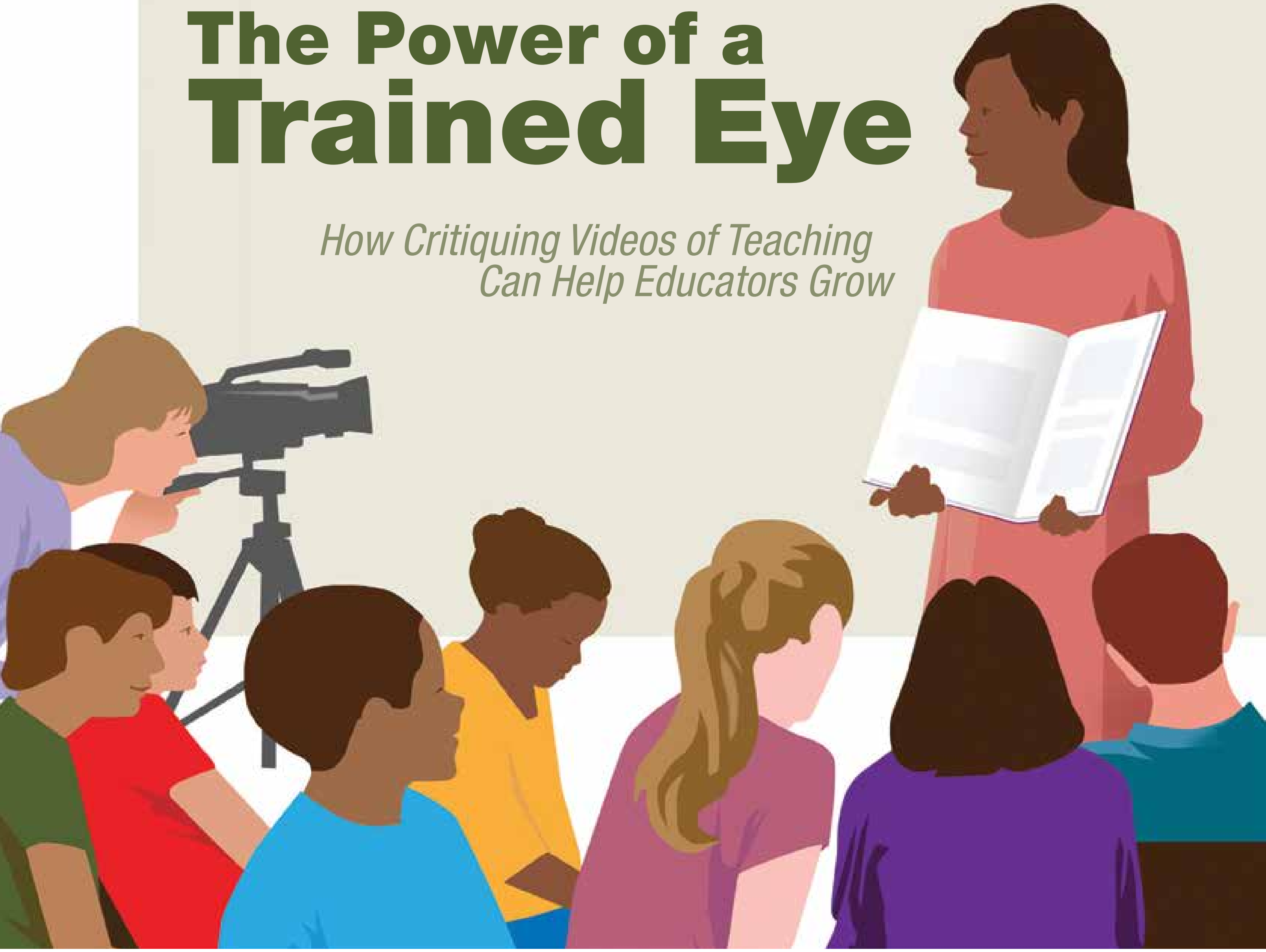
Typically, graduate students do not get a chance to review research articles; we only experience the process of review and revision a handful of times when submitting our own research for publication. This is a shame, since scientific review is a prime way to discuss our research with others outside of our personal sphere.

In the next few years, we at *JEI* hope to expand our reach to more students and teachers and to grow our editorial team. We hope that by submitting manuscripts to *JEI*, students come to understand that any question a scientist is deeply curious about is worth investigating, and that we, as fellow scientists, look forward to reading their work and guiding them. ☐

†For more on the value of teaching effort and persistence in science, see “Stories of Struggle” in the Spring 2017 issue of *American Educator*, available at www.aft.org/ae/spring2017/lin-siegler_ahn_chen_fang_and_luna-lucero.

The Power of a Trained Eye

How Critiquing Videos of Teaching Can Help Educators Grow



BY JEFF ARCHER

One of the best ways to judge your own work is to practice with someone else's. English language arts teachers employ this trick when they engage students in group work that involves editing personal essays and research papers in their classrooms. When students collaborate to apply a set of criteria for quality writing to their classmates' work, they gain a better understanding of what those criteria look like in actual compositions. That, in turn, helps their own work improve because it strengthens their writing and self-editing.

Educators gain a similar benefit when they come together to analyze the craft of teaching. In comparing notes from observing the same lesson, they must explain the importance of what they noted based on a common definition of effective teaching. In an effort to understand the basis for each other's judgements, the resulting discussion sharpens their grasp of that common definition and makes them better analysts of their own practice.

An increasing number of teachers and principals have engaged in such exercises in recent years, in part as a byproduct of the drive for greater consistency in teacher evaluation. At the heart of most evaluation systems is a rubric that defines important aspects of teaching (e.g., discussion techniques and classroom management), and that, for each aspect, describes the differences between more and less effective practice (e.g., asking open-ended questions as opposed to asking only for the recall of facts). Training observers to apply an observation rubric as intended requires examples of teaching at different levels of performance.

How can we identify such examples? By engaging educators in a collaborative process to analyze videos of teaching. Alternatively called "master coding," "master scoring," "pre-scoring," or "anchor rating," the process is analogous to that employed to score "anchor papers" used to train evaluators of student writing

ILLUSTRATIONS BY NENAD JAKESEVIC

Jeff Archer is a coauthor of Better Feedback for Better Teaching: A Practical Guide to Improving Classroom Observations, *and the president of Knowledge Design Partners.*

Master coding represents a rare opportunity to engage in disciplined and collaborative analysis of actual instruction.

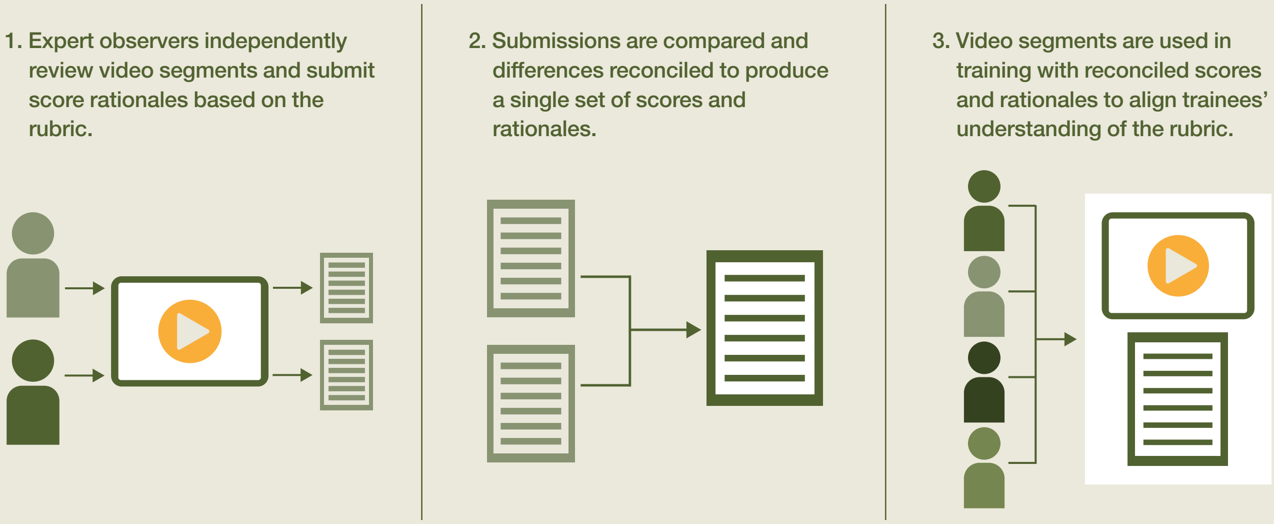
for standardized assessments. For anchor papers, multiple educators review the same student essay and make their case as to why it merits a particular score, based on a common set of criteria. Those judgements are then compared and, if needed, reconciled to produce a clear rationale for the essay's score. With that rationale, the essay can then be used to help new evaluators to understand the scoring process.

In analyzing videos, which I refer to throughout this article as master coding,* multiple educators can learn to become expert observers by reviewing the same video of teaching, and by scoring the observed instruction based on their understanding of an observation rubric (for more on how this process works, see Figure 1 below). When those independent judgements are compared and reconciled, the result is a strong rationale for why the video demonstrated one or more particular aspects of teaching, and at particular levels of effectiveness. With this rationale—or "codes"—the video can then be used to help other observers-in-training (be they classroom teachers, principals, or central office administrators) to recognize the teacher and student actions in a lesson that are most relevant to evaluating each part of a rubric.

