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Views and Value of an Undergraduate General Education on Advancing Students' Science Beliefs, Attitudes, and Engagement

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ABSTRACT

The enhancement of science literacy is a long-standing educational goal of liberal education programs. We conducted a mixed methods study to investigate undergraduate students' attitudes towards science and engagement with science, with specific interests in students' program (science vs. nonscience), level of study (junior: first and second year vs. senior: fourth year and higher), and changes over the duration of a single general education science literacy course (pre vs. post). Data were collected through an online questionnaire (n=272) and semi-structured interviews (n=8). We found that self-assessed science literacy was higher in students at the end of the course compared to at the beginning, in senior students compared to junior students, and for science students compared to nonscience students. Interest in learning about science topics was high overall, but did not increase over a single general education science literacy course or in senior compared to junior students. Belief in pseudoscience was also high overall, including in senior and science students, groups in which we expected pseudoscience belief to be lower. Views about science were generally favourable but were not improved by the science literacy course. This work highlights the need to align science curriculum with students' interests while differentiating science from pseudoscience topics. Findings demonstrate the importance of engaging nonscience majors, who may have less intrinsic interest in science topics and can hold less favourable views about the value of science in their lives. As the last time when most students are formally exposed to science concepts and methods, undergraduate education is critical to promoting individual and societal science literacy.

Keywords: science literacy, science education, higher education, liberal education, undergraduate education

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Introduction

The internet has revolutionized our access to information, along with misinformation, pseudoscience, and conspiracy theories. Each day brings new scientific discoveries and technological advancements that impact the lives of undergraduate students and society in general. Despite an acceleration of scientific advancement, there is a decline in the public trust in science that has been described as the "post-truth" era (Compton et al., 2021; Lewandowsky et al., 2017). Science denialism, a belief that people can choose to accept a reality that is at odds with scientific consensus, is prevalent and can have serious consequences for individuals and communities (Levine, 2018; Peters & Besley, 2020). Science denialism is made worse by social media platforms that provide echo chambers in which scientific misinformation and conspiracy theories are amplified and spread ("Scientific Misinformation: A Perfect Storm, Missteps, and Moving Forward," 2021). We are currently at an artificial intelligence (AI) turning point, where natural language models will make distinguishing human- from AI-written articles difficult if not impossible. In fact, we have reflected that this could be one of our last articles authored without the use of AI tools. Scientific literacy provides competencies for individuals to navigate and make decisions in our increasingly complex world (Vandegrift et al., 2020). These competencies are desirable for both individuals and for society as an important feature of functioning democracies (Miller, 1998; Snow & Dibner, 2016). Undergraduate education remains an effective way to enhance science literacy (Allum et al., 2008) and is often the last occasion when students receive formal science training. It is important that educators consider different elements of student science literacy in curriculum design and that universities promote science education within their programs. Here we explore the attitudes towards science, engagement with science, and pseudoscience beliefs of undergraduate students at a general/liberal education university.

There is no set definition for science literacy or agreement on a core set of knowledge and competencies a scientifically literate person should possess (Benjamin et al., 2017; DeBoer, 2000; Holbrook & Rannikmae, 2009; Meinwald & Hildebrand, 2010). We consider this openness to be more of a benefit than a concern, as it offers curricular flexibility as relevant science concepts change over time and differ between educators and individual learners. We agree with DeBoer (2000) who argued that science literacy should be defined broadly enough for educators to pursue goals and give examples most suitable for their particular situation. This advice remains relevant today and highlights a long-standing appreciation that science instructional goals will change with time. Science education should strive to instill in students a positive view about science, and the motivation, confidence, and interest to engage with scientific content outside of the classroom. This view aligns with others that emphasize the ability to appreciate and communicate science when considering science education (Holbrook & Rannikmae, 2009), and that science ability alone is insufficient to achieve deep

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Imagining SoTL, Volume 3(2) (2023)
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understanding and learning (Vandegrift et al., 2020). Students' beliefs about science as both a body of knowledge and way of knowing impact their motivation to learn and engagement in the classroom (Buehl & Alexander, 2005). Student motivation has been shown to correlate with their grades and the self-reported relevance of science concepts to their career goals (Glynn et al., 2009). As such, an important component of developing science literacy in the classroom is cultivating an interest in science topics and the motivation to engage with science concepts. Students' interest and self-belief in science is particularly important in general education courses designed to empower a diverse student population with the capacity for scientific thinking (Vandegrift et al., 2020).

