Strategies for Incorporating Science Literacy

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What is Science Literacy?

**Scientific literacy** refers to the ability to make use of scientific knowledge in real-world situations (American Association for the Advancement of Science, 2010).

It has been described as the ability to “use evidence and data to evaluate the quality of science information and arguments put forth by scientists and in the media” (National Research Council, 1996).

A critical skill necessary to navigate the world today.

Murcia, (2006)
The State of Science Literacy in Education

Individuals consume credible scientific information and misinformation in similar ways is particularly troubling (Del Vicario et al., 2016).

Despite its importance, first-year college students tend to enter college with limited scientific literacy, showing high levels of belief in pseudoscience (Impey, Buxner, Antonellis, Johnson & King, 2011). Although STEM majors performed better.

Non-majors have been found to show no growth in their scientific literacy during their college careers, and remain no less susceptible to pseudoscience upon graduation (Impey et al., 2011). Importance of GE STEM courses to educating them.
What Does Science Literacy Require?

(a) Recognize what qualifies as scientific evidence and when scientific evidence supports a hypothesis.

(b) Distinguish between types of sources - identify bias, authority, and reliability.

(c) Recognize a valid and ethical scientific course of action and identify appropriate use of science by government, industry, and media that is free of bias and economic, and political pressure to make societal decisions (Gormally, Brickman, & Lutz, 2012).
Consider these articles about hydroxychloroquine as a treatment for COVID-19


As a self-proclaimed “cheerleader for America,” President Trump has been touting hydroxychloroquine for weeks as a potential mitigation drug for the disease.

Today, multiple surveys of thousands of doctors show they would not only prescribe the drug to virus patients, but to members of their own family.

“Sixty-five percent of physicians across the United States said they would prescribe the anti-malaria drugs chloroquine or hydroxychloroquine to treat or prevent COVID-19 in a family member,” a recent Jackson & Coker survey, which questioned 1,271 doctors in 50 states, found. “Only 11 percent said they would not use the drug at all.”

Pavlich is the editor for Townhall.com and a Fox News contributor.
A large study on the use of the antimalaria drug hydroxychloroquine in hospitalized COVID-19 patients found that the drug had no impact on the risk of the most severe outcomes from the disease.

The observational study, published yesterday in the *New England Journal of Medicine*, looked at data on nearly 1,400 patients treated for COVID-19 at a large hospital in New York City, more than half of whom received hydroxychloroquine. Analysis of patient outcomes showed that the risk of intubation or death was not significantly higher or lower among patients who received the drug than among those who did not.

Over a median of 22.5 days, 346 (25.1%) patients had a primary end-point event, with 180 patients being intubated (66 of whom died) and 166 patients dying without intubation. In the unadjusted analysis, patients treated with hydroxychloroquine were more than twice as likely to die or be intubated as those who didn’t receive the drug (hazard ratio [HR], 2.37; 95% confidence interval [CI], 1.84 to 3.02).
How Engaging in Literacy Differs for Science

Scientific writing often includes greater informational density, technical vocabulary and is authoritative in nature with passive voice (Fang, 2005; Fang & Schleppegrell, 2010).

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Scientific writing often includes **greater informational density**, **technical vocabulary** and is **authoritative** in nature with **passive voice** (Fang, 2005; Fang & Schleppegrell, 2010).

Science texts often include **nominalization**, which can result in the abstraction of previously clear concepts (Fang & Schleppegrell, 2010; Goldman et al., 2016)

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Confusing for non-majors and may impede comprehension and learning of content. Scientific language tends to embrace many features of science texts. Thus, promoting student mastery of the language of science can lead to greater overall science development.
Find the Challenging Features of Scientific Texts

- Nominalization
- Technical vocabulary
- Passive voice
- Informational density

**IMMUNIZATION**
Any process by which a person becomes protected from a disease.

**VACCINE**
A product that produces immunity from a disease.

**VACCINATION**
Injection of a killed or weakened organism that produces immunity in the body against that organism.

www.historyofvaccines.org/content/articles/careers-vaccine-research

MPH@GW
Which highlights the challenge....

The language of science can make scientific information difficult to read. When students struggle to comprehend science texts, critical thinking about scientific issues becomes even more difficult.
How Including Writing in Science Classes Can Support Scientific Literacy
Affordances of Writing for Thinking

Many aspects of writing benefits students. It can be structured to support scientific reasoning.

The writing process initiates critical thinking: brainstorming through revision.

