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Susan G. Archambault
Loyola Marymount University, susan.archambault@lmu.edu

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Expanding on the Frames: Making a Case for Algorithmic Literacy

Susan G. Archambault, Loyola Marymount University

Abstract

Traditional information literacy skills (e.g., effectively finding and evaluating information) need to be updated due to the rapidly changing information ecosystem and the growing dominance of online platforms that use algorithms to control and shape information. This article proposes additions to the current ACRL *Framework for Information Literacy for Higher Education* that relate to algorithmic literacy. The "Authority is Constructed and Contextual" frame can be applied to recognizing the need to question algorithmic authority (including algorithmic bias), the Information Has Value" frame can be used to acknowledge online platforms' use of proprietary algorithms allowing third parties to access personal data, and the "Searching as Strategic Exploration" frame can draw attention to search results in online platforms are mediated through algorithms. Classroom activities to teach the new knowledge practices and dispositions are also included.

Keywords: algorithmic literacy, information literacy, algorithmic awareness, AI literacy

Perspectives
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During a typical day, college students interact with algorithms in online platforms and leave behind their digital footprint every time they use their computer, cell phone, and required educational software. Head et al. (2020) argued that to be information literate today, students need a new set of information skills, the most pressing of which is "how information works in the age of algorithms" (p. 8). I agree that improved pedagogy for algorithmic literacy instruction is crucial for students to develop greater awareness of when they are interacting with algorithmically curated content in their online environment. This article will propose additions to the current *Framework for Information Literacy for Higher Education* (Association of College & Research Libraries [ACRL], 2015) that relate to algorithmic literacy.

Overview of Algorithms and Algorithmic Literacy

Algorithms are sets of instructions or sequences of logical steps for a computer to use on a body of data to accomplish a task, such as organizing search results by relevance (Gillespie, 2014). Another way to describe an algorithm is as a recipe, or a step-by-step guide that prescribes how to obtain a certain goal, given specific parameters (Bucher, 2018). For example, the task of giving a user the most relevant search results might involve calculating the combined values of pre-weighted objects in the index database (Gillespie, 2016). Algorithms based on machine learning rewrite themselves, with little human intervention, by incorporating new data into existing statistical models to improve their performance, rather than repeatedly processing a stable set of instructions (Brogan, 2016). Despite being processed by computers, algorithms are not neutral or value free; they are influenced by decisions made by the humans who design them and the preexisting data on which they are trained (Head et al., 2020). Algorithms are also influenced by the data that they receive over time from individual users and from other sources.

Algorithms in the search and social media domains are most directly related to students' information-seeking behaviors because of the way these algorithms shape and control information. Despite their helpfulness in limiting information overload in the domains of search and social media, these algorithms also limit user agency by making decisions about what information to display and filter out (Swart, 2021). Experts warn that filtering

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algorithms can perpetuate bias, create filter bubbles, and limit personal choices (Rainie & Anderson, 2017). Also, they are largely driven by commercialization and corporate bias (Bobkowski & Younger, 2018). Algorithms make decisions that impact other areas of everyday life, such as calculating credit scores, predicting future crimes, and vetting job applicants. These same domains could serve as jumping off points to teach students about the social impacts of algorithms across other domains in everyday life.

Algorithmic literacy is a relatively new concept and it has been classified as part of artificial intelligence literacy (Ridley & Pawlick-Potts, 2021) and media literacy (Cohen, 2018; Valtonen, 2019). It has also been described as overlapping with media literacy, digital literacy, new media literacy, and privacy literacy (Dogruel, 2021). In 2020, Head et al. defined algorithmic literacy for the library and information science field as a subset of information literacy that teaches "a critical awareness of what algorithms are, how they interact with human behavioral data in information systems, and an understanding of the social and ethical issues related to their use" (Head et al., 2020, p. 49). Recent studies have suggested that students' algorithmic literacy skills were too low (Brodsky et al., 2020; Head et al., 2020; Koenig, 2020; Powers, 2017). Other studies have suggested that students' research habits made them vulnerable to algorithmic ranking and filtering. For instance, when students looked for outside sources, they favored the top search results from search engines and clicked on higher-ranked results, even if those results were less credible or relevant (Bhatt & Mackenzie, 2019; Wineburg & McGrew, 2017). Also, students lacked confidence in their ability to distinguish fake news from real news (Head et al., 2018). One study found that students failed to identify a "news story" that came from a satirical website, and they attributed undue weight to easily manipulated signals of credibility (e.g., an organization's non-profit status, links to authoritative sources, appearance). These findings suggested that students would be vulnerable to targeted misinformation or disinformation campaigns (Wineburg et al., 2020). A focus group study of 103 students across eight different colleges and universities found that algorithms barely, if ever, were taught in the classroom (Head et al., 2020).

