I Find Your Lack of Scientific Literacy Disturbing: An Everyday Joe's Guide to Evaluating Scientific Literature

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In this article, Maura Pauline explores the importance of scientific communication and its impact on the greater public, during the COVID-19 pandemic and beyond. Pauline provides an easy-to-follow guide for nonscientists to help them read and better understand scientific articles, as well as performing a genre analysis to discuss how the P-CHAT principles apply to scientific literature.

My whole life, I have loved science. I love the mystery of designing and completing an experiment and the constant discovery of new facts. I also love sharing all the new scientific facts I learn with others. Ask anyone in my family, I jump at any chance to explain scientific concepts to anyone, no matter how nerdy my sister might call me. Given all this, one may think that the novel coronavirus taking over mainstream media and putting science at the forefront of society would be a dream! Unfortunately, you would be mistaken. It is nothing less than a nightmare, and not just due to the increasing cases.

As more and more articles about discoveries surrounding this new disease, COVID-19, came out, I found myself getting more and more frustrated. Many articles misused scientific data to suggest faulty conclusions, or cherrypicked their quotes to get a fear-instilling and catchy headline. "How could people actually believe this stuff?!" I consistently asked myself. As a matter of fact, "the World Health Organization has called the situation an *infodemic*: an overabundance of information—some accurate and some not—rendering it difficult to find trustworthy sources of information and reliable guidance." After writing a paper for science class, it finally hit me. For years, I have been taught not only science, but how to read and write scientific literature. These skills are something only science majors spend time learning.

Scientific writing can seem like a foreign language. There are a lot of words, phrases, and ideas that aren't used in everyday communication that no one would understand unless they have studied science. When understanding these papers seems impossible, it leaves the general public at the mercy of the mainstream media. As previously mentioned, these aren't always the most trustworthy sources. Whether the journalists writing articles don't know how to evaluate scientific papers, or intentionally misrepresent the facts, scientific advice and conclusions shouldn't always be trusted. Oftentimes, if the study referenced is listed and can be accessed by the general public, it's much more accurate to simply read said study yourself. This leads to a new problem for the general population: how does one even go about decoding scientific texts?!

Genre Analysis

According to the ISU Writing Program, a Genre Analysis is "looking very closely at a particular genre and investigating all the different features that might be present." It can also be a deeper analysis, including how genres are used and taken up by the public, and how they are used by certain agendas.

In this article, I plan to reveal some important science "secrets" to help better evaluate these papers, as well as conduct a **genre analysis** to help identify the important sections of scientific literature. Finally, I am going to do a P-CHAT analysis of scientific literature in order to illustrate how other societal factors can impact how we take up and evaluate this kind of information.

Spilling the Tea on Science: Science Principles They Don't Teach You in Middle School

News outlets really like to make things concrete, to have a solid answer for every question a reader may want to ask. Unfortunately, science doesn't fit well into this mold.

Unlike other sources that can be proven right or wrong, "science is not about certainty … science is about the **error bar**." Some may assume that scientists get all their answers from the raw data collected. Unfortunately, gathering the raw data is usually the fun part, as after that, the statistical analysis begins. Scientists use these statistics to test for one thing: significance.

Testing for significance is the way scientists can prove the validity of their results. As an example, let's imagine we're looking at a study about COVID infections that includes 1000 male and 1000 female participants who had been infected with the novel coronavirus (COVID-19). In this fictional data set, 800 males and 775 females who were infected died. One might immediately see this and assume that since more males died, COVID-19 must be more serious in males than females. The problem is, we can't make that conclusion without using statistics to determine the significance of the difference between the two groups. Perhaps, many of the males were ages fifty to sixty-five, heavy smokers, and had diabetes, all of which are factors that we know increases risk of being strongly afflicted with COVID-19. Because there are so many possible factors that could have caused this split, you can't tell for sure by looking at the raw data alone. This is the same process that scientists go through with their raw data sets from their own research projects. The point of a research project isn't just the results, but rather the significance of the difference between variables. As mentioned before, science isn't about certainty. Since scientists cannot base their claims off of 100% yes or no answers, they use significance as a way to support their claims with the most likely causes.

The Error Bar

Error Bars are graphical representations of variability. What? Basically, they are visuals that are included in graphs to help viewers understand the likelihood that the effect being studied is due to some identifiable cause, rather than just being caused by chance (or a sampling error). They can help someone reading a study understand whether the results being reported are *significant*. For more information, scan the following QR code:

The second important thing to understand about science is that it's always changing. As new projects are being done, and more research is being added to the body of work, scientific beliefs will change. This doesn't mean that science isn't to be trusted and is always wrong, it simply means that we won't ever know all there is to know about scientific concepts. All we can hope to do is examine the most up-to-date research and keep adding to it as time goes on.