Greater thinking time leads to higher quality of contributions.
Writing in Science Class Improves Student Learning Of Science Content

Challenges in Incorporating Writing Assignments in Science Courses

Lack of professional development

Feedback

Grading
Strategies for Scientific Literacy

How to Use Writing to Support Scientific Literacy in Your Class

- Improving Reading
- Writing Assignments
- Peer Review
- Using Rubrics
Supporting Students in Reading Scientific Articles Critically
Improving Scientific Reading Comprehension by Setting Goals

- Reading is strategic and purposeful
- Comprehension involves gaining information, relating it to what is already known, and checking for inconsistencies
- Misunderstanding of the science texts can be diminished when students have purpose when they read, set goals, and compare their understanding to these goals
The **GATOR** Strategy for Evaluating Science Information from Online Sources

- **Genuineness**
  - Is the author or source authentic?
  - What are the goals, purposes and mission of the source?
  - Is the site misleading, trying to appear authentic with misleading logos, etc?

- **Accurate**
  - Is the information correct?
  - Is the information consistent with established scientific theories?
  - Is it free from errors?

- **Trustworthy**
  - Is the information reliable and valid?
  - Is the information peer-reviewed?
  - Are references cited?
  - What are the author’s credentials and affiliation?

- **Origin**
  - Where did the information come from?
  - Is the first-hand source reliable?
  - Who manages the site?
  - Is it possible to contact site administrators for clarification?

- **Readability**
  - Is the information presented in a way that’s comprehensible?
  - Is the information presented in a clear and concise way?
  - Is it too technically advanced, or is it too basic?

(Wiblom, Rundgren & Andrée, 2019)
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Creating Writing Prompts to Promote Scientific Literacy
Writing Can Encourage Deep Thinking About Science…. But Does it Have to Be Done Alone?
Collaborative Writing as a Resource

Co-construction of knowledge and initiates deeper critical thinking.

Student learning outcomes can be further enhanced through collaborative writing, particularly as co-writers make requests for clarification from one another (Chen, Hand, & Mcdowell, 2013; McDonough, De Vleeschauwer & Crawford, 2018; Storch, 2005).

While collaborative writing tasks improved learning outcomes for all students, there were additional positive effects for female, low SES, gifted, and special education students (Chen et al., 2013). Effective way to addresses the leaky STEM pipeline.
Science Vocabulary Use over Time
Example Collaborative Writing Prompt

Group weekly written assignment instructions:

Select one of the article types below and write an approximately 1500 word report on the topic covered in class this week. Make sure that your group has a chance to write for each article format at least once. Use real world examples to guide you.

1. A neutral and informative press article for a well-respected newspaper written for a general audience.
2. A mini review publication for a peer-reviewed research journal written for an informed scientific community.
3. A sensationalized magazine article geared toward providing an overview of the outbreak while grabbing the attention of the general public.
4. A mini review publication for a medical journal written for clinicians and the greater medical community.
Example Individual Prompt

“Access an article of online health information and critically evaluate relevant sources about a physical or mental health issue of choice, such as cancer, resistance to antibiotics, depression or eating disorders. You are encouraged to engage in a topic that you find interesting and that is debated in the media in ways that actualised ethical dimensions of public and individual health.” (Wiblom, Rundgren & Andrée, 2019)

Using your research, create a website, podcast, or presentation in which ethical dilemmas in health issues are presented to initiate discussion with peers.
Strategies for Peer Review of Student Writing to Promote Scientific Literacy
Benefits & Challenges of Peer Review

● Improves student writing, and fosters better understanding of scientific communication for both students
● Discussions can promote deeper understanding of science concepts, scientific processes, and scientific reasoning

A Word of Caution...
● Peer review is most effective during the writing processes, not after the assignment is complete
● Students need structure for peer reviews:
  ○ Without structure, students tend to focus on spelling or grammar
I Don’t Believe, I Believe: A Peer Evaluation to Strategy to Support Critical Thinking

This is a role-playing activity to help strengthen critical thinking in writing. Because it’s role-playing, you don’t need to actually believe or doubt your partner’s arguments. Instead, its purpose to help you become aware of counter arguments, see if your thesis needs to evolve, and consider varying perspectives to strengthen your arguments.

**I don’t believe**
- Read your partner’s paper, doubting every claim they make
- Create a doubting list
- Write down every argument you can make against each claim

**I believe**
- Re-read your partner’s paper, believing every claim they make
- Provide recommendations about how to strengthen the paper’s arguments stronger
Using Rubrics for Student Writing
What Are Rubrics?

Rubrics are tools that support student learning and facilitate instruction.

Rubrics make explicit the expectations for an assignment by listing criteria and levels of quality for each criterion (Stiggins, 2001)
How Rubrics Help Students

When given at the same time as the assignment, rubrics help students better understand the learning goals and what it means to be successful.

Rubrics enable students to focus their efforts in their assignments more productively.