Recent literature has called for the integration of algorithmic literacy into existing information literacy instruction (Bakke, 2020; Clark et al., 2017; Head et al., 2020; Ridley & Pawlick-Potts, 2021). A better understanding of the underlying structures at play when the flow of information is shaped by algorithms is a first step in expanding students' information-seeking habits. As Bakke (2020) noted, "greater algorithmic literacy leads to more credible research" (p. 5). In the next section, I unpack three key aspects of algorithmic literacy: 1) the algorithmic curation of information; 2) privacy of personal data; and 3) algorithm bias. These interrelated elements are crucial for improving students' algorithmic literacy, and they are well suited for integration into existing elements of information literacy instruction.

Algorithmic Curation of Information

Algorithmic curation is the process through which algorithms select and prioritize content in online platforms for users to see based on their interests and past behavior. Algorithms are difficult to pin down because they are dynamic and "always in becoming" (Bucher, 2018, p. 28). When users offer up their data and interact with algorithmic systems, algorithms rewrite themselves in an endless feedback loop. Students may fail to perceive the constant algorithmic ranking of their online content, and therefore also may fail to question them or make rational, critical judgments about the information they encounter (Carmi & Yates, 2020). User folk theories about algorithms are defined as intuitive, informal theories that explain the outcomes, effects, or consequences of algorithmic systems, whether accurate or inaccurate (DeVito et al., 2017). Because of algorithms' black box nature and due to the absence of absolute, ground truth for how algorithms actually function, folk theories guide reactions to and behavior towards algorithmic systems. One example of a user behavior explained by a belief in folk theory is attributing a missing story in your Facebook feed to a friend's decision to exclude you rather than to the Facebook News Feed's filtering algorithm (Eslami et al., 2015).

Another consequence of algorithmic curation is the filter bubble effect. Pariser (2011) coined the term "filter bubble" to refer to when people in an online environment are exposed only to opinions and information that conform to their existing beliefs. In popular online platforms such as TikTok or Facebook, algorithms use personalization (i.e., sets of code that observe your digital habits and predict your next choices) to filter and rank information to the extent that content is so personalized that we experience different realities (e.g., User A only ever sees conservative views whereas User B only ever sees liberal views). This limited exposure to different points of view preys upon confirmation bias and allows people to more readily accept information that conforms to their existing beliefs. It weakens their ability to avoid fake news and predatory advertising manufactured in disinformation campaigns by bots (e.g., social media accounts operated by artificial intelligence computer programs). Bots can draw attention to misleading narratives, hijack

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platforms' trending lists, or create the deception of public interest and approval (Wardle, 2018, para. 18).

Privacy of Personal Data

Another key aspect of algorithmic literacy is understanding the privacy risks for your personal data when using online platforms. Web analytic companies use algorithms to observe user web-surfing habits and track users across web sites in order to classify users into categories of identity such as gender, class, or race. Cheney-Lippold (2011) warned that user categorizations constructed by algorithms constituted a form of surveillance, and that "automated categorization practices and the advertisements and content targeted to those categorizations effectively situate and define how we create and manage our own identities" (p. 177). Zuboff (2019) cautioned that data generated through computer usage was exploited for hidden commercial practices, and only some of the behavioral data collected was applied to product or service improvement. The remainder was extra data that helped predict user choices, such as where future users would click. This data was secretly sold to online advertising companies for marketing purposes.

