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Getting Beyond “CRAAP”: Scientific Literacy in FYW and WAD

Erica Duran and Lauren Mecucci Springer

Abstract: *While first-year writing (FYW) programs often bear the responsibility for teaching students to write across the disciplines (Downs and Wardle), too often students restrict the concepts learned in FYW to the humanities, or even worse, a single class. Moreover, students frequently complete research assignments in FYW which restrict them to scholarly or peer-reviewed sources, hindering their ability to learn how to assess popular sources. This can be especially problematic with scholarly STEM sources, which are laden with unfamiliar technical terms. Although the writing and research skills learned in FYW are often intended to be interdisciplinary, FYW faculty have opportunities to make these courses more relevant and useful to students interested in pursuing STEM majors or careers. We argue FYW is a critical space, allowing us to help students learn how to find, assess, and process scientific information, while simultaneously teaching students how the rhetorical situation (i.e., purpose and audience) is important outside of humanities; since future scientists are tasked, now more than ever, with presenting their information to non-experts in an increasing number of arenas, often competing with pseudo-science. Therefore, our article includes ways to build a STEM-themed FYW course and provides instructors with assignments emphasizing both popular and scholarly sources for all majors, helping demonstrate the value of writing about the sciences in various mediums. Ultimately, FYW provides a unique space where instructors have the chance to help both STEM and non-STEM majors prepare to effectively write and research in today’s ever-changing world.*

Introduction

Four decades ago James Berlin argued teaching writing is more than helping students develop a “technical skill” (“Contemporary” 776); rather, it is about helping students make sense of the world. Ten years later he would call this producing “literate citizenry” (“Poststructural” 32). But today’s critical literacy requires the ability to assess a seemingly endless amount of information quickly and accurately and in ways Berlin could not have imagined over forty years ago.

For instance, there is a proliferation of scientific information shared online via sites like *YouTube* and *TikTok*, so it is understandable how easily non-experts, like college students, might believe credible-looking sources. Take the student who watches a video on a scientific topic from a questionable source, let us say “Dr. M.,” who claims to be a “climate change expert.” The video does not include a fake news warning from *YouTube*, and since the speaker is a “doctor,” the student may assume the person has authority and the information is credible. Further, the *YouTube* profile describes the doctor as a “world renowned expert and speaker on environmental issues.” So the student cites the video’s

information in their essay, but upon reading the quote, the instructor quickly realizes the information sounds inaccurate. The faculty then does the work to vet the source themselves, work the student should have done to begin with, and determines that “Dr. M” is a doctor but in an area wholly unrelated to climate change. In fact, the video is espousing their opinions without any citations or verifiable evidence. The student used what they felt was a credible scientific source, yet the faculty member says it is not credible. Distinguishing between actual science, non-contextualized scientific information, and pseudo-science has always been a challenge, but today it is more critical than ever if we hope to achieve “literate citizenry.”

But who is responsible for developing the “literate citizenry,” particularly in higher education? What about *scientific literacy*, which Carol Anelli defines as the ability “to weigh options and make informed decisions as individuals and as citizens of democracy”? (243) At most post-secondary institutions, first-year writing (FYW) bears the responsibility for preparing students to write across the disciplines (Downs and Wardle) and is now often tasked with teaching students how to gather, assess, and present research, scientific or not. In fact, FYW is often viewed as the key course to incorporate information literacy (Artman, Friscaro-Pawlowski, and Monge 94; Sult and Mills 370). Thus, FYW instructors are often relied upon to help students develop skills necessary for success in academe. Today, teaching these skills is complicated by various elements.

With the current ubiquity of fake news, satirical publications, and information overload, ensuring students leave FYW with the skills to accurately assess and comprehend research has never been more important, and for STEM students, this skill set comes with responsibility other disciplines may not encounter. Because information—reliable or otherwise—has never been more accessible, more people are reading scientific information than in previous years, but, too often, scholars write for other scholars, meaning scientific texts are laden with jargon. M. Halliday and J. R. Martin argue children are often turned off by jargon, which engenders a sense of alienation from this discourse; this alienation, according to Halliday and Martin, is carried to adulthood, increasing the likelihood the average reader will avoid jargon-heavy texts. Yet, jargon is something scientists (and other discipline-specific experts) often employ; writing remains critical for sharing scientific knowledge. Therefore, today’s scientists often simultaneously write for their peers and the everyday reader—the ones who may stop reading when inundated with jargon.