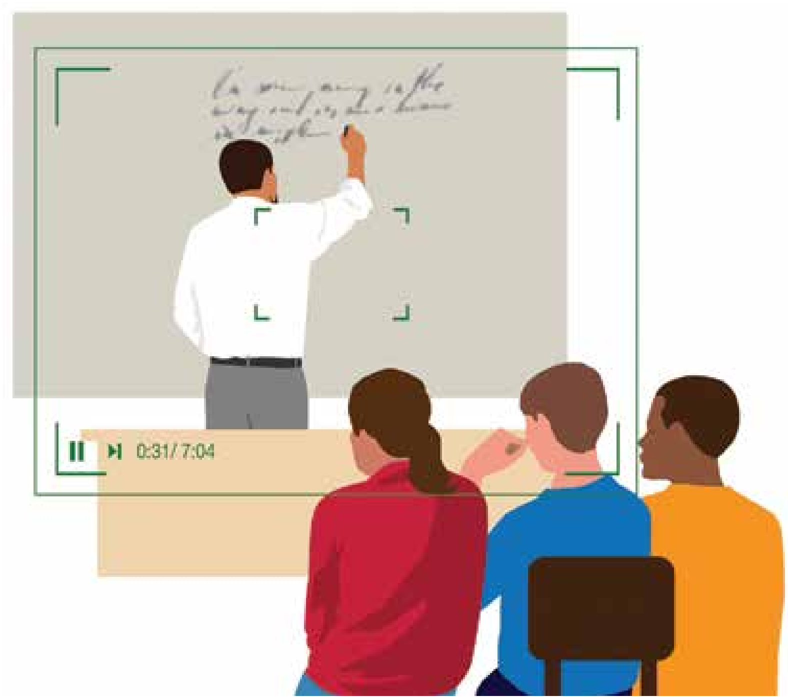
Note that the goal of master coding is not to evaluate the teacher in the video for accountability purposes. It's to identify moments in a lesson that illustrate particular practices at particular performance levels; indeed, master-coded videos used in observer training generally come with a disclaimer that the segments are selected for such illustration and should not be seen as being representative of the overall performance of the

*For more guidance on how to begin and improve a master coding process, read *Better Feedback for Better Teaching: A Practical Guide to Improving Classroom Observations* (Jossey-Bass/Wiley). For more information, visit www.bit.ly/2uz5NDx.

Figure 1: The Master Coding Process



SOURCE: *BETTER FEEDBACK FOR BETTER TEACHING*, PAGE 57. REPRINTED WITH PERMISSION OF JOSSEY-BASS/WILEY.



The AFT's initial impetus for focusing on master coding was to produce a library of coded videos that could be used to train and calibrate the judgements of evaluators.

teacher featured. As another safeguard, master coders typically don't score videos of teachers they know, nor are ratings shared, except for training purposes.

Master Coding in Action

I learned about master coding through my work with the Measures of Effective Teaching (MET) project, a three-year study of educator evaluation methods that involved nearly 3,000 teacher volunteers in six urban districts, funded by the Bill & Melinda Gates Foundation. As an education writer tasked with helping to explain the project, I spent a great deal of time getting to know different observation tools and what it takes to use them reliably. Reliability, I learned, is largely the result of the right training, and the right training makes use of master-coded videos.

During my time with the MET project, I had the opportunity to see master coding in action, thanks to an invitation from the Rhode Island Federation of Teachers and Health Professionals (RIFTHP). An affiliate of the American Federation of Teachers, RIFTHP allowed me to join one of a series of work sessions it had organized to bring together classroom teachers and administrators from across the state for the purpose of coding videos using an observation rubric that the state teachers union had developed. This was part of a larger effort that included the New York State United Teachers (NYSUT), and that was supported by a grant to the AFT through the U.S. Department of Education's Investing in Innovation Fund (i3) program.

My time in Rhode Island showed me that while master-coded videos of teaching are essential in training teachers to observe the work of their peers, the process of producing them is itself a highly valued form of professional learning to the educators who do the coding. For them, master coding represents a rare opportunity to engage in disciplined and collaborative analysis of actual instruction. Many educators who have participated in master coding say the experience makes them a better educator. Classroom teachers say it makes them better at self-assessment, and administrators say it helps them to provide teachers with the kind of specific, evidence-based feedback that can support them in making changes in their practice.

"It makes you think about the rubric so much more deeply, which makes you think about practice so much more deeply," says Katrina Pillay, an assistant principal at a middle school in Cranston, Rhode Island. While in a previous role as a classroom teacher assigned to her district's evaluation planning committee, Pillay took part in a master-coding project organized by RIFTHP. The experience, she says, made the rubric they were working from much more meaningful not just for her but for her fellow master coders, and now for the teachers she directly supports. "It allows you to verbalize expectations for teachers and make it real for folks."

In the work session organized by RIFTHP and held for more than three hours after school one day, participants worked in pairs to review videos showing 10–20 minutes of instruction, compare notes on what they saw, and draft clear rationales for why the video illustrated particular aspects of teaching performed at particular levels. Guiding their work was a one-page template, with space for noting each aspect of teaching observed, the teacher and student actions observed that were relevant to determining the level of performance for each aspect, and the reasons why the observation rubric would call for one rating and not another, given their observations.

In one such exercise, I saw Pillay and another master coder, Keith Remillard—then a principal from West Warwick and now the district's director of federal programming and innovative practice—work together to analyze how a teacher fostered positive student interactions in a video showing part of a fifth-grade writing lesson. The two noted that when a student finished answering a question, the teacher said to the class, "If you guys agree with him, you can make the connect sign." At that point, other students made a back-and-forth motion with their hands, which showed that the teacher had established positive behaviors for expressing agreement.

Looking at the rubric, Pillay and Remillard saw that effective practice in this area entails the teacher both modeling and encouraging positive interactions, which this teacher had clearly done. Before they finished coding the video, Pillay and Remillard completed their template by indicating when on the video they had observed the relevant behaviors, describing those behaviors, and explaining why—based on the language in the rubric—those behaviors indicate "effective" practice, instead of either "highly effective" or merely "developing" practice ("highly effective," in the rubric, requires evidence of "students monitoring each other's behavior"). (For an example of what master coders produce, see Figure 2 below.)

Watching this pair, it became clear to me how both the products and the process of master coding contribute to building a shared understanding of effective teaching. The written rationale that Pillay and Remillard produced meant the video of the fifth-grade writing lesson could then be used to train observers on how to recognize possible evidence of effective practice in fostering positive student interactions. Meanwhile, by taking part in a disciplined analysis of the video using a clear definition of effective practice, Pillay and Remillard sharpened their own understanding of what more or less effective practice might look like, for this very specific and important aspect of teaching.

Remillard later told me that participating as a master coder makes the practices defined in the rubric real for him. In doing so, the process ultimately makes him better at supporting instructional improvement in his work as a school leader, because he's able to make more concrete suggestions to teachers. "After master coding, I now have a picture in my mind of what the rubrics are trying to say," he says. "When I observe teachers, I find that I'm looking for evidence and matching evidence to the rubric much more smoothly, more quickly. I also give more-specific feedback."

Figure 2: An Example of Master Codes

USE OF QUESTIONING: Effective	
Evidence	Score Rationale
Teacher questions: 14:02 "What tools would a scientist use?"	**Why the rating is *effective*.** Most of the questions the teacher asks are open in nature and engage students in deeper thinking and further discussion.
16:58 "What would a butterfly do?"	**Why a lower score is wrong.** The teacher does not use a combination of open and closed questions, with only some questions inviting thoughtful response.
17:59 "How is pollen going to come off the flower and go to another?"	**Why a higher score is wrong.** The teacher's questions do not provide students an opportunity to demonstrate reasoning for formulating their own questions.

SOURCE: *BETTER FEEDBACK FOR BETTER TEACHING*, PAGE 56. REPRINTED WITH PERMISSION OF JOSSEY-BASS/WILEY.

Learning to Give Meaningful Feedback

I found it interesting that despite such testimonials, the AFT's initial impetus for focusing on master coding was not to develop the instructional leadership skills of the educators who did the coding. Rather, it was to produce a library of coded videos that could be used to train and calibrate the judgements of evaluators, so that teachers' observation ratings wouldn't depend on who did the observing and would result in productive feedback. Dawn Krusemark, who coordinated the AFT's i3 grant, says that coded videos could help train evaluators to accurately explain to teachers, "This is your rating, and this is why, and this is specifically what would make it better."

Participants became especially adept at recognizing the indicators of more and less effective practice and providing meaningful feedback.

But by engaging some 80 educators in Rhode Island and New York to help code the videos, the master-coding project had the additional benefit of developing a sizable cadre of "uber-observers." Prompted repeatedly to justify their judgements about what they saw, participants became especially adept at recognizing the indicators of more and less effective practice and making recommendations about taking a teacher's practice to the next level.

