Pseudoscience and Scientific Literacy in the Age of Communication Within Social Media

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Abstract

Social media provides an outlet for information that encourages the dissemination of information, but also doesn't have an efficient, dependable method of monitoring that information. Because of this, much of the material available online is reposted countless times without an expert to correct what is written, and the appreciation of peer-reviewed material is hard to find among social media users. Since social media is a relatively new method of communication, there need to be standards put in place to ensure veracity and accuracy within the communication of scientific ideas and information. In this study, I will investigate patterns of correlation among social media habits, science education and literacy, and the ability to discern between factual and fictional information. Correlation will be measured between variables to determine whether there is a relationship to be studied further.

PSEUDOSCIENCE AND SCIENTIFIC LITERACY IN THE AGE OF COMMUNICATION WITHIN SOCIAL MEDIA

Introduction

The rise of science misinformation is concerning for many scholars in the field. More and more, scientists are forced to prove the validity of their work beyond the point of reasonable expectation and are being undermined by the growing school of thought that science is a matter of opinion, not fact. Social media has had a harmful effect upon the relationship of trust that is essential for the dissemination of scientific knowledge. Individuals outside the scientific community or a specialty field do not have the ability to decipher jargon or facts and they cannot reasonably understand complex scientific language, nor should they need to. Simultaneously, because most people do not understand the technical jargon and complex terminology employed by scientists and researchers to convey their findings and implications, it can be difficult to translate complex ideas into simple explanations.

This gap between scientific knowledge and its interpretation by the public via social media is lacking in research. It needs to be monitored carefully to ensure that the public is not being misinformed or misled, yet due to the rise of social media platforms, this has been increasingly difficult to do. Social media algorithms often perpetuate the spread of false information by allowing it to pass from profile to profile. And, as Thaler and Shiffman (2015) state, “bad science, pseudoscience, and fake science can often spread so effectively that, even when corrected…the false information will remain within the unchecked pool of common knowledge” (p. 88).

Problem Statement

Scientific information has no gatekeeper in the current state of information sharing. In the past, scientific information was accessed through peer reviewed journals and articles written by science journalists, now anyone can publish something that looks official and legitimate. There is no seal of approval that states whether something in the public sphere is legitimate, and very often there is not an easy way to trace an article back to its source.

This phenomenon is understandably complicated and a large-scale investigation of all aspects of it or every possible variable leading to its existence would be far too complex to handle in any one study. On a smaller scale, however, there are two major issues that can be singled out which are contributing to the overall problem of public distrust of science- social media postings and lack of scientific literacy. I will examine statements made on social media concerning the current anti-vaccination debate in order to focus on one subject and the ability that people have to differentiate between factual and false information. After detailing the results of the study, I will explain how it provides recommendations for future areas of research, as well as delineate methods to lead the fight against the belief that science is opinion, not fact. I hope that this analysis combining the parallel narratives of both topics will shed light on how we can eliminate the idea that science is an untrustworthy field.

Significance

For science to progress, there needs to be a system of checks and balances that takes place before information leaves the scientific community, as well as a way to denote the validity of information once it goes into the public domain. This is instrumental towards ensuring that there is a well-informed populace. John Bohannon, among many other academics, has spoken out against the changing nature of the academic journal over the past decade. He has made it clear that there are serious problems that exist within the academic community in regard to what is being published, how it is being published, and where it is being published (Bohannon, 2013).

Outside academia, communications become even more complex in terms of origin and responsibility. Many people cannot tell the difference between real science and fake science, and the journalists and writers covering the information have not been trained to tell the difference. Beall (2017) states outright that “many [scientific journalists] are unable to differentiate valid science from pseudoscience”, and a Pew Research Study recently found that 62% of adults get their news through social media sources, the largest of which was Facebook (Gottfried & Shearer, 2018). The problem of fake science disrupting the credibility of actual scientific research and fact is growing quickly, and the sooner the problem is addressed, the sooner we can begin to draw a line once again separating fact and fiction.