Technologists and systems have been able to collect and process data in real time on a large scale due to the development of 'big data" (Head et al., 2020). Big data works to target the right people for online advertising and arranges advertising campaigns for the targeted audience. Hartman-Caverly and Chisholm (2020) described the privacy paradox, where people's actual behaviors often contradicted their stated privacy values due to information asymmetries between the system and the user, lack of user knowledge of system design, and users lacking the technical and legal literacy needed to understand privacy-related terms of service.

Algorithmic Bias

A third key aspect of algorithmic literacy is algorithmic bias, which is present when algorithmic decisions deliver outcomes that are systematically less favorable to individuals within a particular group. Algorithms make predictions based on the data they have, but these predictions often have serious limitations. O'Neil (2016) further explained that algorithms often lack data for the real behaviors they are interested in (e.g., how likely you are to pay back a credit obligation), so they substitute stand-in data to correlate with that behavior (e.g., your zip code or your Facebook friends' credit scores). Unfortunately, these proxies are often incomplete, inaccurate, or unfair, and they can perpetuate existing biases on a large scale. Noble (2018) explained that in the search engine domain, search engines reinforce racism through stereotyping that is based on predictive text and search results so that "Google's dominant narratives reflect the kind of hegemonic framework and notions that are often resisted by women and people of color" (p. 24). Beer (2017) noted that power is "operationalized through the algorithm, in that the algorithmic output cements, maintains or produces certain truths" (p. 8) and users' understanding of the world is changed through their algorithmic interaction. O'Neil (2016) declared that algorithms "slam doors in the face of millions of people, often for the flimsiest of reasons, and offer no appeal" (p. 31); part of their power is that their lack of transparency makes them difficult to refute. Vulnerable populations often expose their pain points unknowingly through Internet use and get exploited for profit; for example, when predatory ads target low-income residents with for-profit universities and are partnered with "too good to be true" loan options (O'Neil, 2016). Lloyd (2019) argued that students need to question search results and automated decisions, and that key concepts such as bias, trust, credibility, opacity, diversity, and social justice need to supplement the traditional lessons around "search" in information literacy pedagogy. Students also need to develop greater awareness of the ways algorithms can reinforce social inequalities by relying on data that can favor dominant social group perspectives.

Embedding Algorithmic Literacy Instruction

Beginning steps have been taken to integrate algorithmic literacy into existing information literacy instruction. A quick search in the open educational resource (OER) Community of Online Research Assignments (CORA) (Loyola Marymount University, 2023) for the terms *algorithm*, *algorithms*, or *privacy* revealed there are already assignments and activities that embed elements of algorithmic literacy into the information literacy curriculum. The *Framework for Information Literacy for Higher Education* (ACRL, 2015) is organized around six threshold concepts, or key ideas, that are central to information literacy. Each frame also has a related set of knowledge practices (proficiencies or abilities) and dispositions (tendencies to act or think in a particular way). The *Framework* currently contains occasional elements of algorithmic literacy, but it could be strengthened by more explicitly addressing these aspects of algorithmic literacy.

In CORA, assignments can be searched using the six *Framework* frames, which allows for a non-exhaustive look at various algorithmic bias-focused instructional uses. The two frames most often linked to algorithmic literacy are "Authority Is Constructed and Contextual" and

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"Searching as Strategic Exploration." Gardner (2019) linked the "Authority Is Constructed and Contextual" frame with questioning how algorithms shaped personal choices and perspectives. Berg (2016) aligned the frame with lessons about how the Google PageRank algorithm influenced information-seeking behavior and search results, while Clark et al. (2017) aligned the frame with how algorithms constructed our information experience from a technical standpoint. Acosta (2018), Brown-Salazar (2017), and Vital (2017) connected workshops on algorithmic bias using activities with Google Images or Google Autocomplete with not only this frame but also multiple other frames, and Hallman et al. (2022) tied "Authority Is Constructed and Contextual" to several domains in everyday life during a workshop on algorithmic bias. On the other hand, Schubert (2021) applied a tutorial on algorithm bias exclusively to the "Searching as Strategic Exploration" frame. Caffrey (2018) connected the "Information Has Value" frame with recognizing search engine revenue comes from advertising, Chisholm (2021) linked it to a workshop on algorithms and the attention economy, Berg (2016) associated it with lessons about Google's data security and privacy issues, and, in a similar vein, Hartman-Caverly and Chisholm (2020) aligned the frame with privacy literacy (i.e., how personal data and metadata were collected and shared).