Tasked with putting those justifications into concise written rationales, they also honed their abilities to provide meaningful feedback. Instead of just learning how to assign a set of correct ratings, they gained a deeper understanding, through rich discussion with colleagues, of specific elements of teaching and what makes them effective or not.

Says Colleen Callahan, the RIFTHP's director of professional issues: "It's given [the master coders] a language and an analysis skill that helps them feel pretty confident in saying, 'This is what the standard [in the rubric] means.'" That skill and confidence, she adds, carries over into their day-to-day

The biggest benefit is in the growth of committed educators who come together to examine instructional practice critically.

work, enabling them to give more specific feedback grounded in a rubric's language in their formal and informal interactions with teachers.

Getting a group of master coders to that point takes some time and resources. At the beginning of the AFT project, participants took part in a two-day master-coding "boot camp," in which they reviewed the rubrics they would be using, learned how to collect objective evidence (describing without judgement what they see), and practiced the master-coding process. The boot camps were planned with Catherine McClellan of Clowder Consulting, a statistical consulting firm that works with school districts on collecting and interpreting data. McClellan perfected the art of master coding at Educational Testing Service (ETS), where she was director of human constructed-response scoring, which is in its Research and Development division and sets quality standards for ETS's use of human evaluators to evaluate assessment responses.

Even with such preparation, McClellan says master coders need strong support. To many, the process feels unnatural at first. Initially, educators often instinctively jump to judgements based on their own instructional preferences, rather than considering the common criteria of the rubric. Many also find it hard to set aside thoughts about behaviors they see that may not be relevant to the particular aspect of teaching they are analyzing. But over time, and with the right guidance, master coders grow more comfortable with the narrower focus and with the grounding of judgements in the rubric's common language—and debate gives way to deep analysis.

Ellen Sullivan, who coordinated NYSUT's work for the i3 grant, describes the process as learning to see through the lens of the rubric: "Every evaluator walks into the room with a set of knowledge and core dispositions because they've been practitioners in the field for a long time, and they are working from their context and their frame of mind. What we're trying to do with the master-scorer training is not get rid of their professional judgement, but just guide and focus their professional judgement about applying what the language of the rubric says." When local teachers take part in master coding, she adds, another benefit is an increased sense of ownership in the evaluation criteria, because educators from the local context are the ones clarifying what good teaching looks like. Sullivan says that's happened in Albany, New York, where the local district manages a master-coding process.

Education leaders have found ways to make master coding work in different contexts, while still adhering to the same principles of best practice. Whereas organizers in tiny Rhode Island could gather participants from across the state several times a year, NYSUT, the AFT's largest state affiliate, has organized regional meetings. Some school systems use a combination of group trainings and phone calls. In the latter, two master coders independently review, analyze, and score the same video before the call, and the discussion is primarily used to reconcile any differences.

As the main thrust of teacher effectiveness efforts shifts from accountability to professional learning, my hope is that more educators have the opportunity to take part in master coding. The biggest benefit that comes from being able to identify effective teaching isn't the ability to sort effective teachers from less effective ones. It's in the growth of committed educators who come together to examine instructional practice critically and to consider how that practice, as well as their own teaching, might improve.

In the meantime, the work completed as part of the AFT's i3 grant continues to have an impact. NYSUT uses the videos it coded to train evaluators in districts across the state. The AFT affiliate in Albany has brought together teams of teachers and administrators in each of the past two summers to master code new videos to use locally for the same purpose. In Rhode Island, RIFTHP similarly continues to use the videos it coded through its i3 grant work to train evaluators in several districts. It has also used some of its master-coded videos to create an online exercise to check evaluators' accuracy.

As important, says Callahan of the RIFTHP, is the deep understanding of evidence-based evaluation and feedback that the master coders have taken back to their day-to-day work in schools. She says: "The skills they developed make them well-positioned to put a fair, equitable, and meaningful system in place." ☐

Ask the Cognitive Scientist

Do Manipulatives Help Students Learn?

How does the mind work—and especially how does it learn? Teachers' instructional decisions are based on a mix of theories learned in teacher education, trial and error, craft knowledge, and gut instinct. Such knowledge often serves us well, but is there anything sturdier to rely on?

Cognitive science is an interdisciplinary field of researchers from psychology, neuroscience, linguistics, philosophy, computer science, and anthropology who seek to understand the mind. In this regular American Educator *column, we consider findings from this field that are strong and clear enough to merit classroom application.*

By Daniel T. Willingham

Question: Is there any reason to be cautious when using manipulatives in class? I understand that some educators might have mistakenly thought that manipulatives—concrete objects that students handle mostly during math and science lessons—help because they give kinesthetic learners the hands-on experiences they need, and we now know that theory is wrong.[1] Still, isn't it the case that *all* small children learn better via concrete objects than via abstractions? Surely it helps students focus if classroom activities are mixed up a bit, rather than listening to endless teacher talk.

Daniel T. Willingham is a professor of cognitive psychology at the University of Virginia. He is the author of When Can You Trust the Experts? How to Tell Good Science from Bad in Education *and* Why Don't Students Like School? *His most recent book is* Raising Kids Who Read: What Parents and Teachers Can Do. *For his articles on education, go to www.danielwillingham.com. Readers can post questions to "Ask the Cognitive Scientist" by sending an e-mail to ae@aft.org. Future columns will try to address readers' questions.*

Answer: Research in the last few decades has complicated our view of manipulatives. Yes, they often help children understand complex ideas. But their effectiveness depends on the nature of the manipulative and how the teacher encourages its use. When these are not handled in the right way, manipulatives can actually make it harder for children to learn.

In 1992, in the pages of this magazine, Deborah Loewenberg Ball warned against putting too much faith in the efficacy of math manipulatives.* At the time, research on the topic was limited, but Ball noted the unwarranted confidence among many in the education world that "understanding comes through the fingertips." (Manipulatives might also make ideas more memorable; here, I'll focus on whether they aid the understanding of novel ideas.) Ball explained how the embodiment of

*See "Magical Hopes" in the Summer 1992 issue of *American Educator*, available at www.aft.org/ae/summer1992/ball.

ILLUSTRATIONS BY JAMES YANG

a mathematical principle in concrete objects might be much more obvious to adults who know the principle than to children who don't. We see place value, whereas they see bundles of popsicle sticks. And isn't the *lesson*, Ball asked, what really matters—not the manipulative, but how the teacher introduces it, guides its use, and shapes its interpretation?

Manipulatives often help children understand complex ideas.

Twenty-five years later, enthusiasm for manipulatives remains strong, especially in math and science.[2] For example, a joint statement from the National Association for the Education of Young Children and the National Council of Teachers of Mathematics advises, "To support effective teaching and learning, mathematics-rich classrooms require a wide array of materials for young children to explore and manipulate."[3] Teachers seem to heed this advice. Empirical data are scarce, but surveys of teachers indicate that they think it's important to use manipulatives, and early elementary teachers report using them nearly every day.[4]

While enthusiasm for manipulatives seems not to have changed since 1992, the research base has. It shows that, although manipulatives frequently help children understand concepts, they sometimes backfire and prompt confusion.[5] Instead of starting with a catalogue of instances in which manipulatives help (or don't), let's first consider the theories meant to explain how manipulatives influence children's thinking. Research has shown that two prominent theories are likely wrong. A third theory is more solid, and will provide a useful framework for us to consider some research findings. That, in turn, will provide guidance for classroom use of manipulatives.

Why Do Manipulatives Help?

Why might a child learn a concept when it is instantiated in physical materials that can be manipulated, whereas the same concept in symbolic form confounds the child? Jerome Bruner and, even more prominently, Jean Piaget offered answers rooted in the nature of child development.[6] They suggested that young children think more concretely than older children or adults. Children depend on physically interacting with the world to make sense of it, and their capability to think abstractly is absent or, at best, present only in a crude form. The concrete/abstract contrast forms one of the vital differences between two stages of cognitive development in Piaget's theory. In the concrete operational stage (from about age 7 to 12), the child uses concrete objects to support logical reasoning, whereas in the formal operations stage (age 12 to adulthood), the child can think using pure abstractions.

But much research in the last 50 years has shown that this characterization of children's thought is inaccurate. Consider children's understanding of numbers. Piaget suggested that preschoolers have no understanding of numbers as an abstraction—they may recite counting words, but they don't have the cognitive representation of what number names really refer to.[7]

But later work showed that although children may make mistakes in counting, the way they count shows abstract knowledge of what counting is for and how to do it. When counting, they assign one numeric tag to each item in a set, they use the same tags in the same order each time, they claim that the last tag used is the number of items in the set, and they apply these rules to varied sets of objects.[8] Preschoolers show abstract thinking in other domains as well, for example, their understanding of categories like "living things."[9] So it's not the case that children's thinking is tethered to concrete objects.

Another theory suggests that manipulatives help because they demand movement of the body. Some researchers propose that cognition is not a product of the mind alone, but that the body participates as well. In these theories, not all mental representations are completely abstract, but rather may be rooted in perception or action. For example, we might think that we have an abstract idea of what "blue" means, or what is meant when we hear or read the word "kick." But some evidence suggests that thinking of "blue" depends on the same mental representation you use when you actually perceive blue. The meaning of the word "kick" depends on what it feels like to actually kick something.[10]

By this account, manipulatives are effective because their demand for movement is in keeping with the way that thought is represented. If this theory is right, then instructional aids similar to manipulatives that aren't actually manipulated shouldn't help—it's the movement that really matters. The last decade has seen a great deal of research on that question; do computer-based, virtual manipulatives work as well as the real thing? Although there are exceptions,[11] computer-based manipulatives usually help students as much as physical ones.[12] These findings don't mean that movement is completely unrelated to cognition, but they make it doubtful that movement underpins the efficacy of manipulatives.