Literature Review

The erosion of public trust in the sciences

Over the past several years, public trust in scientific experts has been eroding. As the spread of fake news and hoaxes spread like wildfire through various social media platforms, it becomes more and more difficult to discern whether an article that someone sends you is factual. Some examples of inaccurate reporting are obvious, but others may require an operating knowledge of the research process and the ability to analyze the source in order to easily differentiate between what is factual and what is simply sensationalism or blatant lies. Menezes (2018) states that currently, only 3% of journalists have an undergraduate background in science and are qualified to communicate in the language necessary to convey scientific news. Beall (2017) reinforces this statistic, stating that “the number of competent practicing science journalists seems to be declining” (p. 294), and that “many are unable to differentiate valid science from pseudoscience” (p. 294).

It would be unreasonable to expect every media consumer to personally fact-check every scientific article they read. As Verma et al. (2017) states, “fake news articles get shared alongside peer-reviewed scientific articles and fact-checked mainstream media articles” (p. 427). Many readers do have the ability to distinguish between fake news, mainstream fact-checked journalism, and peer-reviewed science articles, but many more do not. Even in the instance of real articles being placed directly next to misleading or fake ones, it can be confusing at times even for those who have some degree of scientific understanding.

To add to the confusion, sometimes experts are misrepresented intentionally to produce false information, which can be hurtful to scientific perception regardless of whether it is intended to entertain or to inform. Thaler & Shiffman (2015) discuss a television production by the Discovery Channel that tricked professional scientists into taking part in a fake documentary, the 2012 production of "Mermaids: The Body Found". During production of this documentary, the Discovery Channel used information from professional scientists, academics, and experts within the National Oceanic and Atmospheric Administration (NOAA) to promote a show about the secret existence of mermaids. Afterwards, there was public outcry directed at these scientists and experts for their willingness to promote fake science, though they knew nothing of the intention of the directors when they agreed to participate. Many of these scientists and experts who had been tricked into taking part were quick to use the opportunity to inform the public about the facts behind their studies. They were able to use the unintended attention to correct some of the damage that had been done to their reputations and the public perception of their work. However, as Thaler and Shiffman (2015) wrote in their article detailing this incident, "bad science, pseudoscience, and fake science can often spread so effectively that, even when corrected…the false information will remain within the unchecked pool of common knowledge" (Thaler & Shiffman, 2015).

Facebook algorithms

What you see on Facebook has been chosen for you- the algorithms that Facebook uses to run its platform generate content based on what the user and their friends have "liked" in the past (Waldrop, 2017). overall, the more time that you spend on Facebook interacting with the site, the more it will populate your newsfeed with ads and articles that agree with the views you already hold, thus reinforcing current viewpoints and keeping users from being exposed to material that they don't agree with (Waldrop, 2017). The problem with this system, while it can be good for Facebook to maintain user presence within their social media community, is that false material can spread quickly without being questioned by opposing viewpoints and ideas. When considering one study's statement that "the claim that the seasonal vaccine somehow causes the flu has been a persistent myth over the years, even among some healthcare workers" (Flu vaccine myths and conspiracies, para. 3), it's easy to see how information could easily be passed between people within whom there is an established trust.

Out of all major forms of social media, Facebook had the highest number of users who depended on it for news. Gottfried & Shearer (2018) reported from a Pew Research Study that 62% of adults get news from social media. In 2013, 47% of users utilized Facebook as their news source; in 2016 that figure rose to 66% of users. One of the most alarming facts of this survey is that "of those who get news on at least one of the [social media] sites, a majority (64%) get news on just one – most commonly Facebook" (Gottfried & Shearer, 2018, para. 6). Recently, Facebook has launched an initiative to combat the dissemination of hoax science and misleading scientific articles. Mark Zuckerberg, CEO and founder of the Facebook, states that part of their initiative to combat fake news is "seeking insight from journalists and the media industry to better understand fact checking systems" (Chaykowski, 2016, p. 3). Regardless of ethical intent to improve the site, however, Facebook's trends are the ones that are most prevalent in the spread of fake news and hoaxes and make it the best choice for this study.