This is not an exhaustive list; a search in, for example, Library, Information Science & Technology Abstracts or ERIC for "information literacy" AND algorithm* would yield additional examples. Building on previous work to align algorithmic literacy with frames from the *Framework*, I will elaborate in the next section on how the description, knowledge practices, and dispositions for three frames can be expanded to include algorithmic literacy more explicitly. The additions I am recommending address the limitations of the current *Framework.*

Expanding Three Frames to Include Algorithmic Literacy

Authority Is Constructed and Contextual

The "Authority Is Constructed and Contextual" frame suggests that authority depends on information need and context, and that users should remain skeptical of the systems that have elevated that authority and the information created by it. This frame's description asserts that experts need to "acknowledge biases that privilege some sources of authority over others, especially in terms of others' worldviews, gender, sexual orientation, and cultural orientation" (ACRL, 2015, p. 12), without explicitly using the term algorithmic bias. Given the relevance of race to algorithmic bias, it is also worth noting that racial diversity is not included here, as pointed out by Rapchak (2019). The description could expand to include the idea of questioning algorithmic authority in online platforms and their role in shaping our information experience. Table 1 illustrates how the frame's description, knowledge practices, and dispositions could be expanded to include algorithmic bias.

Table 1: Expanding "Authority Is Constructed and Contextual": Question Algorithmic Authority

Expanded Description	• Experts understand the need to question both the authority that is delegated to algorithms in algorithm-driven online platforms and the role they play in constructing our information experience.
New Knowledge Practices	• Understand that algorithms are not neutral because they are informed by human decisions and other data algorithms collect that may be skewed. • Understand how algorithmic systems can produce bias from training data. • Understand the ways that algorithms can artificially amplify information to make it appear that certain views are widely shared or trustworthy. • Critically evaluate algorithmic design and decision making.
New Dispositions	• Value unbiased and nondiscriminatory algorithmic design and decision making. • Openly advocate for algorithmic fairness and accountability.

The first proposed new knowledge practice would disabuse students of the idea that algorithms are value-free by establishing that algorithms are not neutral because they are informed by human decisions and other data that may be skewed. The second proposed knowledge practice would explain how training data works and how bias can be produced from the training data.

Discussions of how algorithmic processes can produce bias need not be limited to only students' information-seeking in the educational context but could also include other domains in everyday life. The third proposed knowledge practice would teach students how manufactured amplification can occur when the reach or spread of information is boosted through artificial means (either by humans or machines), including bots and disinformation campaigns. The fourth proposed knowledge practice would teach students to critically evaluate algorithmic design and decisions.

The existing "Authority Is Constructed and Contextual" dispositions urge learners to "develop awareness of the importance of assessing content with a skeptical stance and with a self-awareness of their own biases and worldview" (ACRL, 2015, p. 13), without including algorithmic bias. The first proposed disposition to include algorithmic bias encourages students to value algorithmic design that is unbiased. The second proposed disposition fosters active advocacy for algorithmic fairness and accountability.

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A good tool to help students understand why algorithms are not neutral is the interactive *Myth of the Impartial Machine* (https://parametric.press/issue-01/the-myth-of-the-impartial-machine/; Feng & Wu, 2019). It enables a more nuanced understanding of the different causes of algorithmic bias. Examples of biased data include sampling errors leading to biased models and skewed data distributions. An example of skewed data distributions is an image database in which the model was trained on images largely from the United States, despite this only representing 4% of the world population. The tool also provides examples in which algorithms themselves amplify bias when they make predictions that are more skewed than the training data, including algorithms incentivized to predict the majority group and runaway feedback loops. An example of a runaway feedback loop is a predictive policing algorithm that uses historical data on past crime occurrences. The tool lets students change data inputs to see the impact on outputs. The tool also offers detailed explanations of the various types of bias.