Furthermore, and crucial to our purposes, both theories—children are concrete thinkers, and physical movement is central to thought—seem to predict that manipulatives will always lead to better understanding. As we'll see, manipulatives are often helpful, but not always.[13]

A third theory provides a better fit to the data. It suggests that manipulatives help children understand and remember new concepts because they serve as analogies; the things manipulated are symbols for the new, to-be-understood idea. This hypothesis is a bit counterintuitive, because we think of manipulatives working exactly because they are easily understood, readily interpretable. But they are not to be interpreted literally. Popsicle sticks or counters or rods are *symbols* for something else.[14] A set of popsicle sticks reifies the concept of number, which is abstract and difficult for the young child to wrap his or her mind around. Manipulatives are used so often in math and science exactly because those subjects are rife with unintuitive concepts like number, place value, and velocity.[15]

Analogies help us understand difficult new ideas by drawing parallels to familiar ideas. For example, children are already familiar with fractions in some contexts. They may not have the words to describe their thinking, but they understand that a pizza can be considered a whole that is divisible by eight slices, and that when each of two people take four slices, they divide the pizza equally. The manipulative, then, calls on an existing memory (of pizza) and uses it as a metaphor, extending this existing knowledge to something new (the abstract idea of fractions).[16]

The data that posed a problem for other theories are no problem here: this theory doesn't predict that children can't think abstractly, and it doesn't accord any special role to moving the body. Indeed, this theory sits comfortably with other studies showing that embedding problems in familiar situations helps students, even if there is nothing to manipulate physically or virtually.

For example, one study compared how well novices solved algebra problems in symbolic form and when problems were embedded in a familiar scenario.[17] Some students saw "Solve for X, where X = .37(7) + .22," and others read "After buying donuts at Wholey Donuts, Laura multiplies the 7 donuts she bought by their price of $0.37 per donut. Then she adds the $0.22 charge for the box they came in and gets the total amount she paid. How much did she pay?" Students in the latter condition were more successful than those in the former.

In the next section we put this theory to work. Manipulatives sometimes flop when common sense would have us believe they ought to help. Thinking of manipulatives as analogies clarifies what might otherwise be a confusing pattern of experimental results.

> But their effectiveness depends on the nature of the manipulative and how the teacher encourages its use.

Manipulatives Aid Understanding When Attention Is on the Relevant Feature

It seems obvious that children must attend to a manipulative if it is to work, and much research has focused on manipulatives' perceptual richness (i.e., whether they are colorful and visually complex) because perceptual richness can draw the student's attention. For example, in one study, researchers had fifth-graders solve mathematical word problems involving money.[18] Some students were given play money as manipulatives to use while working the problems; these would be considered perceptually rich because they were printed with lots of detail. Other children were also given coins and bills as manipulatives, but they were bland: simple slips of white paper with the monetary value written on them. A third group received no manipulatives. The researchers didn't just count the number of problems correctly worked; they also differentiated types of errors when students got a problem wrong: conceptual errors (where students set up the math incorrectly) or nonconceptual (e.g., copying the information inaccurately, adding two digits incorrectly, forgetting to show one's work). Researchers found students made fewer conceptual errors when using the perceptually rich materials. (They also made many *more* nonconceptual errors, a point to which we will return.)

Another experiment concerning attention and perceptual richness focused on 3- to 4-year-olds learning numerical concepts. Two sets of counters were placed on a table, and a crocodile was to be positioned so that it would "eat" the numerically larger set.[19] Researchers found that children learned more from the game if the counters were perceptually rich (realistic-looking frogs) instead of bland (simple green counters).

But in addition to varying the counter, experimenters also examined the role of instruction. In one condition, the experimenter acted as a player, taking turns with the child. In the other, the experimenter modeled how to play and provided feedback after the child's turn. In this second condition, the instruction guided attention effectively. With it, children using the bland counters learned as much as those using the perceptually rich counters. Again, the child's attention is thought to be critical; it can be drawn by the perceptually rich materials, or directed by the teacher.

In some instances, the guidance of attention may be less explicit by simply instructing the student how the manipulative is to be used, which in turn makes attention to the right feature of the manipulative likely. Consider use of a physical, numbered line to help understand the concept of addition. Given the problem 6 + 3, the child might find 6 and then count "1, 2, 3," and so find the answer, 9. But using the manipulative that way does not focus the child's attention on the continuity of numbers. A better method is to find 6, and then count "7, 8, 9."[20]

Researchers tested this idea by having kindergartners play a game similar to Chutes and Ladders, with a 10 by 10 array of numbers from 1 to 100 on a game board that players were to progress through, with a spinner determining the number of spaces to move on each turn.[21] They instructed some children to count out their moves from 1; that is, if they were on number 27 on the game board and spun a 3, they were to count aloud "1, 2, 3." Other children were asked to count from the initial number, i.e., "28, 29, 30." After two weeks of game play, the latter group showed significant gains in number understanding, compared with the former group.

Bruner thought teacher guidance was crucial for manipulatives to aid learning.[22] He suggested that students were unlikely to learn the target concepts if they were simply given the materials and encouraged to do with them what they wished. Bruner's caution is in keeping with other research on pure discovery learning. When children are given little guidance in the hope that they will, in the course of loosely structured exploration, discover key concepts in math and science, outcomes are usually disappointing, compared with situations using more explicit instruction.[23] At the same time, overly restrictive, moment-by-moment instructions about exactly what to do with manipulatives might be expected to backfire as well; this practice raises the risk that students would simply follow the teacher's directions without giving the process much thought.[24]

Manipulatives Don't Aid Understanding When Attention Is Not on the Relevant Feature

We might think that perceptually rich manipulatives are always the way to go. Why use green dots when you can use frogs? *Of course* frogs are going to be more engaging for students! But that conclusion would be hasty. Remember, manipulatives are analogies, and analogies are usually imperfect. In an analogy, an unfamiliar, to-be-learned idea (e.g., fractions) is likened to a familiar idea (e.g., pizza) because they share one or more important qualities (e.g., divisibility). But pizzas have lots of qualities that you would not want to impute to fractions: they are edible, they are purchasable, they are often found at parties, and so on. So it's not enough that a manipulative call attention to itself by being perceptually rich; it must call attention to the key feature, and not to other features. And indeed, manipulatives fail to aid understanding when children focus attention on a feature that is irrelevant to the analogy. There are several ways that might happen.

First, the manipulative might simply be poorly designed in that it's missing the crucial feature. A series of experiments has shown that playing a board game with numbers arrayed linearly helps children understand some properties of numbers.[25] The benefit is obvious because we recognize the game is analogous to the number line. But if the game board's numbers are arranged in a circle instead of a line, children don't benefit.[26]

Second, the manipulative might have the relevant feature, but the child does not attend to it because some other feature is more salient. This is where perceptual richness can backfire. Imagine Cuisenaire rods (meant to help children understand number concepts) painted to look like superhero action figures. Students could hardly be blamed if they failed to focus on the differing length of the rods, which is their important symbolic feature.*

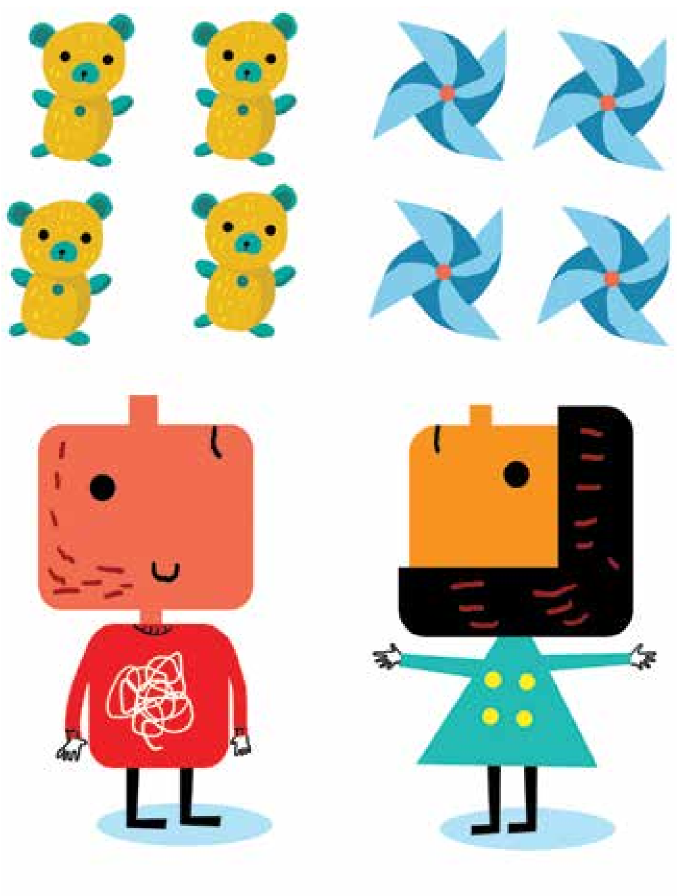
> Manipulatives fail to aid understanding when children focus attention on a feature that is irrelevant to the analogy.