We argue FYW is positioned to make this specific rhetorical situation clear to students, particularly STEM students, who too often think concerns surrounding audience and purpose are restricted to the humanities; FYW is a space positioned to help both Berlin’s “literate citizenry” and Anelli’s “scientific literacy” become a reality at a time when science knowledge is especially integral to making sense of the world.

The Relationship Between FYW, WAD, and Information Literacy

Colleges, universities, and even faculty commonly expect FYW faculty to teach college-level writing *and* research skills, including information literacy, in order to prepare students to succeed across the disciplines. Library instruction, in fact, often targets FYW courses as a logical place to teach information literacy since both “writing and research-

ing are viewed as non-linear processes" (Sult and Mills 369). FYW instructors' (unrealistic) course expectations are hampered by a variety of challenges, including time-constraints, students' various skill levels, the available school resources, and the depth of knowledge required by the FYW faculty member to teach both successfully.

While scholars have discussed information literacy in FYW and/or general composition classes (Artman, Friscaro-Pawlowski, and Monge; Holliday and Fagerheim; Jacobs and Jacobs; Sult and Mills), they're often broad discussions, leaving science literacy in FYW out of the conversation. It's unlikely, then, students, generally speaking, are effectively learning to write and read across the disciplines.

Writing Across the Disciplines

Wardle explains FYW is often criticized for its inability to help students learn to write across the disciplines (WAD) despite the fact WAD is often inherently part of FYW's goals across higher education. Wardle asserts, "the rhetorical situations of FYW courses around the country do not mirror the multiple, diverse, and complex rhetorical situations found across the university in even the most basic ways" (766). If students of all majors leave FYW without the ability to write for different rhetorical situations, it is unlikely FYW STEM students leave with the ability to think about the rhetorical situation outside of academia, either.

Although teaching audience awareness is often a tenet of FYW, assignments can end up presuming a general readership represented by the instructor and perhaps other students in the class. Chris Anson and Jessie Moore explain teaching "genre, purpose, and audience" helps promote the writing transfer that skilled writers need (9). But the general readership paradigm still prevalent in FYW assignments may lead STEM students to conclude such writing is wholly disconnected from that which is required of professional scientists; although science journalism may be presented and used as sources for research papers in their FYW courses, it is unlikely this genre is discussed as a potential career requirement for STEM students. Therefore, it is critical FYW faculty make obvious to STEM students *why* writing with a general audience awareness is valuable for all disciplines. This instruction will help STEM students to envision these assignments as useful across the disciplines rather than a one-off type of assignment in a first-year course. Hyland argues faculty should

take care in using popular texts as models for scientific writing as differences in constructing proximity mean that they will not help students see how scientific facts can be questioned or modified. Comparisons, however, can have an important consciousness raising function by highlighting features of scientific discourse for learner noticing. Their study, moreover, may help students see something of the importance of audience. (126)

Bringing both popular and scholarly sources into FYW can help students better understand the varying rhetorical choices authors must consider with regard to different audiences.

Thankfully, some students retain the ability to access prior knowledge post-FYW. Jerry Stinnett explains students must "develop metacognitive rhetorical knowledge

about writing” to help them transfer writing skills among contexts. In doing so, students develop an “awareness of how writing changes from situation to situation” (357). While it’s unlikely students will learn to see every situation outside FYW as rhetorical, the course can initiate this understanding. Simply asking students, for example, to identify differences in writing tasks between their other classes and FYW highlights how audience awareness is not a humanities-specific concept. Helping students understand the rhetorical situation can be difficult, especially as FYW instructors are simultaneously tasked with teaching college-level research skills expected to transfer across higher education and the professional world.

Information Literacy

In order to meet the expectation of equipping students with research skills, instructors often rely on librarians to teach these basic skills in a single class. Leslie Sult and Vicki Mills discuss how library instruction targets FYW courses in an effort to help all students learn information literacy. While this practice has merit, research shows one-time or limited librarian support is problematic, too. Margaret Artman, Erica Frisicar-Pawlowski, and Robert Monge discuss these “one-shot instruction” moments as ineffective, and other scholars argue first-year students rely (almost solely) on ongoing librarian instruction to develop legitimate information literacy skills (Bowles-Terry and Clinnin 327). Worse, some FYW instructors rely on librarians to help students develop research skills simply at the reference desk without any context (Birmingham et al.). Each of these practices severely limits students’ ability to develop their own data literacy, especially as it relates to challenging scientific sources.