I'm Overwhelmed!: A Genre Analysis of a Scientific Paper and the Parts that Really Matter

So, a local news site has uploaded an article about a new COVID-19 study, but it seems a bit off to you. Upon first finding this article, or any other article that interests you, you should see the original study referenced. The study might appear as a hyperlink in the first few paragraphs, or a separate link at the end. Once you find the scientific paper, there are a few initial questions to ask yourself. First, look at the site/institution the study was produced by. Do you know anything about this site that might cause you to be skeptical? Do they have any motives for wanting a specific result? Are they reputable? If you can't find anything sketchy about the institution that sponsored it, keep reading! If you do, maybe go back and look for a different study. Oftentimes, there are hundreds, if not thousands, of scientific papers written on the same topic!

Second, look to see if the paper has been **peer reviewed** yet. If this paper has already been published in a scientific journal, it has most likely been peer reviewed. So, if you are looking for information about the recent novel coronavirus, look at the top of the article to see if it has been peer reviewed yet. This is important, as most articles are so new that they haven't been peer reviewed. This is actually super important to look out for! Peer reviews serve as a way to keep scientists honest. They also serve as a way to further validate results by **replicating** them. If a paper hasn't been peer reviewed yet, keep in mind that regardless of what the results of it are, it could be an anomaly, as no one has tried to (or been able to) replicate them yet. Now that we've gone over some of the key terms important for gauging the honesty of an article, let's look at a breakdown of what the article itself is comprised of.

Replication

In science, the term Replication refers to repeating a similar study and getting similar results (which indicates that the first studies results are not due to some kind of accident or error).

Abstract: The "Spark Notes" of the Study

The first part of a scientific paper is called the **abstract**. This paragraph serves as a summary of the whole paper: the inspiration, the experiment, and the results. This part of the paper doesn't have too much confusing background info and is a good place to start, even for someone not familiar with the subject. It is almost like a guide for the rest of the paper and can set you on the right path for understanding the key findings.

Introduction: Step Right Up and Meet the Background Information

If you remember taking the science portion of the ACT, you probably remember being very confused by the vocabulary and concepts you didn't really understand. Reading the introduction of a scientific paper will likely bring on the same feelings. This section of the paper is supposed to serve as a source of **background knowledge** about the subject being discussed. It might introduce the gap in knowledge trying to be filled, or past experiments that inspired this study. If you are already familiar with the subject, go on and read this section, you might learn something new! If you are not familiar with the field of study, you can skip this section.

Materials and Methods: The To-Do List

Once again, this section is really long and confusing, with many technical terms. There is one part you might want to look closely at. **Methods** is the section of a paper where a scientist will explain their process, not only for the actual experiment, but also for the way their samples or their subjects are handled. This section is really important to look out for. Even without statistics training, this section can still be understood. Any experiment or study should be free of biases, so look at this part and ask yourself some questions to determine the validity of the results. Were the subjects randomly selected? How many subjects were observed/tested? How many different factors were they observing/testing for? These questions can help you determine if the methods have been improperly influenced or appear unbiased.

Results: The Raw Data Doesn't Lie. Or Does It?

This section can also be rather intimidating. There are graphs and tables everywhere! This section is really just the **results** with no explanation, just the presentation of any data gathered. You can skip this section if you have no familiarity with the subject (the important part is in the next section: discussion).

If you do want to look at the results, here are a couple things to keep in mind:

If there are graphs, pay attention to each **graph's axis**. What is their scale? Some graphs are manipulated to make it seem like the differences between categories is much more, or less, than it really is. Just double check that the scale of the axis makes sense in the context of each graph.

If data tables are present, first take a breath! There are a lot of numbers in these, but not all of them are important. The only

Graph Axis

An axis is a reference line on a graph used to show measurements. On most graphs, there are two axis, one that goes up and down and one that goes horizontal. Various numbers are placed along these axis, and certain distances and along specific scale (like counting by 5s or 10s). Sometimes these scales can be manipulated to create the illusion of certain relationships within the data that aren't really there.

The QR code below offers more examples of how graphs can be manipulated to skew data perception.

number you really need to look for is at the end of the table, typically called the **p-value**. This is another statistical concept, but in reality, it's not that difficult to understand. This value represents the percent chance of the result happening at random, not because of the variables. The lower this percentage, the more likely it is that this result was due to whatever factor was being controlled by the experimenter. A typical value used for comparison is .05 (or 5%), so typically anything under this is a good result.