But the feature doesn't need to be that obviously distracting to confuse children. *The child has no way of knowing which features of the manipulative are important and which are not.* If the teacher uses apples as counters, is it important that apples are roughly spherical? That we know what the inside looks like, even though it's not visible?[27] Recall the experiment mentioned earlier using play money. Perceptually rich manipulatives reduced conceptual errors (children set up the math problem correctly) but *increased* other types of errors (e.g., calculation errors). Detailed manipulatives draw attention (which helps) but then may direct attention to irrelevant details (what Washington looks like on the bill).

Third, even if the child knows which feature of the manipulative is relevant, it may be difficult to keep in mind that it is a symbol. In the play money experiment, the children already had some experience with real money, and the play money was meant to serve the same purpose familiar to them. More often, the symbolic connection is new. A child is used to thinking of a slice of pie as something to eat. Now it's supposed to represent the abstract idea "⅛ of a whole."

Research has shown that this duality poses a problem. Researchers asked 3- and 4-year-olds to perform a counting task using manipulatives.[28] The manipulatives varied in their perceptual richness and in children's familiarity with the object: Some children were given objects to use as counters that were perceptually rich and familiar (e.g., small animal figurines). Others got objects that were familiar, but not perceptually rich (popsicle sticks). Still others got counters that were unfamiliar and perceptually rich (multicolored pinwheel blades) or counters that were unfamiliar and not

*For more on how embellishment can be distracting, see "Keep It Simple to Avoid Data Distractions" in the Summer 2013 issue of *American Educator*, available at www.aft.org/ae/summer2013/notebook.



perceptually rich (monochrome plastic chips).

The researchers observed a substantial disadvantage in the counting task for children using the animal figurines, compared with the other groups. As we've seen in previous experiments, richness drew attention to the manipulative, just as it did in the play money experiment. In that case, the children were meant to think of the manipulative (play money) in the same way they thought of its symbolic referent (real money). But children already know animal figurines to be toys, which one plays with. It's hard to also think of them as counters representing the abstract concept of number. The perceptually rich pinwheel blades did not pose the same problem because, even though they drew the child's attention, they were unfamiliar; it was easier to think of them as a symbol for something else, because the child did not think of them as having another purpose.

Thinking of an object as having two meanings overwhelms working memory in young children.

Thinking of an object as having two meanings overwhelms working memory in young children. This interpretation is supported by other landmark work on mental representation. In the standard paradigm, children are shown a diorama of a room and are told it is an exact model of a larger room that they will be shown. Then the experimenter hides a small Snoopy doll in the diorama and says that big Snoopy will be hiding in exactly the same place in the large room.[29] The child is then taken to the large room (which is, indeed, identical in every way to the diorama, except for size) and is encouraged to find large Snoopy. Two-and-a-half-year-olds are terrible at this task. But they improve dramatically if they are shown the diorama behind a pane of glass; that makes them less likely to think of the diorama as a toy, leaving the child free to see it as a symbol. And 3-year-olds (who normally perform pretty well on the task) are worse at finding big Snoopy if they are prompted to think of the diorama as a toy by encouraging them to play with it before searching for big Snoopy.[30]

Moving Beyond the Manipulative

Obviously, our intention in using manipulatives is not to make children forever dependent on them; we don't expect a high school student to pull out strings of beads as he or she prepares to do math homework. It's not just that manipulatives are time-consuming and inconvenient to use. They also fail to apply to an entire domain. Helping a child understand the idea of fractions by dividing a circular pizza or pie works well until you encounter a fraction with the denominator 9. Or 10,000. Or suppose a teacher uses colored chips to model counting and addition: black chips represent positive numbers and red chips are negative numbers. This manipulative leads to intuitive representations for many problems, but not for all. How would you represent 5 + (−3)? Five black chips and three red chips?

These might seem like phantom problems. We use manipulatives because we believe they will aid student understanding. We expect using pizza manipulatives will give students the conceptual understanding of fractions that they will then transfer to the symbolic representation, so they won't need a manipulative for a fraction with a denominator of 10,000. We expect that the conceptual knowledge will successfully apply to other concrete representations, like calculating how many books can fit on a bookshelf. Alas, it's not so simple.

As we've seen, manipulatives that are perceptually rich draw attention to themselves, which can be good because they could highlight the right properties. For example, a "10s" rod is 10 times the length of a "1s" rod. In another example, college undergraduates were taught a principle of self-organization called competitive specialization, which is applicable to ant foraging. An interactive computer simulation depicted ants foraging for fruit, and students learned more quickly if the ants and fruit looked realistic (rather than being depicted as dots and color patches).[31]

But crucially, the study showed that transfer to a conceptually similar problem is *worse* with the realistic-looking ants than with the dots. Other work confirms that generalization. Undergraduates were taught a new math concept (commutative mathematical group of order 3) either using geometric shapes that were meaningless to the principle, or using sym-

bols (cups of water) about which students had prior knowledge that was applicable to learning the new concept. Sure enough, students learned the concept more quickly with the familiar symbols, but transfer to different problems was better with the abstract symbols.[32]

Even if students learn a concept with manipulatives and simultaneously learn it with written symbols, the two may remain separate, with students never drawing the connection between them. This duality would explain the results of a yearlong study of third-graders using Dienes blocks (and other manipulatives) in their math classroom.[33] The researchers found that most children became proficient in using the blocks to solve problems, but those who were most proficient were actually the worst in working the same problems with standard written notation. It was as if using the blocks stayed mentally separate from the symbolic representation.

> Students are more likely to understand the concept the manipulative is meant to convey if that parallel is made explicit to them.

What guidance can this research review offer to classroom practice? A simple review of key conclusions makes a few things clear. First, we must temper our endorsement of manipulatives in classrooms with some caveats; there are instances where manipulatives will not speed children's learning, and may even slow it down. Second, the objects themselves should draw attention to whichever feature is meant to convey information, for example, the length of a rod if it is meant as an analogy to number. Third, teachers should provide instruction in the use of the manipulative so that this feature is salient to students, but teachers should not be so controlling that students are merely executing instructions without thinking. In addition, students are more likely to understand the concept the manipulative is meant to convey if that parallel is made explicit to them.

Two other ideas have less direct empirical support but are worth considering.

You'll recall there was a tradeoff between the perceptual richness of the object used as a manipulative and the likelihood of successful transfer of learning. Students were quicker to learn the foraging principle when illustrated with realistic-looking ants, but the knowledge then seemed stuck to the example with the ants.

A principle known as concreteness fading might address this problem. Originally proposed by Bruner,[34] the idea is that instruction begins with concrete, perceptually rich manipulatives, and students gradually move to more abstract symbols.[35] The Singapore math method offers an example.[36] Preschoolers might initially use stuffed animals when working with number concepts, then animal stickers, then plain circular stickers, and then square blocks appended to form a line. Although concreteness fading was proposed 50 years ago, empirical research confirming the utility of this intuitively appealing idea is limited.

Another idea that seems like it ought to work (and yet has limited experimental backing) is the consistent use of the same set of manipulatives for the same concept. It's tempting for a teacher to use stickers as counters one day, Cheerios another, and so on. It adds some variety and would, it would seem, boost student engagement.

But thinking of manipulatives as analogies suggests student comprehension will be better if there is consistency between manipulatives and what they are to represent. Concreteness fading might be used to get students to the point of thinking of black chips as number units, for example, and, thereafter, they are used anytime number units are invoked. That reduces the memory load for students, allowing them to benefit fully from their previous work. ☐

Endnotes

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Investing Wisely in Teacher Preparation

A San Francisco Residency Program Recruits and Retains Classroom Talent

Andy Castro listens to a second-grader at El Dorado Elementary School, where he recently completed his student teaching as part of the San Francisco Teacher Residency, while his mentor teacher, Nikki Thornton Street, left, leads a lesson.

PHOTOGRAPHS BY RUSS CURTIS

By Jennifer Dubin

One morning in March, the second-graders in Room 11 at El Dorado Elementary School in San Francisco sit on the reading carpet and squirm. To help them focus, Andy Castro asks them to close their eyes and take a few mindful breaths. Once they settle down, he begins a lesson on opinion writing. Today, he tells them, they will practice writing introductions. "Let's hook our readers," he says. "That means grab their attention."

He points to a large sheet of paper next to him with a few helpful reminders. "Opinion writers hook in readers by asking a question. Have you ever…? Do you…?" After reviewing some examples, he asks students to brainstorm introductory sentences with their partners. Little voices excitedly call out "Do you like ninja games?" and "Do you like school?" When Castro asks a boy named Raydell to stand and read the first line of his piece about skateboarding and then compliments his work, the student beams.

The lesson on hooking readers is an apt metaphor for what Castro himself has been engaging in all year: getting hooked on teaching. It's a fundamental goal of school districts across the country. And Castro is in a residency program that is grabbing their attention.