Undergraduate education is often the last occasion when students receive formal science training, which places the crucial responsibility of advancing individual and by extension societal science literacy on post-secondary education. Liberal education programs that are focused on providing students with a broad integrated interdisciplinary curriculum are well suited to advance science literacy (Meinwald & Hildebrand, 2010). However, how, and even if, broad science literacy can be effectively enhanced through undergraduate courses remains controversial (Cartwright et al., 2020; Ding et al., 2016; Lederman & Lederman, 2019). Ding et al. (2016) found that, regardless of program, scientific reasoning in a group of Chinese students did not change over four years of undergraduate education. In a Canadian context, practical science literacy assessed with the Test of Scientific Literacy Survey (TOSLS) (Gormally et al., 2012) did not increase during a fourth-year science course with specific science literacy activities. However, despite this lack of measurable gains in science literacy, students evaluated their perceived science literacy to have increased (Cartwright et al., 2020). Student confidence in their own science literacy is an important educational outcome; however, more work is needed to enhance teaching strategies that develop practical science literacy skills as well.

The ability to use scientific reasoning to make personal decisions or to use scientific knowledge to appreciate natural phenomena or cultural events more fully should not be limited to scientists or science students. It is important that general education science courses strive to offer value for all students, not just the minority who will become career scientists. Science anxiety can be high among students, even in general education courses aimed at nonscience majors (Udo et al., 2004). Core science courses can be particularly difficult for nonscience majors, who often do not see the relevance of science to their chosen career (Glynn et al., 2009). Together, high anxiety and difficulty with lack of perceived relevance can lead to poor motivation among nonscience students, which has been shown to lead to low achievement (Glynn et al., 2007). Understanding the scientific beliefs and misbeliefs of undergraduate students is key to enhancing the goals of general education. The value that general education science courses have in advancing student science literacy has motivated us to explore the science attitudes and

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

engagement of undergraduate students at our institution.

Our institution takes a general education approach where each student takes up to 30% of their undergraduate courses in four thematic clusters to give them a well-rounded knowledge base. One of these clusters specifically focuses on numeracy and science literacy. All students must take one of two foundation courses on numeracy and science literacy with the majority (1,400 students Fall 2021 and 840 students Winter 2022) enrolling in a course called GNED 1101: Scientific and Mathematical Literacy for the Modern World. The authors of this paper are scientists and General Education instructors and teach GNED 1101. The objective of this project is to better understand our students' attitudes towards science and engagement with science, as well as their pseudoscientific beliefs.

Pseudoscience concepts attempt to appear scientific while being incompatible with the scientific method. There are many examples of pseudoscience, and we investigated undergraduate student beliefs about four pseudoscience examples: astrology, numerology, psychic powers, and reflexology. We employed a mixed methods approach that included a custom science literacy questionnaire and follow-up semi-structured interviews. Student programs (science vs. nonscience) and level of study (junior: first and second year vs. senior: fourth year and higher) were groups of interest. We also investigated differences between students in GNED 1101 at the beginning (pre) and end (post) of the semester to see how science attitudes and engagement may be influenced by a single first-year science literacy course. We hypothesized that senior and science students will hold more positive views about science, engage more with science content outside of their courses, and hold fewer pseudoscientific beliefs compared with nonscience and junior students. We also hypothesized that students at the end (post) of a first-year general education science literacy course will also hold more favourable views about science, engage more with science content outside of their courses, and hold fewer pseudoscientific beliefs compared to students at the beginning of the same course (pre).