Other individuals are combatting the spread of fake science knowledge on Facebook in a different way. Craig McClain offers a challenge to scientists to become a "Nerd of Trust" to their Facebook friends (McClain, 2017). He claims that "many scientists are already a 'Nerd of Trust' within their network of family and friends", which means that they are a trusted source that people in their network could come to with a question about the scientific field they are in (McClain, 2017, Becoming a nerd of trust, para 4). Additionally, McClain states that "(t)hese connections can often traverse ideological affiliations with nearly 20% of liberals maintaining Facebook friendships with conservatives and vice versa" (McClain, 2017, Becoming a nerd of trust, para 4). Scientists could have a valuable opportunity to educate those around them among many sides of a debate, and by doing so, begin correcting some of the misinformation that continuously cycles through Facebook.

The problem with peer review

Unfortunately, the scientific community has been undergoing its own problems during the past several years concerning the issue of credibility. While there has been a serious lack of trust in the scientific community on the part of the public, there has also been reason for scientists to distrust their own colleagues' material. Recently, there have been several instances in which peer-reviewed journals have accepted work that was computer-generated or completely fabricated (Haider & Åström, 2013, pp. 453-454). One of instances is referenced in Haider & Åström's study of the effect on scientific communication stemming from John Bohannon's 2013 article outlining the weaknesses of the peer reviewed journal as an academic institution.

"Bohannon submitted a deliberately flawed research article", the authors recount in the introduction to their article, and yet "slightly more than half of those journals accepted the submission and proceeded to publish the article" (Haider & Åström, 2017, p.450).

Following the submission of the fabricated articles, Bohannon published an article in *Science Magazine* in October 2013 detailing the experience. Concerning articles that were printed, from the "106 journals that discernibly performed any review, 70% ultimately accepted the paper" (Bohannon, 2013, p. 64). Additionally, Bohannon states that "the identity and location of the journals' editors, as well as the financial workings of their publishers, are often purposefully obscured" (Bohannon, 2013, p. 60). Based on the research that Haider & Åström conducted concerning the aftermath of Bohannon's "sting" (Haider & Åström, 2017, p. 450), as it was termed, both the public as well as the scientific community felt as though they had lost faith in the process of the peer reviewed journal. The revelation of the state of peer review had a huge impact on the public image of the accuracy and validity of the findings of the scientific community. Moving forward, Haider and Åström state that scholarly research needs "to be communicable to a wider audience outside their own field of research, and with some stamp of approval letting the reader know that an article is based on bonafide research" (Haider & Åström, 2017, p. 462). It seems that it is one of the ways that the scientific community can make progress toward building trust within itself and without.

Combatting scientific illiteracy

The Metcalf Institute for Marine and Environmental Reporting, located at the University of Rhode Island, holds an Annual Science Immersion Workshop for Journalists to help journalists get a better grasp of basic science concepts relevant to the news today. Each year 10 spots are available for interested journalists, for which the institute receives over 100 applications (Menezes, 2018, p.3). It's clear that although only 3% of journalists have a science background, as mentioned previously in this paper, there is a distinct desire to improve their skills and become better communicators within the field of science journalism (Menezes, 2018).

Additionally, some educational systems in different areas of the world have been trying to combat the lack of scientific literacy by using *Adapted Primary Literature* (APL) in their teaching of STEM disciplines. An APL is "written by scientists with the added pedagogical expertise of teachers" (Schaeffer, 2017, p. 39-40). The main benefit of APLs is that students become familiar with scientific writing, including graphs and charts, with language that has been made more accessible to them (Shaeffer, 2017). This could go a long way toward improving scientific literacy and the ability of people without a strong science background to at least be able to discern for themselves what is fact and what is fiction.