Often, then, the onus to find and assess sources still resides with someone other than the student. Librarians are called to support both students and instructors (Bowles-Terry and Clinnin), which increases the likelihood FYW instructors rely on generalized research rules for college-level work, likely amplifying the chances scholarly sources are prioritized. This amplification can lead some instructors to limit the source types students can employ, thus decreasing students’ exposure to popular sources and limiting their understanding of the value of popular sources in disseminating information to general audiences.

Due to the time constraints of a roughly 16-week semester wherein they must teach both college-level writing and research, FYW instructors often rely on generalized ways to teach source evaluation basics to their students. One such generalized evaluation process is the CRAAP test. According to Chico State, it is a commonly used checklist provided to first-year students to help them determine the validity and quality of sources. CRAAP is an acronym for five criteria to evaluate in a source: currency, relevance to topic, authority of the source, accuracy of the information, and purpose of the text (Chico State). But due to the proliferation of online sources since its development, the test is outdated. While CRAAP can be a useful tool, it can also be overly simplistic for a process that necessitates critical thinking. Fielding explains why CRAAP does not fully serve students: “While...CRAAP’s individual assessments have ongoing value, it has become vitally important to place information into a wider context to adequately evaluate its credibility, as well as teach how information is ranked and presented on search

engines and social media" (622). All criteria in CRAAP are presented as equally important, which is a superficial, misleading approach; the criteria "accuracy" and "authority," for example, are often more critical than the other criteria and are especially challenging for students to understand. Moreover, scholars note students may understand *how* to evaluate sources but often *do not* rely on the evaluation criteria while choosing sources (Kim and Sin; List and Alexander). Thus, students may be using other criteria, such as convenience or urgency, when they decide which sources to use, again, highlighting the need to help students assess popular sources, too.

Information and Audience Awareness in FYW for STEM Students

Audience awareness and information literacy is especially critical for students engaging popular STEM sources, such as science journalism. Alongside the proliferation of online science news sources, STEM reporting by non-scientists has also increased. While always important, information literacy and audience awareness are arguably even more critical when it comes to popular STEM sources. In an attempt to avoid the problem of evaluating such sources, instructors might be tempted to require students use only scholarly STEM material. But these sources, too, are not without their own credibility and accuracy challenges (Besançon et al.). David Barel-Ben et al. argue there is an ongoing crisis in scientific journalism due to the ubiquity of online media and an increase in staff writers assigned to STEM and tech topics when such writers are without the credentials to take them on; this presents difficulties for students attempting to use basic evaluation criteria to vet their popular sources. Barel-Ben et al. note that online news outlets may cut corners on fact-checking simply due to shortened timelines for publication compared to academic papers. According to the National Research Council, scientific literacy is the ability to "use evidence and data to evaluate the quality of science information and arguments put forth by scientists and in the media" (22). This definition, however, relies on the information the reader is consuming to be accurate, complete, and up-to-date.

The average reader who encounters an online STEM source may not seek out the original data to "evaluate the quality" of the online source's information, especially if they believe the source to be credible. For example, it is now common for social media users, including those working for so-called media outlets, to promote and disseminate scientific information on platforms like *Twitter*. However, in order to avoid misrepresenting scientific studies and research, scientific information communicated via "science journalists" must be as accurate as possible; scientists have been called upon to help engender this accuracy. At the AAAS Annual Meeting Communicating Science seminar, science journalist Flora Lichtman noted, "journalists don't often let people look at the final piece before publication" (par. 12), something often embraced in FYW via peer-editing. FYW, then, has an opportunity to also illustrate the dangers of publishing without any editing or peer review. Lichtman recommended scientists make themselves available for fact-checking following interviews (if they have given them) to help assist with accuracy. Similarly, FYW may task students with conferences (with peers and/or their instructor), helping FYW students become comfortable discussing their written

ideas after the fact. Thus, FYW has the space to parallel future scientists' experiences vis-à-vis writing and publishing.