Discussion: Let's Talk about It

This is a very important section! As science students, we are taught that this section of a paper should discuss the impact of the results: what gaps in knowledge they fill in, how it can improve treatment or public policy, and what experiments could be done next. This really is the important section for someone just looking to educate themselves. For instance, in a paper on the coronavirus this section might include information increasing our understanding of how the disease is spread, or how it might impact the development of vaccines. For a paper on climate change, this section may include predictions about what might happen in the environment based on their study's results.

Conclusion: Predicting the Future?

As in any paper, this section just wraps up everything already written. You might want to skim it just to be sure that you didn't miss anything. This section may also state some future experiments the scientists want to do based off of the results they got or suggest new studies that might further advance our knowledge. This section will help give you an idea of the future direction of work in that particular field. This is especially important if you plan on staying up-to-date in that field of study!

P-CHAT Analysis

In the ISU Writing Program, P-CHAT, or pedagogical cultural-historical activity theory, is a way to look at a text and understand how it interacts with the world around us. There are seven terms that fall under P-CHAT, a CHAT-based model used for thinking about the complexity of literate activity. In the context of scientific literature, I am only going to focus on reception, socialization, and representation.

These three terms actually work very closely together, especially when looking at scientific literature. **Reception** refers to the ways in which a text is taken up and used (ISU Writing Program). The reception of scientific literature really depends on the person who is reading the text. In other words, what happens when someone clicks on a link to a scientific paper from a news article? If the person is a scientist, they will read the whole article and learn something new. If the person is an everyday Joe with no scientific training, they will probably look it over and decide it's too confusing. They might then exit out, taking what the article said as the truth rather than coming to their own conclusions about it. This term also refers to how people may repurpose the article, like the way journalists may misuse scientific studies to prove a point, oftentimes even in opposition to the conclusions of the original study.

Representation refers to the ways in which people who produce a text plan it and talk about it. This is actually a big issue with scientific writing. Scientific writing is mainly written by scientists, for scientists. The problem is that in today's day and age, especially during a pandemic, results of these studies are becoming more important for all non-scientists to understand. When science becomes part of new political policies with the potential to appear on ballots, people need to be able to understand scientific concepts and studies in order to form educated opinions. Fortunately, this is becoming a shared goal for the scientific community. Although this article might serve as a quick way to increase your literacy in science, scientists have some literacies of their own to learn. If knowledge is meant to be understood by the general population, it needs to be presented in a way that doesn't require an intensive background in science. Scientists also have the responsibility to think about the ways they present their research, especially when it relates to public health and policy. Scientists must rethink how they present their research if they want it to be accessible and understandable to everyone.

This leads us to our third concept, **socialization**. This term refers to how people and institutions interact when engaging with texts. This could refer to many possible situations, such as the way a journalist and their employer might interact with a paper. If a journalist has a particular stance (or their employer does), they may interpret the study in a way other than what was actually concluded by experts. This could be done accidentally or intentionally to serve another purpose. There are numerous ways that the socialization of scientific studies can be beneficial, and not used in a misleading way. Scientists use studies to grow their field of knowledge. When the COVID-19 pandemic started, the first papers coming out were about the physical nature of the disease, what classification it was, and what its DNA sequences looked like. After these things were discovered, scientists could use the information presented in those studies to discover how it was transmitted and how it functioned in the body. Now, scientists are using all the previous information discovered to create a vaccine to help fight COVID-19. Without sharing their findings and building off other people's work, we wouldn't know half as much about COVID-19.

Whether we understand it or not, science is becoming increasingly important in all of our lives. It is easy to apply this to life in our current situation, but this will still be true long after the COVID-19 pandemic is over. Self-driving cars, personalized medicine, and other new technological advances will eventually require legislation and policies to regulate them. When these events occur, it is everyone's responsibility to educate themselves, in order to make wise decisions in our daily lives, and vote in informed ways on new policies.

This article is meant to serve not just a guide, but also as a conversation starter. The strategies listed in this article are my personal recommendations, and after reading this, I hope you take the opportunity talk to the scientists that might be in your life. This could be for advice or tips for decoding scientific literature, or just to learn about their area of expertise and their understanding of the scientific method. In the end, it is up to all of us, scientists and not, to leave our biases at the door and invest ourselves in expanding our literacies in order to make the information we all need more accessible, available, and understandable.

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