Methodology

Research design

The purpose of this pilot study is to determine whether a sample population can analyze whether scientific facts circulated through social media are scientifically accurate or not. The sheer volume of scientific information within social media sites is prohibitive to a study that would be able to analyze every false claim or pseudoscience article. For this pilot study, data will be collected from a survey on Facebook, chosen because of its status as the one of the largest social media networks. The survey will be focused on common statements concerning vaccination facts in order to focus solely on one topic.

This study will examine if there are any potential correlations between an individual's ability to discern between accurate and inaccurate vaccination information on social media and their educational background and scientific literacy. It's unsure whether educational background makes a difference. Additionally, social media algorithms perpetuate the cycle so that you see what you want to see without having to question other points of view (Waldrop, 2017). This study seeks a preliminary answer to the question of whether an individual's background in science education and social media habits make a difference in their ability to discern factual and fictional information about vaccinations.

Data collection

To gather data for this pilot study, a survey was created using Survey Monkey and was distributed through Facebook (Appendix A). The survey consisted of two separate sections separated into two pages. The first section gathered information about the participant's past science education and confidence level of discerning fake news from factual news. The second section consisted solely of statements commonly found on social media concerning vaccines; factual and fictional statements were mixed. Participants were asked to select either "true" or "false" concerning the statements about vaccines. Snowball sampling was utilized in an effort to mimic as closely as possible the experience an individual may have on Facebook when encountering a quiz or test. Data was coded and entered into SPSS to provide quantitative variables for analysis. Post-survey correlational analysis examined the data for trends between scientific education and the ability to easily discern scientific fact, in addition to the social media habits of users. The results of this survey will provide a benchmark to collect further data and refine the results, since in my research I have not found data measuring these particular aspects of social media literacy.

Results

The data resulted in responses from 90 participants, 8 of which did not finish the survey and whose results were not included to avoid skewed data, for a total of 82 participant responses used within this survey. Data was coded in SPSS and variables were analyzed to find potential areas of correlation between variables. Correlations were found between four unique intersections of variables concerning science education and social media trends, and two unique intersections of science education and factual versus fictional questions. Correlation was measured using Pearson's r, and critical values for Pearson's r based upon a two-tailed test. Tables from SPSS displaying data from areas of significant correlation are shown below.

Table 1

Correlations

		HSBiology	UndergradScience	GradScience	ComfortDiscerningFakeFromFact
HSBiology	Pearson Correlation	1	-.019	-.049	.079
	Sig. (2-tailed)		.864	.660	.479
	N	82	82	82	82
UndergradScience	Pearson Correlation	-.019	1	.216	.132
	Sig. (2-tailed)	.864		.051	.239
	N	82	82	82	82
GradScience	Pearson Correlation	-.049	.216	1	.233*
	Sig. (2-tailed)	.660	.051		.035
	N	82	82	82	82
ComfortDiscerningFakeFromFact	Pearson Correlation	.079	.132	.233*	1
	Sig. (2-tailed)	.479	.239	.035	
	N	82	82	82	82

*. Correlation is significant at the 0.05 level (2-tailed).

Table 2

Correlations

		HSBiology	UndergradScience	GradScience	FrequencySharingNewsOnSocialMedia
HSBiology	Pearson Correlation	1	-.019	-.049	-.234*
	Sig. (2-tailed)		.864	.660	.034
	N	82	82	82	82
UndergradScience	Pearson Correlation	-.019	1	.216	-.021
	Sig. (2-tailed)	.864		.051	.851
	N	82	82	82	82
GradScience	Pearson Correlation	-.049	.216	1	-.135
	Sig. (2-tailed)	.660	.051		.228
	N	82	82	82	82
FrequencySharingNewsOnSocialMedia	Pearson Correlation	-.234*	-.021	-.135	1
	Sig. (2-tailed)	.034	.851	.228	
	N	82	82	82	82

*. Correlation is significant at the 0.05 level (2-tailed).