Barel-Ben et al. highlight studies demonstrating how scientists can help fill the gap in communicating science to lay people by writing the articles themselves. In their study of 150 scientific writings for online sources written by both scientists and science reporters, they concluded "in most cases no differences were found between the ways audiences responded to scientific reports written by scientists-as-science-reporters, and stories written by news site reporters" (12). This is encouraging: it means scientists' works, when they learn the rhetorical skills to write *for* a general audience, are read with the same level of interest *by* a general audience. Given this need for more science writing directed at general audiences, FYW offers an early and critical opportunity for students to see these different rhetorical opportunities at the start of their STEM studies so this form of writing can be identified and amplified for STEM students struggling to see connections back to FYW.

Audience Awareness and Popular Sources/Media

While scholarly sources provide a model for STEM students' future research and writing, learning to write for mainstream sources can also be valuable, perhaps for reasons the students haven't considered. For instance, STEM majors typically anticipate working as active scientists, which often requires original research and writing. While the practice of peer-reviewed journal publication will likely remain the cornerstone of scientific research dissemination, outside that community exists a far larger audience who will continue accessing scientific research filtered through mainstream sources like magazines, websites, and social media. This practice, unfortunately, leaves many scientists at the mercy of staff writers and non-scientists who may purposefully and/or inadvertently mischaracterize their research, leading more scientists to mistrust popular sources. In her piece, "The Incredibly True Story of Fake Headlines," author Chi Luu describes a recent example from the *Atlantic*:

The original headline "The Arrogance of the Anthropocene" accurately described an interesting, well-researched essay on geological time and humanity's role in it, while the more provocative, social media-friendly follow-up headline, "The Anthropocene Is a Joke," framed it in the worst possible way. It's not hard to see how subjective and dismissive the informal language of this headline is, but since "anthropocene" is also widely used by scientists as a linguistic shorthand to describe the human-focused crisis we find ourselves in, this was also a fairly irresponsible way to frame what was otherwise a decent story. Unsurprisingly, on social media, it was also shared by climate denialists as support for their beliefs.

Depending on where a reader encounters this article, their perception of its angle, information, bias, and thus its credibility may all be different. This example also illustrates

why STEM students need to see the connections between science and rhetoric; a simple word change affected the connotation in the title alone.

Information Literacy and Popular Sources/Media

Scholarly sources for any topic, particularly STEM, can further confuse students who lack the vocabulary and context to translate them. While there are multiple instruments to test STEM students' scientific literacy in scientific courses (Shaffer et al.), these tools are not typically known about or employed in FYW courses, especially if students are non-STEM majors. In fact, before one can become scientifically literate, a minimum degree of general literacy and reading comprehension is required, which many students still grapple with even in college. According to Olney et al.'s study, only 32% of college freshmen read at a 12th grade level (396). This statistic only slightly improved as of 2019 when the National Assessment of Educational Progress annual report card reported 37% of high school seniors were reading at 12th grade level. When these students enter college, they are exposed to a vast number of information sources for which minimal information literacy education is provided unless they take specific courses to help them with this; the information literacy provided in overburdened FYW is often insufficient for many incoming freshmen. Irina Holden notes "a growing concern among secondary educators with the lack of information literacy skills observed in our students" and the need for students to be able to deal with "rapid changes in the information landscapes" (qtd. in McMillen et al.). Faculty and librarians alike bombard students with tips about identifying scholarly sources by jargon or an article's length, but these tips do nothing to strengthen students' reading comprehensions, especially when scientific terms and jargon are difficult for *anyone* outside of STEM to fully understand.

Additionally, struggles to understand researched sources are sometimes compounded when students' own "research is typically addressed in a separate unit, positioned at the end of the course" (Purdy 48). While some FYW faculty introduce research to students from the beginning, weaving it into multiple assignments, most faculty rely heavily on the supplemental instruction of college librarians (Bowles-Terry and Clinnin) and the final research paper. Heidi Jacobs and Dale Jacobs argue that, for a variety of reasons, information literacy is challenging to teach in FYW and note one component typically left out is revision. While composition is taught as a revisionary process, research is not, when the most comprehensive research instruction given is during the "one shot," end-of-term class, which results in "the collection of information more like a scavenger hunt than a critical, self-reflective process" (74). Additionally, Jacobs and Jacobs note faculty are contending with a charge to address a number of competing student needs, so discipline-specific research skills are not a priority when basic research skills provide the most efficient means to an end for a uniform class assignment like a research essay:

Students taking composition come from all programs, all majors, and all years; an average class might include a visual arts major, a computer science major, a sociology major, and several undeclared students. Thus we (instructors and librarians) are not teaching discipline-specific research methods in the way that we might teach history majors how to do archival research or biology majors how to do scientific research. (76)

FYW faculty might better prepare students writing on STEM topics by teaching them to complete their own scholarly research earlier in the course and by allowing students to utilize more mainstream sources where they are likely to encounter vocabulary they comprehend. This allows students to gradually become more familiar with scientific jargon with a smaller risk of misunderstanding, and exposing students to mainstream writing on STEM topics acquaints students with specific rhetorical situations where technical and scientific knowledge are communicated.

Students who are taught to determine textual authority and accuracy independently often choose not to use that evaluation criteria when choosing sources (Kim and Sin; List and Alexander). Many FYW faculty limit students to peer-reviewed scholarship when conducting research in order to mitigate the problems caused by student choices; however, this ultimately compounds the problem faculty are trying to solve because it limits students' ability to develop the strong critical thinking skills to assess sources on their own (Purdy). The problem occurs when students find a popular source written by a self-proclaimed scientist or doctor: their FYW instructor and librarian may not have covered how to evaluate scientific literature for credibility. If students have only ever been required to use scholarly sources, they have not learned how to evaluate the credibility of these online "experts" beyond a generalized evaluation checklist which they may or may not use (Kim and Sin; List and Alexander). Social media only compounds this problem, especially when scientists and non-scientists alike are using these platforms to share scientific information. J. Holmberg et al. explain how scientists often utilize *Twitter*, for example, to share new scientific publications (qtd. in Boothby et al.). *Twitter* works well since "several features of the scientific paper that are readily transferable to tweets, such as the title, abstract, and figures, are formal cues that may contribute to credibility" (Boothby et al.). Although some information may indeed be accurate, the formula for sharing information to make it appear credible, such as adding charts or graphs and linking to outside sources, can be easily replicated by non-scientists and those who are not experts. Thus, credibility can be even more difficult to determine. This limitation is augmented for FYW students learning about STEM topics primarily through scholarly sources. Thankfully, there are some successful models to follow for credible science online, including the practices of a growing number of celebrity scientists.

Popular Media and Science Communication Artifacts

Celebrity scientists are not new, but their ability to connect with the public is increasing due to the evolution of the web and social media. For example, many are familiar with Jane Goodall, Carl Sagan, and Bill Nye the Science Guy because they regularly appeared on television for three decades. These scientists found great value in direct communication with public audiences while sharing information in layman's terms. Additionally, Goodall and Nye emphasized the importance of sharing their knowledge with younger generations and making science accessible to all ages. While Goodall and Sagan are certainly considered giants among their professional peers, they also managed to success-

fully communicate beyond the scientific community via regular talk show appearances, public speaking tours, and even their own televised specials.

Today, we see this trend continuing and expanding with figures such as Neil DeGrasse Tyson and Richard Dawkins, who have embraced these same types of popular appearances, in addition to actively participating in new media. Each, for instance, have millions of followers on platforms like *Twitter*. They've also published numerous books for general audiences, appeared on countless television programs and podcasts, and worked continuously to engage mainstream audiences. In fact, mainstream audiences are enamored with today's scientists. In 2014 *ScienceMag* published "The Top 50 Science Stars of Twitter." While discussing celebrity scientists, meteorology scholar and author Marshall Shepherd points out "some critics and 'Ivory Tower' gatekeepers accuse them of being 'popularizers' of science and not serious scholars," but he strongly feels that "scientists should engage more broadly in non-traditional outlets such as the media, policy forums, and social media. If we don't, then people with agendas or limited backgrounds will gladly and strategically fill voids that we leave behind" (par. 2). Tzipora Rakedzon et al. note while "academic writing programs are prevalent in universities around the world, there are few programs that train scientists how to write and communicate with the lay public" (29). Thus, FYW programs should consider how they present writing about scientific topics so students gain introductory knowledge of the many valuable ways in which scientists can and even should write for general audiences. By creating assignments in which non-STEM faculty and students alike can engage with science, FYW instructors can help build both information literacy and audience awareness across disciplines.

The following excerpts come from assignments we developed for our own students, irrespective of majors, to introduce writing about STEM topics for general audiences.