When used to support peer review, students can give their peers accurate feedback that can match that of course instructors (Hafner & Hafner, 2003)
How Rubrics Help Instructors

- Provides students with clear feedback that is focused on ways to improve learning.
- Develops consistency in evaluating student learning across students.
- Reduces the time spent on grading.
# A Rubric for Evaluating Student Writing Assignments

<table>
<thead>
<tr>
<th></th>
<th>Proficient</th>
<th>Satisfactory</th>
<th>Some</th>
<th>Insufficient</th>
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</thead>
<tbody>
<tr>
<td><strong>Critical Thinking &amp; Analysis</strong></td>
<td>The level of thinking/analysis is strong. The ideas are clearly communicated with focus. The writer understands methods for producing knowledge in STEM.</td>
<td>The level of thinking/analysis is appropriate. The ideas are general specific and focused. Some are insightful. The writer seems to understand the methods for producing knowledge in STEM.</td>
<td>There is some evidence of thinking/analysis, or an attempt is evident. The ideas are intermittently thought-through and appropriate to the task. The writer includes some content relevant for STEM audiences.</td>
<td>There is little or no evidence of critical thinking and analysis. The level of insight and clarity of presenting ideas is lacking. The thinking lacks focus and clarity, illustrates misconceptions; little of no evidence of awareness of STEM audiences.</td>
</tr>
<tr>
<td><strong>Use of Evidence/Research</strong></td>
<td>Uses evidence/sources appropriately and effectively. Considers previous STEM knowledge</td>
<td>Generally uses evidence/sources appropriately and effectively. Shows awareness of previous STEM knowledge.</td>
<td>Evidence/sources have occasionally been used appropriately. Evidence/sources are presented with some degree of clarity with some misreading or simplistic reading.</td>
<td>Evidence/sources, if present at all, are used inappropriately, simplistically, or misreading is evident. The writing shows little or know evidence of how to present evidence and use sources in STEM.</td>
</tr>
<tr>
<td><strong>Development &amp; Structure</strong></td>
<td>Writing clearly reflects STEM methods of written discourse. Organization is apparent, coherent, and contributes to overall goals. The reader is effortlessly guided through the writer's chain of reasoning.</td>
<td>Writing generally shows understanding of STEM's methods of written discourse. Organization is usually apparent, coherent and contributes to overall goals. The reader is guided through the writer's chain of reasoning.</td>
<td>Writing sporadically shows understanding of STEM's methods of written discourse. Organization is intermittently apparent, coherent, and on occasion, contributes to the overall goals. The reader can occasionally follow the writer's chain of reasoning.</td>
<td>Writing does not show understanding of STEM's methods of written discourse. Organization is random, simplistic, or inappropriately sequential and rarely contributes to the overall goals. The reader has difficulty following the writer's chain of reasoning.</td>
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<tr>
<td><strong>Language Styles &amp; Conventions</strong></td>
<td>Writing is styled and eloquent. Writer chooses words for their precise meanings and uses an appropriate level of specificity, showing facility with STEM writing. Correct and appropriate use of citations.</td>
<td>Writing is generally appropriately styled. Writer generally chooses words for their precise meanings and uses an appropriate level of specificity, showing facility with STEM writing. Correct and appropriate use of citations.</td>
<td>Writing shows some aspects of style appropriate for STEM. Writer sporadically chooses words for their precise meanings and uses some level of specificity. Some awareness of citation methods.</td>
<td>Writing shows little ability to use style appropriate for STEM. Word choice is typically inappropriate and generalized, showing little understanding of STEM discourse. Little or no awareness/presence of citation methods.</td>
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Adapted from UCI’s Upper Division Writing Assessment Rubric
A Rubric for Evaluating Student’s Research Reports
# A Rubric for Evaluating Students’ Research Reports

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Expert</th>
<th>Intermediate</th>
<th>Novice</th>
<th>Not Addressed</th>
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<tbody>
<tr>
<td><strong>Introduction</strong></td>
<td>A clear sense of why this knowledge may be of interest to a broad audience</td>
<td>The writer provides one explanation for why others would find the topic interesting.</td>
<td>The writer provides a generic or vague rationale for the importance of the question.</td>
<td>The importance of the question is not addressed.</td>
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<td>Context:</td>
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<td>Demonstrates a clear understanding of the big picture</td>
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<td>Accuracy:</td>
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<td>Content knowledge is accurate, relevant and provides appropriate background</td>
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<td><strong>Hypothesis</strong></td>
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<td>Testable:</td>
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<td>Hypotheses are clearly stated, testable, and consider plausible alternative explanations.</td>
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<td>Scientific Merit:</td>
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<tr>
<td>Hypotheses have scientific merit</td>
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<td><strong>Methods</strong></td>
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<td>Controls and Replication:</td>
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<tr>
<td>Appropriate controls (including replication) are present and explained</td>
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<td>Experimental Design:</td>
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<td>Experimental design is likely to produce salient results (actually tests the hypotheses posted)</td>
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<tr>
<td><strong>Results</strong></td>
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<tr>
<td>Data Selection:</td>
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<tr>
<td>Data chosen are comprehensive, accurate and relevant</td>
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<tr>
<td>Data Presentation:</td>
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<tr>
<td>Data are summarized in a logical and appropriate format</td>
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<tr>
<td>Statistical Analysis:</td>
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<tr>
<td>Statistical analysis is appropriate for hypotheses tested and appears correctly performed and interpreted with relevant values reported and explained</td>
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(Crotwell Timmerman, Strickland, Johnson & Payne, 2011)