Another tool to help students understand algorithmic bias is *How Normal am I?* (https://www.hownormalami.eu/; Schep, 2020). Students grant the facial recognition algorithm access to the camera in order for it to rank how attractive they are. When using these kinds of activities, students could also look at the privacy policies on these tools, and they could be given the chance to opt out if it requires sharing data about themselves that they don't want collected. Students who choose to participate might experience discomfort when having their attractiveness quantified by an algorithm. This exercise could be followed by a discussion of how the algorithm may have been trained to recognize "universal beauty." Facing biases can be difficult, so students should be given a choice in whether to participate. They may need to process some discomfort while doing the activity, but challenging students to come out of their comfort zones can be conducive for student growth.

Another possible activity is *Survival of the Best Fit* (https://www.survivalofthebestfit.com/; Csapo et al., 2019), an online game to assist students in better understanding how bias can get produced from training data. Students role-play using a hiring algorithm to aid in hiring decisions, but they soon realize that the algorithm is learning biased patterns. Students could reflect on what criteria were biased, how the algorithm might favor certain social identities, and how the algorithm could be modified to increase algorithmic fairness. When doing activities that point to social inequities and biases, like this activity and *How Normal am I?,* it is important to establish a sense of safety and belonging among the student group and to acknowledge that these activities may elicit strong emotional reactions such as guilt, shame, denial, or anger. One way to help students feel more secure to express their opinions without fear of backlash or judgment is by creating an online anonymous space for them to engage in discussion, such as a Google form.

To help students learn to critically evaluate algorithmic design and decision making, they could participate in speculative futuring (speculation about the negative implications of technology in the future), described by Burton et al. (2018) and Fiesler (2018). Students could select popular science fiction stories that feature algorithms and could critique the algorithmic systems that were in place. Examples include episodes of the Netflix series *Black Mirror* (Bathurst, 2018), such as "Arkangel," about a child surveillance system, or "Be Right Back," about AI that creates a digital double of the deceased. Students could also invent a near future technology for information retrieval and craft a cautionary tale of algorithmic bias. Afterwards, they could brainstorm about how the negative consequences could be prevented.

Fact checking exercises could be designed to illustrate examples of artificial amplification using tools like the *Botomoter* (https://botometer.osome.iu.edu/) to identify social media bots, or *TinEye* (https://tineye.com/) to verify fake images on social media. Using these tools, students could tag or report any misinformation they discovered. Students could ask AI language models like *Chat GPT* (https://chat.openai.com/) to write brief essays on informational topics and then verify the information rather than taking it at face value. Because *Chat GPT* requires users to provide their email and phone number, a shared account for the class is a good idea so that students do not have to share personal information.

Some students may have little prior experience to draw from when it comes to bias, so stories are a good way to help students look outside their personal experiences to see the larger systemic issues that impact society. Students' dispositions towards valuing unbiased and nondiscriminatory algorithmic design and decision making could be elicited through case studies such as those described in resources like *Weapons of Math Destruction: How Big Data Increases Inequality and Threatens Democracy* (O'Neil, 2016), *Algorithms of Oppression: How Search Engines Reinforce Racism* (Noble, 2018), *Machine Bias: Investigating Algorithmic Injustice* (ProPublica, 2015–2023), and the documentary *Coded Bias* (Kantayya et al., 2020). More recent case studies might include the exploitation of outsourced data labelers who remove toxic content from Facebook (Perrigo, 2022) and OpenAI language models (Perrigo, 2023). Students' broader advocacy for algorithmic fairness and accountability could be fostered through hypothetical self-advocacy letters to the enforcer of a harmful machine learning model (Register & Ko, 2020), or organizing a protest to complain about educational

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surveillance tools, such as online proctoring systems, that may be biased against disabled or neurodivergent students at a university board meeting.