Table 3

Correlations

		HSBiology	UndergradScience	GradScience	FrequencyReadingScienceOnSocialMedia
HSBiology	Pearson Correlation	1	-.019	-.049	.133
	Sig. (2-tailed)		.864	.660	.235
	N	82	82	82	82
UndergradScience	Pearson Correlation	-.019	1	.216	.023
	Sig. (2-tailed)	.864		.051	.839
	N	82	82	82	82
GradScience	Pearson Correlation	-.049	.216	1	.294**
	Sig. (2-tailed)	.660	.051		.007
	N	82	82	82	82
FrequencyReadingScienceOnSocialMedia	Pearson Correlation	.133	.023	.294**	1
	Sig. (2-tailed)	.235	.839	.007	
	N	82	82	82	82

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4

Correlations

		HSBiology	UndergradScience	GradScience	FrequencySharingScienceOnSocialMedia
HSBiology	Pearson Correlation	1	-.019	-.049	-.062
	Sig. (2-tailed)		.864	.660	.583
	N	82	82	82	82
UndergradScience	Pearson Correlation	-.019	1	.216	.066
	Sig. (2-tailed)	.864		.051	.553
	N	82	82	82	82
GradScience	Pearson Correlation	-.049	.216	1	.218*
	Sig. (2-tailed)	.660	.051		.049
	N	82	82	82	82
FrequencySharingScienceOnSocialMedia	Pearson Correlation	-.062	.066	.218*	1
	Sig. (2-tailed)	.583	.553	.049	
	N	82	82	82	82

*. Correlation is significant at the 0.05 level (2-tailed).

Table 5

Correlations

		HSBiology	UndergradScience	GradScience	TrueFalse3
HSBiology	Pearson Correlation	1	-.019	-.049	-.231*
	Sig. (2-tailed)		.864	.660	.037
	N	82	82	82	82
UndergradScience	Pearson Correlation	-.019	1	.216	.025
	Sig. (2-tailed)	.864		.051	.825
	N	82	82	82	82
GradScience	Pearson Correlation	-.049	.216	1	-.003
	Sig. (2-tailed)	.660	.051		.981
	N	82	82	82	82
TrueFalse3	Pearson Correlation	-.231*	.025	-.003	1
	Sig. (2-tailed)	.037	.825	.981	
	N	82	82	82	82

*. Correlation is significant at the 0.05 level (2-tailed).

Table 6

Correlations

		HSBiology	UndergradScience	GradScience	TrueFalse4
HSBiology	Pearson Correlation	1	-.019	-.049	-.018
	Sig. (2-tailed)		.864	.660	.872
	N	82	82	82	82
UndergradScience	Pearson Correlation	-.019	1	.216	.057
	Sig. (2-tailed)	.864		.051	.610
	N	82	82	82	82
GradScience	Pearson Correlation	-.049	.216	1	.295**
	Sig. (2-tailed)	.660	.051		.007
	N	82	82	82	82
TrueFalse4	Pearson Correlation	-.018	.057	.295**	1
	Sig. (2-tailed)	.872	.610	.007	
	N	82	82	82	82

**. Correlation is significant at the 0.01 level (2-tailed).

Correlational relationships were found between participants who have taken graduate level science classes and three separate variables: comfort discerning fake news from factual information (p=.05, r_{crit}=.2172, Pearson's r=.233, sig.=.035), frequency of reading science articles on social media (p=.01, r_{crit}=.2830, Pearson's r=.294, sig.=.007), and frequency of sharing science articles on social media (p=.05, r_{crit}=.2172, Pearson's r=.218, sig.=.049). A correlational relationship was also found between participants who had completed high school biology and frequency of sharing news on social media (p=.05, r_{crit}=.2172, Pearson's r=.234, sig.=.034).