- Find a scientific study on any topic. Then find a mainstream news source summarizing the *same* study. Write a comparison and contrast essay examining the connections between the "conclusion" or "findings" of the scientific study and the mainstream article. Be sure to identify any gaps in the mainstream article that may lead to a reader's misunderstanding of the actual scientific study.
- Choose up to three fake news stories about the *same* STEM topic. Write a 5-to-7-page, thesis-driven essay summarizing the stories, explaining the purpose of the stories (e.g., Do they create fear? Do they have a call to action?), and explaining the risk(s) of someone believing the stories you chose.
- Find an article about a STEM topic in a major newspaper like *The New York Times* or *Los Angeles Times*. Write a letter to the editor responding to the article. Address any concerns you have about the topic relating to one or more of the following: the original author's accuracy or tone, potential impact on your own community, or a dissenting view based on evidence not presented in the article. Support your response with a scientific article (popular or scholarly) on the same topic.
- Using the six conventions of scientific writing (structure, objective, analysis, accuracy, formality, and clarity), write a 5-page, APA formatted, essay explaining one of the lab reports you chose from this semester's research to a general audience. This is your opportunity to take scientific information written by scientists and translate it into digestible and interesting information for a mainstream reader.

- Write a 3-to-4-page rhetorical analysis of one of the science and technology articles we read as a class. In your analysis, identify the audience for the piece, examine how the author's word choice effectively communicates scientific information to that audience, and identify areas where the author was less effective and why.
- Write a 2-to-4-page personal narrative about a time in your life that was significantly impacted by science or technology. Common incidents might include things like your participation in an online gaming community or receiving or witnessing a life-saving medical treatment. Be detailed in your descriptions of both the science/technology and its impact on your life.

These assignments provide opportunities for non-expert FYW faculty to incorporate various STEM-focused writing opportunities that emphasize rhetorical situation. For assistance in developing these, faculty can even look to university websites and samples in WAC/WAD research. Additionally, these assignments provide students opportunities to actively engage both scholarly and popular sources on STEM topics and identify the many differences in how they approach their audiences. Finally, these assignments embed information literacy for STEM topics early in the semester and consistently, so students are applying these skills throughout the course with different types of sources.

Valuing Popular Sources and Media in FYW Research

The term “popular sources” is a loaded one, even for professionals; so the average FYW student can be forgiven for having trouble distinguishing among the good, the bad, the incomplete, and propaganda. The broadest definitions define popular sources as those written for a general audience, including magazines, newspapers, and websites. A source's popularity and ubiquity can also mask its credibility, especially when the source presents scientific information.

Many first-year students enter college with misconceptions about research and their own levels of information literacy (Latham et al.). In their introduction to the college library, most FYW courses include instruction about using college databases, practice developing search terms, an in-depth look at MLA format and citations, and methods for evaluation of source quality (Rinto and Cogbill-Seiders). Both instructors and librarians distinguish between so-called “popular sources” and “scholarly sources.” Although there is value placed on each, scholarly sources are often privileged by instructors in FYW and are certainly preferred by instructors across the disciplines; in fact, this is a practice often continued from high school, where teachers prefer scholarly sources as preparation for college-level writing and assignments. Students in turn privilege scholarly sources (Insua et al.), even though many still have trouble understanding them. In fact, James P. Purdy explains college-level instructors frequently caution students about research done via the web, thus compounding this idea that popular sources are less valuable than scholarly ones. While it is prudent to ensure students can identify different types of sources (e.g., scholarly versus popular), according to Purdy, classroom policies restricting students from utilizing technology and sources they are likely familiar with can unnecessarily create classroom barriers for students; it is likely ineffective, too, since

instructors ultimately cannot control the research tools students will utilize. Glenda M. Insua et al. argue something similar:

To address the issue of students adhering to strict guidelines recalled from high school, the research team has moved toward more nuanced instruction regarding popular and scholarly articles. Rather than pitting popular and scholarly articles against each other, a better choice might be to have students engage each type and explore its contribution to research on a topic. (152)

Moving past this idea of "either/or" when it comes to popular versus scholarly sources can strengthen students' ability to locate, assess, and comprehend scientific research.