Information Has Value

The "Information Has Value" frame suggests the importance of recognizing different dimensions of value for information, including as a commodity, as a means to educate, as a means to influence, and as a means to understand the world. The frame's description asserts that the value of information is manifested through "the commodification of personal information and intellectual property laws" (ACRL, 2015, p. 16), and that users need to understand these values as both users and creators of information. It does not explicitly name the revenue of online platforms from advertising fueled by personal data and metadata. The description could be expanded to include the role of financial influence and capital in the algorithms used in online platforms and an acknowledgement of the role that third party companies play in obtaining personal data for advertising.

Another shortcoming of the "Information Has Value" frame lies in its knowledge practices. Although it is asserted that learners should "make informed choices regarding their online actions in full awareness of issues related to privacy and the commodification of personal information" (ACRL, 2015, p. 17), big data collection practices and digital profiling are not specified. The proposed new knowledge practices are intended to fill this gap. Table 2 illustrates how the frame's description, knowledge practices, and dispositions could be expanded to include recognizing how personal information feeds into big data collection practices.

Table 2: Expanding "Information Has Value": Recognize Personal Information Feeds Big Data

Expanded Description	• Experts understand that online platforms often use proprietary algorithms that allow third parties to access, aggregate, or sell personal data.
New Knowledge Practices	• Understand that the revenue of free online platforms comes from advertising. • Identify general data collection and use practices of free online platforms. • Understand the laws and legal aspects related to privacy protection. • Understand the ways individual digital profiles classify you and others, based on presumed preferences or characteristics.
New Dispositions	• Recognize the value of critically evaluating potential privacy risks of free online platforms before using them. • Recognize the value of privacy as a civil right.

The first proposed knowledge practice is understanding that free online platforms obtain revenue from advertising. The second proposed knowledge practice is determining the data collection and use practices of free online platforms exploiting data for commercial purposes. The third proposed knowledge practice would allow students to understand basic privacy laws governing online intellectual property in order to consider how algorithms are regulated. For example, Google argues that prioritizing information for users is a First Amendment right (Souto-Otero & Beneito-Montagut, 2013), the Freedom of Information Act (FOIA, 1967) protects trade secrets, allowing third party companies to still obtain personal data (Diakopoulos, 2015), and Section 230 of the Communications Decency Act (CDA) of 1996 shields social media companies from legal responsibility for user-generated content. Also, the Computer Fraud and Abuse Act (CFAA, 2008) outlaws conduct that victimizes computer systems, but should this include the use of algorithms to provide each user with a customized experience that may be discriminatory? The fourth proposed knowledge practice would allow students to understand how algorithmic classification based on their demographic data works to target them for advertising.

The frame's existing dispositions encourage learners to "see themselves as contributors to the information marketplace rather than only consumers of it" (ACRL, 2015, p. 17), without a direct reference to the potential privacy violations and surveillance generated through the use of online platforms. Since often the point at which users can exert the most control is before they install a free app or register to use it, the first proposed new disposition encourages the critical evaluation of free online platforms before use to safeguard privacy. The second suggested disposition is valuing privacy as a civil right.

A suggested activity to help students better understand how digital profiling works is having students examine how they generate data in the world by comparing their Google ad setting categorizations with each other. Watching selected episodes of the Canadian *Do Not Track* documentary series (Gaylor, 2015), where episodes are personalized based on the data a person shares, could help students explore how information about people is collected and used. To better understand the data collection and use practices of Google products, students could download data they generated from their Google search history and Google Maps location history to reflect on their digital profile. Students could also research an algorithm such as PageRank, using terms of service, white papers, and corporate statements to identify both Google's business model and values (Gallagher, 2017). Finally, students could use the Simple Search browser extension (only available for Firefox) to strip ads and

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related products from their search results and to show only the raw web search results from Google (Varner & Morris, 2020). This would help reveal the role of advertising in information retrieval.