Among the six factual versus fictional questions, two correlational relationships were identified within questions three and four. A significant number of participants (see Table 5) who had completed high school biology answered question three as being a true statement when it is actually false ("Credible studies exist that have proven some potential dangers of vaccination"), $p=.05$, $r_{crit}=.2172$, Pearson's $r=.231$, sig.=.037. Additionally, Table 6 shows that a significant number of participants who had taken science classes at the graduate level answered question four correctly compared to other participants ("You have the potential to contract the flu when you get a flu vaccination"), $p=.01$, $r_{crit}=.2830$, Pearson's $r=.295$, sig.=.007.

Conclusions and Recommendations

This survey was a pilot study used to assess whether there were specific areas among science and social media where a correlation could be found to answer the study hypothesis stating that there is no relationship between science educational background, ability to discern scientific fact from fiction, and social media usage. The general findings that are supported by correlational relationships are that individuals who have taken graduate-level classes within the science fields have a greater ability to discern scientific fact from fiction and interpret pseudoscience (see Table 1). These findings are not necessarily surprising, since individuals who have taken science classes at the graduate level have studied in greater depth than any high school or undergraduate class. Within the data of this study, graduate students read more science articles on social media and share more science articles on social media (see Tables 3 and 4). Importantly, though, the argument can be made that individuals who have taken graduate-level science classes have been part of the scientific process at a more intense level and have been part of experimental work and/or submitted to peer-reviewed journals. These individuals would be more likely to have better insight into the scientific process and be able to discern what is and is not factual science. This could also explain why participants who have studied at the graduate level had a significantly higher knowledge concerning the details of the flu vaccine.

The other population that had a correlational significance was that of the participants who have taken biology in high school. It is important to restate that this data includes all participants who have taken high school biology, regardless of whether they have also taken science at the undergraduate and/or graduate level. When removing the participants who have taken science classes beyond high school biology, it seems likely that Pearson's r would have a higher value and would show a stronger correlation than currently present. A future study could create a scale detailing the amount of biology taken by the participant or specify further which science courses had been taken and at what level in an effort to get even more detailed information than this preliminary study has.

Outside of these limitations, it is still interesting to observe that the group of participants that includes all students who have taken high school biology, as opposed to the separate groups who have taken science on an undergraduate or graduate basis, are significantly more likely to share news stories on social media (Table 2) and are more likely to agree that there are credible studies that have found potential dangers of vaccination (Table 5). Concurrently, this group of participants is more likely, though not significantly, to feel unsure of their ability to discern scientific fact from fiction (see Table 1). Further study should be conducted to investigate more specific populations within this group and examine the phenomenon of both method of science education as well as the different types of interaction with news and science articles. It could be interesting to see how differences in science education create more different levels of confidence approaching scientific topics and scientific articles.

Because this is a pilot study, there are some major limitations within the scope of the study. Using a snowball sampling method restricts the variety of data that can be collected and may not represent the overall population. In this study, out of the 82 participants used, there were 73 females and only 9 males. Additionally, the age distribution was heavily skewed, as observed within Table 7.

Table 7

Age

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	18-24	5	6.0	6.1	6.1
	25-34	50	60.2	61.0	67.1
	35-44	9	10.8	11.0	78.0
	45-54	9	10.8	11.0	89.0
	55-64	4	4.8	4.9	93.9
	65+	5	6.0	6.1	100.0
	Total	82	98.8	100.0	
Missing	System	1	1.2		
Total		83	100.0		

In addition to demographics, the statements that were used for the true and false portion of the survey were not actual Facebook postings, but rather were used in tandem with the science education and social media information to observe correlations between the two. Responses may be different within the participant's average social media use, and any future studies done should attempt to create an environment that is closer to the participant's actual social media use and should attempt to span more than one social media source. Finally, future studies should also consider expanding the study to examine a wide variety of science topics that lend themselves to the influence of pseudoscience, rather than remaining focused on one specific topic.