Because FYW students do not typically read scholarly research, especially scientific publications, outside of a classroom setting, they are more likely to consume scientific information in popular online sources. A 2018 study conducted by the Knight Foundation and Information Literacy Project surveyed nearly 6,000 college students and their newsgathering habits. Remarkably, 93% of respondents said they got their news from peers, 89% from social media, and 76% from online media websites like mainstream news media outlets (Head et al. 5). Educators can take solace in knowing respondents also noted 70% of the time they learned about news from college classes or individual instructors. While these statistics may seem alarming overall, they are unsurprising given that these news-gathering habits mirror that of most Americans. According to a 2017 study, which looked specifically at how people get scientific news, "54% [of respondents] say they regularly get their science news from general news outlets" (Gottfried and Funk par. 2). Interestingly, this study found just 28% of the same respondents felt the science news reported in those general outlets was accurate. When asked why they felt it was inaccurate, 73% of respondents cited "the way the news media cover scientific research" (Gottfried and Funk par. 5). These studies, when related to college students and general news, illustrate that most non-scientists are consuming news from popular online sources, which they acknowledge may not be accurate. Further, the general public's perceptions about popular sources and media are backed up by research on the reputation of specific social media sites, such as *Twitter*. In fact, "Twitter is often considered less credible than other online news media (Schmierbach & Oeldorf-Hirsch). This reputation is often premised in the strong body of recent literature devoted to assessing the spread of misinformation, hostility, or bot-like behavior on *Twitter* (Anderson & Huntington; Robinson-Garcia, Costas et al.; Shao, Ciampaglia et al.; Vosoughi, Roy, & Aral) and to containing and correcting misinformation (Bode et al.; Smith & Seitz). None of this is news to FYW faculty, who have traditionally responded by teaching students to transition their reliance on popular sources to the more academically accepted scholarly sources, at least for the sake of their class assignments and larger research papers, thus reproducing a perceived dichotomy between these genres.

However, by restricting them to scholarly sources, FYW instructors are unintentionally hindering students' ability to understand the concept of audience awareness and are unintentionally creating academic barriers. Students are dissuaded from using what they likely find familiar (Purdy). A recent study on information literacy and college freshmen found that many participants believed "Google to be a sufficient search tool" and "that freely available Internet resources are sufficient for academic work" (Hinchliffe

11). Hinchliffe further argues that student reliance on search engines, however, comes with other risks: students' experiences have led them to see the research process as linear, where questions have just one answer (Hinchliffe). It is not just the students who view research as linear, however: instructors often facilitate research as a linear process rather than a recursive one (Jacobs and Jacobs 74). For example, students develop an argument, find sources, and write the paper. Purdy argues presenting the research process as linear disconnects the research from the writing for students, unintentionally implying "research and writing are wholly separate [and]...uninformed by one another" (48). Separating research and writing contradicts what students are taught about rhetorical situation, especially audience awareness. Additionally, STEM students may encounter research by scientists *only* in scholarly works, curtailing these novices' exposure to non-expert audience models. While traditional FYW research instruction should help students see themselves as burgeoning scholars using scholarly sources, the addition of science communication to the curriculum can and should include non-scholarly sources for mainstream audiences as well. In framing scholarly sources as "experts writing for other experts," instructors may unintentionally leave out the public intellectuals in STEM who often work to translate the raw findings of science for the layperson in palpable and credible ways.

Because of the peer review editing process, audience awareness and information literacy skills are arguably less crucial for students working exclusively with academic sources. STEM students exposed only to scientific articles do not necessarily learn necessary rhetorical principles when encountering other types of science communications. Determining the authority of a traditional, mainstream source can be challenging, even for those with experience vetting sources on a regular basis, but this skill is not typically required or emphasized when students are restricted to scholarly sources. In other words, teaching students to assess sources while simultaneously restricting them to scholarly sources means students are not actually practicing real-world skills needed to make such evaluations.

When we ask novice researchers to assess source authority, faculty must consider how far into the weeds we can ask students to go. Indeed students are in a catch 22 position: evaluation requires knowledge, but knowledge requires reading source material. For instance, both *The Daily Mail* and *The New York Post* are known, at least to academics, as untrustworthy tabloids. Yet online, where search engine results often dictate what appears credible or not, students may not have the background necessary to investigate the authority of either of these sources. Where paper publications used to provide some visual clue as to what was truth versus what was sensational, websites are not always as straightforward. Elise Silva et al. point out, "While [first-year university students] show some hesitancy with design that is too flashy or overbearing, these novices are generally unable to point out what characteristics authoritative sources actually display" (26). Essentially, students believe they can recognize a bad source, but they are not sure what a good one looks like. To distinguish between them, readers must first have a fundamental understanding of who is producing the material they are reading or watching. Thus,

without tasking students with rigorous source assessment, they will likely leave FYW without ever having truly employed this skill.