As a graduate student earning a master's degree in education at the University of San Francisco, Castro is actually a student teacher. While student teaching is a crucial part of teacher preparation, in most programs it lasts only a few months. What makes

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Castro's experience unique is that he has taught in the same classroom with the same teacher who has mentored him all school year. He has also received extensive coaching and considerable financial assistance to complete his degree and earn his teacher certification—far more than what many education programs offer. That's because he also participates in a program that provides select student teachers with targeted supports: the San Francisco Teacher Residency (SFTR).

SFTR is a consortium that includes the San Francisco Unified School District, the United Educators of San Francisco, and two area colleges, the University of San Francisco School of Education and the Stanford Teacher Education Program. SFTR pairs graduate students ("residents") from both universities with mentors (called "cooperating teachers") who are classroom teachers in San Francisco. And it provides residents and cooperating teachers with coaches who observe lessons and support each pair in working together. After completing the program, SFTR graduates are guaranteed teaching positions in San Francisco public schools. Just as important, the program continues to provide each new teacher with coaching during his or her first two years on the job.

Inspired by teacher residencies in Boston and Chicago and built on the medical residency model, SFTR began in 2010. Like those two programs, it was established to recruit, prepare, and retain teachers, particularly for hard-to-staff, high-poverty schools. There are about 50 such residencies nationwide.

Since SFTR's inception, this competitive program has graduated nearly 175 educators, 80 percent of whom still teach in the city. District officials say the program's stellar retention rate, along with other teacher pipeline initiatives, can help mitigate the effects of the local teacher shortage, which shows few signs of abating. Two summers ago, the district had to fill 656 vacant teaching positions—vacancies that resulted from a mix of retirements and resignations. This past summer, that figure slightly increased to 664. In recent years, district officials say they have hired upward of 200 teachers on emergency credentials, compared with only a handful a decade ago.

San Francisco is hardly alone in trying to attract educators. In fact, the entire state of California faces an alarming teacher shortage.[1] But the high cost of living in the Bay Area, the tech capital of the world, has made it especially difficult for teachers to afford to live there. In the last few years, housing costs in the city have skyrocketed; the average home now sells for more than a million dollars.[2] That's a steep price tag for beginning teachers in San Francisco, who earn about $57,000 a year. To save money, many young teachers live with roommates just as they did in college, or they endure long commutes. As soon as they decide to start families, however, they find teaching positions and cheaper housing elsewhere. By providing residents with a partial tuition reimbursement, a living stipend, and a housing allowance, SFTR hopes to reverse this trend.

SFTR has graduated nearly 175 educators, 80 percent of whom still teach in the city.

Brittany Villalobos-Gillett, third from left, an eighth-grade science teacher at Visitacion Valley Middle School, and her former resident, Bianca Shiu, second from left, talk with students. Villalobos-Gillett is also a graduate of SFTR.

SFTR organizers also seek to diversify the city's educator workforce to reflect the racial and ethnic makeup of students. Of the district's 3,744 teachers in 2016–2017, approximately half were white, while only 14 percent of the district's 55,613 students were white. In the last three years, two-thirds of the residents SFTR has enrolled identify as people of color.

Recently, research has highlighted the promise of teacher residencies: they retain teachers for more than the three to five years that new teachers tend to stay in the classroom, they recruit a greater proportion of teachers of color, and the handful of programs that have been studied have shown a positive impact on student achievement.*

At a time when our schools face a national teacher shortage, including the challenge of recruiting and retaining teachers of color, the teacher residency offers a way for a school district, a teachers union, and local universities to join together in nurturing the next generation of classroom talent. It's also a way to bolster teacher preparation programs, which have long been criticized for a lack of rigor and for focusing too much on educational theory and too little on classroom practice. "Teacher education is under attack constantly," says Ruth Ann Costanzo, director of clinical work at the Stanford Teacher Education Program (STEP) and the

university's liaison to SFTR. "We have a really good model, and our graduates are proof of that."

Supporting Clinical Work

The history of SFTR starts with Linda Darling-Hammond, professor emeritus of education at Stanford, the former faculty sponsor of STEP, and now the CEO of the Learning Policy Institute. According to Costanzo, who has been with SFTR since it began in 2010, Darling-Hammond guided STEP in establishing a residency to give prospective teachers more intensive clinical preparation. STEP then sought out partners, including the San Francisco Unified School District, the United Educators of San Francisco, and the University of San Francisco.

Together, they created a curriculum and a structure to support a select group of graduate students. In that first year, the program accepted 15 residents. Last year, the number grew to 43. This year, organizers capped it at 35 to maintain program quality. As a sign of growing demand, nearly 150 people applied this year, compared with 130 last year.

To qualify, candidates apply concurrently to SFTR and to the master's program at either the University of San Francisco or Stanford. They submit an essay about why they want to teach in a high-need San Francisco school, and they sit for an hourlong interview with representatives from all SFTR's partner organizations.

Each of the university's graduate programs lasts one year, as does the one year of student teaching that SFTR requires. Besides their university coursework, every Friday residents attend a three-hour seminar, referred to as a practicum, led by SFTR staff members, in which residents discuss their student teaching experiences and hear from speakers such as school district leaders, teachers, parents, and others connected to schools in San Francisco.

Tuition for graduate programs in education at the University of San Francisco and Stanford total about $33,000 and $48,000, respectively. To offset these costs, residents have received a living stipend of about $13,500 and an education award of about $6,000. (This school year, the living stipend, which was provided by AmeriCorps, is no longer available.) After earning their master's degree and teaching credential, and upon becoming teachers in the San Francisco school district, residents also become eligible for a $4,800 housing stipend each year for three years, provided by the Teachers Housing Cooperative, a nonprofit that has provided grants since 2000 to San Francisco Unified School District teachers renting in San Francisco.

SFTR relies on grants and school district funding to support four full-time and two part-time coaches who work with residents and cooperating teachers. As compensation for mentoring residents, cooperating teachers, who teach various grade levels throughout the district, receive a $2,500 stipend, funded by a local parcel tax.

"Years ago, we were strict about looking for cooperating teachers who had at least five years of teaching experience," says Jonathan Osler, SFTR's former executive director. But over time that requirement has shifted, given the district's teacher turnover rate. Also, SFTR officials have found that placing residents with cooperating teachers who are recent SFTR graduates enables cooperating teachers to continue receiving instructional guidance.

The model is "closer to what we would like to see in teacher preparation, which is a lot of support for their practical work," says Rick Ayers, associate professor of teacher education at the University of San Francisco. A yearlong residency, he adds, contrasts with "these quickie credential programs like Teach for America" in which candidates attend a few weeks of summer training for what are often isolating classroom experiences. "Those, I think, do not prepare people well."

Ayers is not alone in this view, which research supports. A study found that only 20 percent of teachers from Teach for America placed in the San Francisco district were still teaching there five years later.[3] Last year, amid growing concerns, the district did not renew its contract with the organization.[4]

Lita Blanc, the president of the United Educators of San Francisco, notes that an important aspect of the residency is that it offers a continuum of professional growth. "The SFTR model takes into account that the cooperating teacher also has a stake in perfecting her craft."

*For more on the teacher residency model, see "The Teacher Residency" in the Spring 2017 issue of *American Educator*, available at www.aft.org/ae/spring2017/guha_hyler_and_darling-hammond.

Blanc also lauds it as a genuine example of labor-management collaboration.* The union is an equal partner in SFTR, with union officials sitting on the program's advisory board, which meets quarterly. In the past, the union has helped raise funds for the program, such as a three-year grant for $178,000 each year from the National Education Association (NEA). Since the grant ends this year, the United Educators of San Francisco hopes to pursue further NEA funding.

Coming together on a project like SFTR has enabled the union and the district to work together, Blanc says, and that has had a ripple effect. "It serves us well when we're trying to problem solve in other areas."

Chris Canelake, the executive director of the school district's office of professional learning and leadership, which oversees SFTR, agrees. The school district and the union have a common interest in raising the bar on teacher preparation, he says. That shared purpose has made the residency "the gold standard of teacher preparation," he explains, adding that his district receives queries from other school districts across the country looking to replicate the model. The district also participates in the National Center for Teacher Residencies, a network that enables programs to learn from each other.

Canelake says that once residents graduate from SFTR, they are highly sought after. The district's principals have come to understand that to find "the very best-prepared teachers, the residency is really one of the first places to look."

Strengthening the Teacher Pipeline

El Dorado Elementary School, where Andy Castro did his student teaching, is in San Francisco's Visitacion Valley, about six miles from downtown. The neighborhood is one of the city's poorest, with 72 percent of its 236 students eligible to receive free or reduced-price meals. More than a third are English language learners, most of whom speak Spanish at home.

The school has partnered with SFTR since the program's inception; for years El Dorado has been a hard-to-staff school. Of its 12 classroom teachers, about four leave every year, says Silvia Cordero, El Dorado's principal. In her five years as principal, Cordero has come to value SFTR. Through the program, "I've been able to hire some good teachers," she says. One of her most recent hires is Castro, now officially teaching second grade. That makes six teachers at El Dorado—in kindergarten, first, second, third, and fifth grades—alumni of the program.