In order to better understand the laws and legal aspects related to privacy protection in the digital age, students could read recent lawsuits such as those featuring AI text to image tools like *Stable Diffusion* (https://stablediffusionweb.com/) and *Midjourney* (https://www.midjourney.com/home/) (Vincent, 2023). This would allow them to discuss what proper attribution and citation should look like in the world of widespread internet scraping and the appropriation of image metadata by technology companies. They could also compare results from image generation tools and creative fiction language models with the original work of art that is being imitated. This would foster a discussion about human creativity versus AI creativity and the impact on intellectual property laws. Alternatively, students could read cases like the one involving Google Books (*Authors Guild v. Google, Inc.*, 2015), and debate whether scraping publicly available data from the Internet violates the Computer Fraud and Abuse Act (CFAA; 2008) or the doctrine of fair use. To enhance online privacy protection, students could consider using tools like password managers (e.g., https://1password.com/), preventing search engines from storing credit card information, and implementing two-factor authentication. Dark patterns, or tricks used in websites and apps that make users do things not in their best interest, could be taught to students. One dark pattern example is a platform that forces you to connect your social networks to your phone number before you are able to sign up by obscuring the choice to sign up using email. Students could then look for dark patterns and report these to the Dark Patterns Tip Line (Stanford Digital Civil Society Lab, 2023) in order to advocate for privacy as a civil right. The Tip Line asks students to describe the type of harm, upload a screenshot of the pattern, and classify the design pattern from a list of choices that includes denial of choice, discrimination, shaming, trickery, forced subscription, lost money, and lost privacy.

Searching as Strategic Exploration

The "Searching as Strategic Exploration" frame suggests that locating information is difficult and requires diverse search strategies and the revision of those search strategies. This frame's description asserts, "Experts realize that information searching is a contextualized, complex experience that affects, and is affected by, the cognitive, affective, and social dimensions of the searcher" (ACRL, 2015, p. 22). This hints at but fails to explicitly include the idea that search results are personalized through both invisible digital profiling and the collective actions of other users (e.g., popularity ranking) in endless dynamic feedback loops. The existing description could be expanded to include the hidden ("black box"), mediating role that algorithms play in pushing search results as the searcher is perpetually affecting and affected by their search results. Table 3 illustrates how the frame's description, knowledge practices, and dispositions could be expanded to include recognizing that online searching is mediated through algorithms.

Table 3: Expanding "Searching as Strategic Exploration": Recognize that Online Search is Mediated through Algorithms

Expanded Description	• Experts recognize that search results in online platforms are unstable and mediated through "black box" algorithms, whose operations cannot be well understood.
New Knowledge Practices	• Understand, to the extent possible, key data points that inform ranking and filtering decisions in the search results of online platforms. • When searching online, identify content that has been subject to algorithmic curation (e.g., ranking, filtering). • Develop awareness that search engine algorithms make the content seen by each person different .
New Dispositions	• Deliberately engage in small strategic practices (e.g., tactical clicking, liking, or hashtag practices) to affect algorithmic outputs and exercise user agency when using online platforms. • Self-reflect on the ways your assumptions and informal theories (i.e., folk theories) for how algorithmic systems work shape your use.

One of the frame's current knowledge practices maintains that learners will "understand how information systems are organized in order to access relevant information" (ACRL, 2015, p. 22), yet it fails to include an understanding of key variables or ranking signals that impact search results. Even though the signals in search and social media ranking algorithms are variable and not completely transparent due to their "black box" nature, the first proposed new knowledge practice would suggest teaching students a rudimentary idea of how algorithms work (usually documented through platform blogs and help pages). This approach helps students understand typical key ranking factors used in their search results, thereby improving their awareness of algorithmic bias. The second proposed knowledge practice would involve teaching students to recognize algorithmic curation when searching online. The third knowledge practice would teach students to develop an understanding that search engine results are different for each person. The first proposed new disposition would encourage deliberate and strategic engagement with algorithmic systems in order to exert influence over the flow of information—for example, clicking on or liking certain

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content to see more of it in search results, recommender systems, or newsfeeds, or applying popular hashtags to content you created to gain more views. The second proposed disposition would encourage metacognition in students by having them scrutinize their folk theories or mental models about how online platforms function, and how these beliefs shape their usage. These new dispositions would result in students being empowered to take on more agency in maneuvering their interactions with online platforms.