For instructors, the authority of a source is obviously and directly connected to its credibility; however, instructors and FYW students may define credibility very differently, especially for Internet sources. Ideally, traditional news sources have a chain of gatekeepers through which the information must flow prior to publication; this is especially true for scholarly sources. The problem, though, is "as the current information environment online does not often include professional gatekeepers who filter information sources, traditional indicators of authority, competency, and honesty can be hard to spot by consumers" (Silva et al. 25). *YouTube*, for example, makes it easy to find dubious and even dangerous scientific misinformation masquerading as fact. Remember the example of Dr. M from the intro? Unfortunately, as Emma Grey Ellis points out, this type of fake news is not typically picked up by algorithms used to identify other fake news like anti-vaxxing conspiracy theories. Thus, "YouTube and Instagram have built up dozens of resident food scientists, dermatologists, registered dietitians, OB-GYNs, surgeons, astronomers, veterinarians, and biochemists with specialties in beauty-product quality assurance" (par. 7). Human-powered fact-checkers, however, will always be behind the speed of algorithms, especially in an online world where fake stories are generated hourly. This engenders inconsistent flagging of fake videos as false or even dangerous, but because viewers have become familiar with seeing fake news warnings, à la "this post contains information which has been disputed," the lack of a warning on other videos may inadvertently provide FYW students with an unintended perception of approval.

Although scholarly sources should be the standard-bearers of academic writing, prioritizing them above all sources, especially in a world where non-academics do not, is risky, especially for STEM students who will likely be tasked with disseminating scientific information to public audiences throughout their careers.

Conclusion

As we have noted, one critical component to FYW is basic research instruction, including an often less-than-effective introduction to evaluating popular sources, as well as emphasizing scholarly sources for culminating research assignments. Popular sources, especially when related to STEM topics, are often less valued by FYW faculty than peer-reviewed sources. However, when FYW faculty emphasize the quality of scholarly research over popular sources, they limit opportunities for their students to assess and incorporate content for a general audience, a skill they will utilize far beyond FYW. Purdy explains why this is problematic: "In failing to change, we also risk alienating students from valuable practices and resources because we establish the activities and spaces of academic research as inapplicable to their lives outside of the academy" (57). When FYW faculty restrict students to scholarly research, they imply popular sources are inherently less valuable than peer-reviewed research, and this restriction leaves STEM students poorly positioned to effectively evaluate or communicate science to the general population in the future. Instead, FYW students should be shown how to effectively evaluate and utilize both popular and scholarly sources on STEM topics early and often

for them to gain guided practice with the assessment and usage of both in their own writing. Additionally, FYW faculty teaching STEM majors should consider assigning writing tasks on STEM topics that not only analyze and engage peer-reviewed scientific research but assignments representing various rhetorical situations, including breaking down complicated scientific information for a general audience. A combination of these practices, a change in research and in the types of writing opportunities assigned, will provide FYW students with a clearer and stronger understanding of the myriad and valuable ways in which science is communicated.

By developing STEM-themed writing assignments, FYW instructors are uniquely poised to expose STEM students, especially, to the craft of writing about science and technology for a general audience in much the same way scientific journalists do. This type of instruction also allows for more in-depth analysis for all FYW students about information literacy and audience awareness across disciplines. Fortunately, these types of assignments need not be exclusive to STEM students; they can provide opportunities for any FYW student to write about science and technology relevant to their own lives. In fact, many WAD courses and programs already employ interdisciplinary writing assignments. For instance, the Writing Across the Curriculum (WAC) Program at SUNY Oswego recommends genre exercises as “one of the most fundamental functions of writing in a WAC course is to introduce students to the language, perspectives, conventions, evidence forms, objectives, and genres practiced in the field” (par. 5) While not all FYW instructors will be part of college-organized WAC/WAD programs, institutional support to help interested instructors take on this task would potentially benefit both students in and outside of STEM.

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