Castro says that during his residency, he learned a great deal from his cooperating teacher, Nikki Thornton Street. In her second-grade classroom, he learned how to plan lessons, engage students in their learning, use concise language, and implement effective classroom management techniques. Throughout the school year, Thornton Street offered increasingly tapered support, with Castro gradually taking the lead on instruction. In March, he felt confident enough to teach what SFTR calls a "solo week." The week entails a resident teaching the entire school day, while the cooperating teacher observes and offers suggestions.

Castro and Thornton Street both agree the week went smoothly; he effectively covered the material. But a few times, students lost their focus, and Castro had trouble getting them back on track. When it comes to discipline, "Nikki does that very well," he says. "She's like this warm demander." By that he means students know their teacher cares about them and also expects them to pay attention.

Thornton Street has been a cooperating teacher since SFTR began, which makes Castro her seventh resident. She's impressed with how reflective and open he is to suggestions, and she praises his ability to build strong relationships with students. A visit to the classroom in March was proof of that, with students clamoring to work with him.

Serving as a mentor, she says, has made her a better teacher. "Having someone in here watching me, I feel like I have to be more intentional in my moves." And having to explain them has pushed her to improve. Working with Tim Nunes, Castro's instructional coach from SFTR, has also helped Thornton Street hone her craft. When Nunes would observe Castro teach for 45 minutes to an hour every other week, he would also suggest ways Thornton Street could better support Castro.

Thornton Street knew from an early age she wanted to be a teacher; as a child she often played school at home. Castro, however, decided to pursue teaching after graduating from the University of California, Los Angeles. For a time, he worked in an afterschool program, where he enjoyed helping elementary school students develop social and emotional skills.

But he graduated with a significant amount of debt. Concerned about adding to it, he chose to apply to the University of San Francisco and SFTR after a director at the afterschool program sent around an informational e-mail. The intensive preparation and financial assistance appealed to him, and he applied.

Being the son of immigrants has helped Andy Castro connect with El Dorado students.

Throughout the school year, Thornton Street offered increasingly tapered support, with Castro gradually taking the lead on instruction.

*For more on the benefits of labor-management collaboration, see the Winter 2013–2014 issue of *American Educator*, available at www.aft.org/ae/winter2013-2014.

To save money, Castro lives in Oakland, where housing tends to be slightly cheaper. He rents a studio apartment and takes public transportation to El Dorado. His nearly hour-and-a-half commute and his long workday illustrate his commitment to his career. He wakes up each day at 5 a.m. to arrive at El Dorado by 7 a.m. Just like the official classroom teachers, he stays the full school day as well as after school for meetings, except Fridays when he leaves before 1 p.m. to attend an SFTR seminar. In the evenings, he takes classes at the University of San Francisco before heading home.

Originally from Los Angeles, Castro says that his parents, immigrants from El Salvador, support his chosen profession but did not have the resources to guide him through higher education. He and his older brother, a college counselor in New York City, are the first in their family to graduate from college.

Visitacion Valley faces challenges similar to El Dorado's. "We're literally and sometimes figuratively on the margins of the city," says Joe Truss, the principal. He explains that the school is far from "the glitz and glamour of San Francisco" but very close to Sunnydale, the city's largest public housing project, where many students live. As a sign of families' economic struggles, more than 80 percent of students receive free or reduced-price meals.

Truss says many parents work two jobs. Recently, he spoke with a principal from a more affluent part of the city whose PTA raised $300,000. "We raise zero dollars," Truss says. So he spends part of his time writing grant applications and soliciting funds to help support his school.

Now in his third year as principal, Truss has been impressed with SFTR residents, whom he considers hard-working and highly skilled. "They tend to come with a really good mindset and a philosophy toward equity in education."

Castro says being the son of immigrants has helped him connect with El Dorado students whose parents also came to this country seeking a better life. Other SFTR residents with similar backgrounds say the same thing.

Learning from Student Teaching

A mile away from El Dorado is Visitacion Valley Middle School, where Bianca Shiu completed her residency. Like Castro, Shiu, who grew up in Arlington, Texas, is the child of immigrants. Because her parents came to this country from Hong Kong and Taiwan, she is keenly aware of the language and cultural barriers many families face.

Roughly 50 percent of the school's 473 students are English language learners, and most speak Spanish at home. Although hardly fluent, Shiu speaks some Spanish and always makes an effort to do so when talking to families. "That can really show parents that our school is trying to reach out to them," she says.

He says that Shiu and her cooperating teacher, Brittany Villalobos-Gillett, an eighth-grade science teacher, enjoy a strong partnership. In fact, they work so well together and are so close in age that when a visitor watches them teach in March, it's difficult to tell the resident from the cooperating teacher.

When we spoke, Shiu, who is 25, was earning her master's degree in education from Stanford. After graduating from Pomona College with a degree in neuroscience, she worked with AmeriCorps for two years teaching students in an afterschool program in Oakland. She had volunteered in afterschool programs while at Pomona and enjoyed the work so much that she decided to pursue a career in education. When she searched online for information about teacher education programs, she came across SFTR. The financial help and professional support convinced her to apply.

Spending an entire year with an experienced teacher has prepared her to plan and facilitate lessons and manage a classroom. This year, she's putting her knowledge and skills to use teaching eighth-grade science in Oakland. "I just didn't want to be thrown in there immediately and not serve my kids very well," she says.

Working with Villalobos-Gillett, who is 28 and an alumna of SFTR, was a good fit. Shiu appreciates how intentional the program is in pairing residents with cooperating teachers. To that end, residents fill out a survey about their personalities, values, and working styles so SFTR officials can make the best match.

While Shiu has already taken a wide variety of education courses—in curriculum and instruction in science, equity in schooling, supporting students with special needs, language policies and practices, and assessment, among other topics—she values the weekly seminar where residents from both Stanford and the University of San Francisco discuss their common experiences teaching in the San Francisco Unified School District.

Spending an entire year with an experienced teacher like Villalobos-Gillett has prepared Shiu to plan and facilitate lessons and manage a classroom.

Amy Millikan, the director of clinical education for SFTR, says that unlike a typical teacher preparation course, the seminar does not give students typical graduate assignments outside of class. Rather, residents "use their classroom experience as the text for processing what's happening," she says. In other words, residents spend that time mostly reflecting on and analyzing their teaching experiences. And they also discuss broader questions, such as what it means to teach in an underresourced school in San Francisco. After all, "this is a context-specific program in which we're working to help our residents first understand how to teach well and then understand how to teach historically marginalized students in San Francisco well," she says.

As California faces its worst teacher shortage in decades, SFTR offers a powerful model of teacher preparation worth expanding. It requires a significant investment in terms of both funding and logistical support from a school district, a teachers union, and local universities—organizations that may not have a strong history of working together.

But if such a partnership exists, as it does in San Francisco, then a residency program can rigorously prepare teachers for hard-to-staff schools. And by pairing residents with mentors, these programs can help strengthen instruction beyond the ranks of novice educators. In any profession, the best mentors admit they still have more to learn.

Now in her fifth year of teaching, Villalobos-Gillett recalls the intensive support she herself needed as a resident. Observing her teaching, it's hard to believe she once had trouble commanding a classroom. The UCLA graduate with a degree in public health says she relied on plenty of guidance in structuring lessons, engaging students, and even speaking in front of a class.

Just as important, she undertook all this work without paying the full cost of tuition. Thanks to SFTR, she now owes $20,000 for her master's degree from the University of San Francisco. Part of her salary of about $61,000 a year goes toward paying that off, as well as paying off the $35,000 of debt she accrued in earning her undergraduate degree.

Among the many benefits of SFTR is the chance it has given her to advocate for the profession. In February, the organization asked her to testify at a joint hearing of the California Senate and Assembly education committees as they examined the causes of and potential solutions to the state's teacher shortage. In her remarks, Villalobos-Gillett explained how "SFTR attracts quality teachers by elevating the profession to the level of respect it deserves."

She also extolled the program's comprehensive approach to teacher preparation. By the time she graduated, she had analyzed school accountability report cards and districtwide health and wellness surveys, met with the local teachers union president and San Francisco parents, and been trained in restorative justice practices. She also spoke of the bus trips she had taken "to the parts of the city my students call home."

Today, Villalobos-Gillett's home is about a 10-minute drive to Visitacion Valley Middle School. She pays $1,250 a month to share an in-law unit with a roommate in the basement of a house. "It's not necessarily in one of the more up-and-coming areas," she says. But it's what she can afford.

Like Castro and Shiu, Villalobos-Gillett did not graduate from college intent on becoming a public school teacher. The residency program solidified her decision because it offered rigorous training. It also provided financial support for a career that has increasingly become out of reach for those who want to teach but lack the funds to do so. As a result, Villalobos-Gillett plans to spend her career sharing her passion for science in a high-poverty school.