Having mentioned the limitations of this study, it is important to stress that further research should be done on this topic. The trend of pseudoscience finding its way into the public sphere is not a new phenomenon, but it is easily accelerated by the use of social media. Further research is needed to better understand this topic. The current state of scientific authority right now is rocky, and changes must be in the manner that people access scientific material and understand the scientific process. The current system of composing and sourcing scientific material for the public makes a difference as to whether it is taken seriously, as well as the authority with which it is written. From here, we need to evaluate the way that individuals access information, and what makes them trust a source. By creating an environment in which there is a universal trust of scientists, hopefully science will no longer be a matter of opinion, but of fact.

References

Beall, J. (2017). Scientific Soundness and the Problem of Predatory Journals. In Kaufman, A., & Kaufman, J. (Eds.), *Pseudoscience: The conspiracy against science (pp. 283-299).* Cambridge, MA, US: MIT Press.

Bohannon, J. (2013). Who's afraid of peer review? *Science, 342*(6154), 60-65. DOI: 10.1126/science.342.6154.60

Chaykowski, K. (2016). Mark Zuckerberg outlines plan to tackle fake news. *Forbes.com*, 3.

Flu Vaccine Myths and Conspiracies: Misinformation spreads like a virus. (2018). *Hospital Employee Health*, *37*(4), 12-13.

Gottfried, J., & Shearer, E. (2018, May). News use across social media platforms 2016. *Pew Research Center.* Retrieved from http://www.journalism.org/2016/05/26/news-use-across-social-media-platforms-2016/

Haider, J., & Åström, F. (2017). Dimensions of trust in scholarly communication: Problematizing peer review in the aftermath of John Bohannon's 'Sting' in science. *Journal Of The Association For Information Science & Technology*, *68*(2), 450-467.

McClain CR (2017) Practices and promises of Facebook for science outreach: Becoming a "Nerd of Trust". *PLOS, 15*(6): e2002020. https://doi.org/10.1371/journal.pbio.2002020

Menezes, S. (2018). Science training for journalists: An essential tool in the post-specialist era of journalism. *Frontiers In Communication, 3*. doi:10.3389/fcomm.2018.00004/full

Schaeffer, H., & Shapiro, B. (2017). Promoting scientific literacy through the use of adapted primary literature in secondary science. *Alberta Science Education Journal*, *45*(1), 39-44.

Thaler, A., & Shiffman, D. (2015). Fish tales: Combating fake science in popular media. *Ocean & Coastal Management*, *115*(88). doi:10.1016/j.ocecoaman.2015.04.005

Verma, N., Fleischmann, K., & Koltai, K. (2017). Human values and trust in scientific journals, the mainstream media and fake news. *Proceedings Of The Association For Information Science & Technology*, *54*(1), 426-435.

Waldrop, M. (2017) The genuine problem of fake news. *Proceedings of the National Academy of Sciences*, *114*(52). doi: 10.1073/pnas.1719005114

Appendix A.

Survey questions

1. What is your age?

2. What is your gender?

3. Which science classes did you take at the high school level? (Select all that apply)

- Biology
- Chemistry
- Physics
- Earth Science
- Environmental Science
- Other

4. Have you taken any science classes as a college undergraduate?

5. Have you taken any science classes as a graduate student?

6. How comfortable are you with discerning fake news from factual information?

7. How often do you read news articles on social media?

8. How often do you share news articles on social media?

9. How often do you read science articles on social media?

10. How often do you share science articles on social media?

True or False:

1. Vaccines contain a level of formaldehyde that is not harmful.

2. It’s healthier to spread out a child’s vaccination schedule.

3. Credible studies exist that have proven some potential dangers of vaccination.

4. You have the potential to contract the flu when you get a flu vaccination.

5. Herd immunity- having the majority of a population vaccinated- provides protection for those who cannot receive vaccinations.

6. It’s safe and effective to combine vaccines within a child’s vaccination schedule.