One activity illustrating algorithmic curation would have students comparing recommended reviews on Yelp when they are logged in versus not logged in. This would show that Yelp presents reviews as "recommended" to the author if they are logged in, but it may filter out this review for other users (Eslami et al., 2019). Hobbs (2020) suggested a group activity where students signed into their Google accounts and conducted searches on countries like Finland, United States, or Germany on the same day and compared results to facilitate awareness that algorithms curate the content seen by users differently. Another activity to facilitate this awareness could include the *Image Atlas* tool (https://imageatlas.org/), which displays search results from search engines in different countries at the same time in order to highlight cultural differences. Along similar lines, Ochigame and Ye (2021) developed *Search Atlas* (https://searchatlas.com/), a tool to highlight how search results for the same query differed across different countries. This would allow users to reflect on the way results are shaped by cultural and political bias. *Split Screen* (Keegan, 2021) is another tool that could help teach about the filter bubble effect because it shows Facebook feeds from different political perspectives.

Activities that foster more deliberate algorithmic engagement in order to influence search results include having students analyze trends in the products Amazon recommended when they were logged in, and then having students search for five products they would never want to purchase. Afterwards, students could see if logging out led Amazon to make different types of recommendations (Koenig, 2020). Gallagher (2017) suggested having students try to manipulate Facebook's algorithmically driven timeline so that their writing could be read by a wider audience, as well as changing the metadata of their YouTube videos (e.g., title, description, tags) to increase their videos' circulation.

Journal entries or reflective pieces about online platforms could nurture the habit of metacognition in students, as they examine their folk theories and assumptions about algorithmic systems. Bakke (2020) suggested the "Search Reflection Assignment" to increase student awareness of how their default search habits affected the information they found.

The assignment asked students to screen-record ten minutes of themselves searching for information online while thinking out loud, and then analyzing their search habits and patterns to identify strengths and weaknesses. This could be combined with research on what is known about the key variables or ranking signals that impact the platform's search results and feed into personalization. Such an activity would allow for self-reflection on how students' mental models and assumptions about the platform shape usage. Sample prompts could include the following: (a) draw a diagram to represent how you think the platform works; (b) compare what you learned through research about how the platform works with your diagram on how you thought it worked; (c) does your research change how you might interact with the platform in the future, including in how you search within it; (d) does your research change how you feel about using the platform?

Conclusion

This article has argued for the need to expand traditional information literacy instruction to include algorithmic literacy, a new set of skills involving basic algorithmic awareness, an understanding of human-algorithm interplay in online platforms, and the social and ethical issues related to their use (Head et al., 2020). Algorithms are now everywhere; they appear across many fields of study to digitally mediate everyday life and make decisions both for and with people, often without people's awareness. The *Framework* can be strengthened to address algorithmic literacy more explicitly than it currently does within the "Authority Is Constructed and Contextual," "Information Has Value," and "Searching as Strategic Exploration" frames.

The information landscape is increasingly complex, and it is important that students understand the underlying power structures at play in the information systems they use for both their academic and personal lives. Recognizing when algorithms are behind the scenes curating and controlling information in everyday life, having a basic idea of how algorithms function and of the privacy risks associated with digital platforms' data collection and use practices, and understanding the causes of algorithmic bias will empower students to be better digital citizens. Hargittai and Micheli (2019) listed "awareness of how algorithms influence what people see" as one of ten critical dimensions of Internet skills (p. 113), yet students' algorithmic awareness remains low, and algorithms are rarely taught in college to non-computer science majors. For information literacy skills to be a means of personal empowerment for lifelong learning, it is important that the curriculum be expanded to

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include algorithmic literacy. Doing so will enable students to develop new tactics and management strategies to protect their personal data and more effectively interact with algorithmic systems.

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