"I'm eternally grateful for the training I got," she says. It goes without saying that her colleagues and her students are too. ☐

(Endnotes on page 40)

ILLUMINATING "A DARK TURNING POINT"

The deadly, hate-fueled events in Charlottesville, Virginia, over the summer prompted a strong call for tolerance and justice from AFT members and leaders. Around the country, AFT members took part in candlelight vigils and rallies (like the one shown below in Washington, D.C.) that were cosponsored by the union, Indivisible, and other organizations committed to safety, tolerance, and justice. AFT President Randi Weingarten, Secretary-Treasurer Lorretta Johnson, and Executive Vice President Mary Cathryn Ricker described the recent high-profile mobilization of white supremacists, the Ku Klux Klan, and other hate groups as "a dark turning point in America." The AFT leaders also sharply criticized President Donald Trump for shirking the moral responsibilities of his office. The union is helping frontline educators support students through its online resource Share My Lesson, which is offering free lessons on civil rights, bullying, and coping with traumatic events. Learn more at **http://go.aft.org/AE317news1**.

PAMELA WOLFE

DETROIT SCHOOLS KEEP DOORS OPEN

In a victory for community control of education, 24 Detroit schools threatened with closure have been granted a reprieve after Michigan and the Detroit school board signed a three-year "partnership agreement." The move gives schools leeway to form their own leadership teams and get help from local universities, says Ruby Newbold, president of the Detroit Association of Educational Office Employees and an AFT vice president. Details are available at **http://go.aft.org/AE317news4**.

PARTNERING FOR APPRENTICESHIPS

The AFT and North America's Building Trades Unions (NABTU) are forging a nationwide partnership to promote apprenticeships. The effort will also develop and distribute information to guidance counselors aimed at advancing career and technical education (CTE). The two groups, representing millions of members across the education and trade sectors, will collaborate in the drafting of K–12 lesson plans and other resources. This partnership will help spread the word to U.S. high school students about the direct link between CTE and career opportunities, and the program will be informed by NABTU's Multi-Craft Core Curriculum (MC3). Read more at **http://go.aft.org/AE317news5**.

A SUMMER OF TEXAS PRIDE

AFT members, affiliates, and community partners across Texas played a major role in turning back a slew of state legislative proposals that would have undercut teacher rights and public education. Among the proposals introduced at the urging of Gov. Greg Abbott during a special summer session were bills to eliminate educators' right to have union dues deducted from payroll and to divert state funding from public schools to private or charter schools through vouchers for special education. Also at issue was a "bathroom bill" targeting the rights of transgender students, and an overhaul of the process for property appraisals and tax rates that would further cripple districts' ability to fund public education. The measures were rejected by a bipartisan majority of lawmakers, after spirited opposition from AFT members partnering with faith leaders, parent organizations, school board members, and administrators. Read more at **http://go.aft.org/AE317news3**.

Separately, AFT members and affiliates have stepped up to the historic challenge of helping colleagues cope with the destruction caused by Hurricane Harvey, and the AFT's disaster relief fund is directly supporting members and communities in need. To contribute, visit **www.aft.org/disaster-relief-fund**.

DeVOS WALKS BACK STUDENT LOAN PROTECTIONS

Education Secretary Betsy DeVos and the Trump administration are drawing fire for rolling back policies and rules to protect student loan borrowers. The Education Department "has withdrawn, delayed, or announced plans to revamp" more than six federal student aid protections crafted under the Obama administration, the *Washington Post* reports. The changes signal the Trump administration's misguided plan to completely overhaul such protections. Read the story at **www.wapo.st/2wil8XU**.

HISTORY IN PUERTO RICO

The Asociación de Maestros de Puerto Rico (AMPR), the union representing more than 40,000 Puerto Rican educators, voted in August to affiliate with the AFT. The move will bolster the fight against privatization in Puerto Rico and strengthen public education and economic opportunity for its people. Puerto Rico is facing a $70 billion debt crisis that has led to 60,000 fewer students in the school system, tens of thousands of people leaving the island, the closure of 164 neighborhood public schools, and the loss of benefits and retirement security for teachers and public employees. "With the AFT, we can work hand in hand to improve our working conditions and reclaim all that has been denied to us," said AMPR President Aida Diaz. Read more at **http://go.aft.org/AE317news2**.

Diaz, left, with AFT President Randi Weingarten and AMPR-Local Sindical Secretary-General Grichelle Toledo.

AFT STAFF

AFT Materials That Support Science Education

IF YOU'RE LOOKING to promote scientific inquiry, interest families in STEM-related activities, connect with educators in professional learning communities, and engage students in project-based learning, four new free publications from the AFT's educational issues department can help.

Questions to Promote Scientific Inquiry and Engineering Design

http://go.aft.org/AE317tft1

This brochure encourages educators to reflect on the questions they pose to students. Purposeful questions can bolster scientific thinking and deepen understanding of scientific topics by spurring students to:

1. Ask questions and define problems.
2. Develop and use models.
3. Plan and carry out investigations.
4. Analyze and interpret data.
5. Use mathematics and computational thinking.
6. Construct explanations and design solutions.
7. Engage in argument from evidence.
8. Obtain, evaluate, and communicate information.

Planning Family Science Nights

http://go.aft.org/AE317tft2

With the release of the Next Generation Science Standards and a shift toward taking a more integrated approach to teaching science, technology, engineering, and math (STEM), the time is ripe for amplifying STEM education. This guide will help you think through how to plan a family science or STEM night at your school.

Creating a Professional Learning Community

http://go.aft.org/AE317tft3

A professional learning community, or PLC, is a group of educators who analyze student performance together and learn from one another to improve teaching and learning. PLCs can be organized in various ways, such as by grade level or subject area. This brochure details how to set up a PLC focused on science, and includes topics such as developing essential questions to lead PLC discussions, monitoring student performance, and using tools for analyzing student data.

Teaching with Project-Based Learning

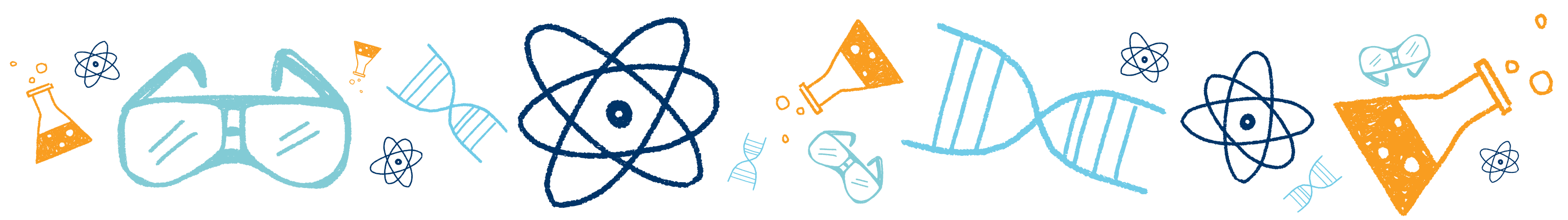
http://go.aft.org/AE317tft4

Project-based learning allows students to gain knowledge and skills by working for an extended period of time to investigate a complex question, problem, phenomenon, or challenge. Since STEM education naturally lends itself to project-based learning, this brochure describes its benefits, ways to approach it, and resources for incorporating it into STEM courses.

* * *

To see more publications from the educational issues department, go to **www.aft.org/education/publications**.

–AFT EDUCATIONAL ISSUES DEPARTMENT



RESOURCES

DEMYSTIFYING LOAN FORGIVENESS

Public Service Loan Forgiveness is a federal program to help ease student loan debt for those pursuing a career in public service. It is available to anyone who has a federal loan and is employed by a qualifying public or nonprofit entity, making it open to the vast majority of AFT members. As part of the Debt-Free Future campaign, the AFT has recently updated online materials to promote a better understanding of this program and ways to maximize its benefits (see **www.forgivemystudentdebt.org**).

A BLUEPRINT FOR BREAKFAST

The Breakfast Blueprint (**www.aft.org/breakfastblueprint**) is a toolkit focused on strategies for planning, implementing, and evaluating after-the-bell programs such as breakfast in the classroom, second chance breakfast, and "grab and go." The AFT and the Food Research & Action Center listened to the varied perspectives of nearly 600 teachers, paraprofessionals, custodians, school health professionals, and food service workers to inform the toolkit's eight-part guide, which includes step-by-step questions for developing a district plan, recommendations for choosing the best breakfast models, and a review of effective practices.

THE KINDNESS CHALLENGE

The AFT has partnered with leading national organizations to launch the Middle School Kindness Challenge. Open to any school with any combination of grades 5–8, the challenge offers free resources to teach, foster, and celebrate kindness (see **www.kindschoolsproject.org**). The heart of the challenge is a four-week series of readily doable events and activities, and the effort is designed to help teachers and staff members foster a higher level of kindness in school and life.

DIVERSIFYING THE EDUCATOR WORKFORCE

The AFT report "Union Role in Diversifying the Educator Workforce" highlights the urgency to recruit and retain more people of color to teach in public schools. The resource (**http://go.aft.org/AE317res1**) outlines several union-led programs that, by helping paraprofessionals and other members of the school community to become teachers, have constructed a successful "grow your own" approach. Building on relationships already in place is a huge benefit of this strategy: the closer teachers are to students' own communities, the more they can connect and engage with them, according to the report.

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(Continued from page 9)

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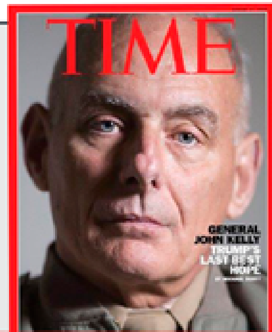

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