Part 1of 2
## A Rubric for Evaluating Students’ Research Reports

**Part 2 of 2**

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<tbody>
<tr>
<td><strong>Discussion</strong></td>
<td>Conclusions Based on Data Selected: Conclusion is clearly and logically drawn from the data. A logical chain of reasoning from hypothesis to data to conclusions is clearly explained.</td>
<td>Conclusions are completely justified by data. Connections between hypothesis, data, and conclusion are comprehensive. Conclusions address and logically refute or explain conflicting data.</td>
<td>Conclusions are clearly and logically drawn from the data provided with no gaps in logic. A reasonable and clear chain of logic is made. Conclusions attempt to discuss or explain conflicting or missing data.</td>
<td>Conclusions have some direct basis in the data, but may contain some gaps in logic or data are overly broad. Connections are present but weak. Conflicting or missing data are poorly addressed.</td>
<td>Conclusions have little or no basis in data provided. Limited, vague or insufficient connections are made. Conflicting data not addressed</td>
</tr>
<tr>
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<td>Alternative Explanations: Alternative explanations (hypotheses) are considered and clearly eliminated by data in a persuasive discussion</td>
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<td>Limitations of design: Limitations of the data and/or experimental design and corresponding implications for data interpretation are discussed</td>
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<td>Significance of research: Paper gives a clear indication of the significance and direction of the research in the future</td>
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<tr>
<td><strong>Primary Literature</strong></td>
<td>Writer provides a relevant and reasonably complete discussion of how this research project relates to others’ work in the field using primary literature</td>
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<tr>
<td><strong>Writing Quality</strong></td>
<td>Grammar, word usage and organization facilitate the reader's understanding of the paper</td>
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## A Rubric for Promoting Teamwork

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<tr>
<th></th>
<th>Team Leader</th>
<th>Active Member</th>
<th>Active Member</th>
<th>Team-Player</th>
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</thead>
<tbody>
<tr>
<td><strong>Contributes to Team Meetings</strong></td>
<td>Helps the team move forward by articulating the merits of alternative ideas or proposals.</td>
<td>Offers alternative solutions or courses of action that build on the ideas of others.</td>
<td>Offers new suggestions to advance the work of the group.</td>
<td>Shares ideas but does not advance the work of the group.</td>
</tr>
<tr>
<td><strong>Facilitates the Contributions of Team Members</strong></td>
<td>Engages team members in ways that facilitate their contributions to meetings by both constructively building upon or synthesizing the contributions of others as well as noticing when someone is not participating and inviting them to engage.</td>
<td>Engages team members in ways that facilitate their contributions to meetings by constructively building upon or synthesizing the contributions of others.</td>
<td>Engages team members in ways that facilitate their contributions to meetings by restating the views of other team members and/or asking questions for clarification.</td>
<td>Engages team members by taking turns and listening to others without interrupting.</td>
</tr>
<tr>
<td><strong>Individual Contributions Outside of Team Meetings</strong></td>
<td>Complete all assigned tasks by deadline; work accomplished is thorough, comprehensive, and advances the project. Proactively helps other team members complete their assigned tasks to a similar level of excellence.</td>
<td>Completes all assigned tasks by deadline; work accomplished is thorough, comprehensive, and advances the project.</td>
<td>Completes all assigned tasks by deadline; work accomplished advances the project.</td>
<td>Completes all tasks by deadline.</td>
</tr>
</tbody>
</table>
| **Fosters Constructive Team Climate** | Supports a constructive team climate by doing any of the following:  
  • Treats team members respectfully by being polite and constructive in communication  
  • Motivates teammates by expressing confidence about the importance of the task and the team's ability to accomplish it  
  • Provides assistance and/or encouragement to team members | Supports a constructive team climate by doing any of the following:  
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Thank you

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https://sites.google.com/uci.edu/penelopecollins/home
References