Methods

Approach and Participants

We employed a mixed methods study design that combined a custom online questionnaire (n = 272) with follow-up online one-on-one interviews (n = 8). Approximately 2,500 students were invited to participate through announcements posted to course websites. Junior undergraduate students, defined as being in the first or second year of their programs, were recruited from a first-year math and science foundation course (GNED 1101: Scientific and Mathematical Literacy for the Modern World). Senior students, defined as being in the fourth year of study or

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

higher, were recruited from a selection of fourth-year courses taken from all programs across the university. GNED 1101 is a multi-section course. There were 35 sections in Fall 2021 and 21 sections in Winter 2022, when data collection took place. Each section has a maximum enrollment of 40 students. Half of the sections were given the questionnaire to complete within the first three weeks of the semester (pre group, n = 66) and half were given the questionnaire to complete in the final three weeks of the semester (post group, n = 67). Students in GNED 1101 who were also in their first or second year of study (13 pre or post participants were in their third year or higher) formed the junior group (n = 120) while students from the fourth-year courses in their fourth year or higher formed the senior group (n = 139). We did not use a cohort design, and students in the pre-post and junior-senior groups are unique. Students were also divided into science (n = 88) and nonscience (n = 182) groups based on their program of study. Participant groups are presented in Table 1. Follow-up interviews were conducted in the semesters following the questionnaires and included 5 senior (2 science, 3 nonscience) and 3 junior (1 science, 2 nonscience) participants. Interview participants have been given pseudonyms to preserve their anonymity. Participants gave informed written consent prior to starting both the questionnaire and interview. This study protocol was approved by our local human research ethics board (HREB ID #102305).

Table 1

Number of Participants Across Study Groups

	Science	Nonscience	Total
Pre	11	55	66
Post	16	51	67
Junior	26	95	121
Senior	49	70	119

Questionnaire

The questionnaire was created and administered using Qualtrics software (Qualtrics, Provo, Utah, USA). The full questionnaire was designed to be completed in less than 20 minutes and included additional questions beyond the scope of the current project. Students were informed of the time it would take to complete the questionnaire in the consent form that they had to sign prior to starting. The questionnaire with the questions relevant to the current study is provided in the

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

appendix. Some questions are novel and were created for this project while others were adapted from previous studies (Benjamin et al., 2017; Gormally et al., 2012; Holden, 2012). The full questionnaire consisted of blocks of questions, which included personal characteristics (e.g., age, gender, year, and program of study) as well as questions regarding students' self-assessed level of science literacy, their attitudes towards science and engagement with science, their foundational knowledge, and their understanding of the nature of science and science beliefs (i.e., pseudoscience beliefs, although the word *pseudoscience* was not used in the questionnaire). For senior students only, there were also two questions about how they believed that their science knowledge and interests had changed over their time as an undergraduate student. With the exception of personal characteristics, the questions were either five-point Likert scale or true-false. An open response question was provided to capture student feedback but was not used in the analysis. The current project focuses on the questions regarding self-assessed science literacy, attitudes and engagement, and pseudoscience beliefs, as well as the questions for senior students.

Interviews

Questionnaire participants were asked if they would be willing to participate in a follow-up interview. We contacted interested participants and completed 8 one-on-one 30-to-60 minute online semi-structured interviews using Google Meet with a Meet Transcription extension. We used a semi-structured approach, following pre-set questions to cover general themes while allowing flexibility to adjust the order and structure of questions based on participants' responses. Interview questions covered five main topics: students' general understanding of science literacy, their attitudes towards science, their beliefs in pseudoscience, their engagement with science, and their science literacy self-assessment.

Analysis

We used descriptive statistics (percentages) to analyze senior students' science knowledge and interest questions, science attitudes and engagement, as well as pseudoscience belief questions. Differences in self-assessed science literacy and interest in learning science topics were compared pre-post and junior-senior using unpaired Mann-Whitney tests. Differences between pre-post science and nonscience students and junior-senior science and nonscience students were compared using a Kruskal-Wallis test. Significant main effects were examined with Dunn's multiple comparisons tests. Statistically significant differences are assumed at $P<0.05$. All statistical analysis and results figures were generated using GraphPad Prism Version 9.

The qualitative data from the interviews were analyzed using the coding strategies presented by a grounded theory approach. Coding in grounded theory

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

involves the twin practices of abstraction and generalization. Abstraction practice involves separating a whole into elements that are distinct from one another. These distinct elements shape their original context. Generalizing practice involves finding what is common or repeated among these elements (Corbin & Strauss, 2008; Packer, 2010). After coding the entire text, we made a list of all code words and grouped similar codes. We then identified the redundant codes to reduce the list of codes to a smaller, more manageable number.

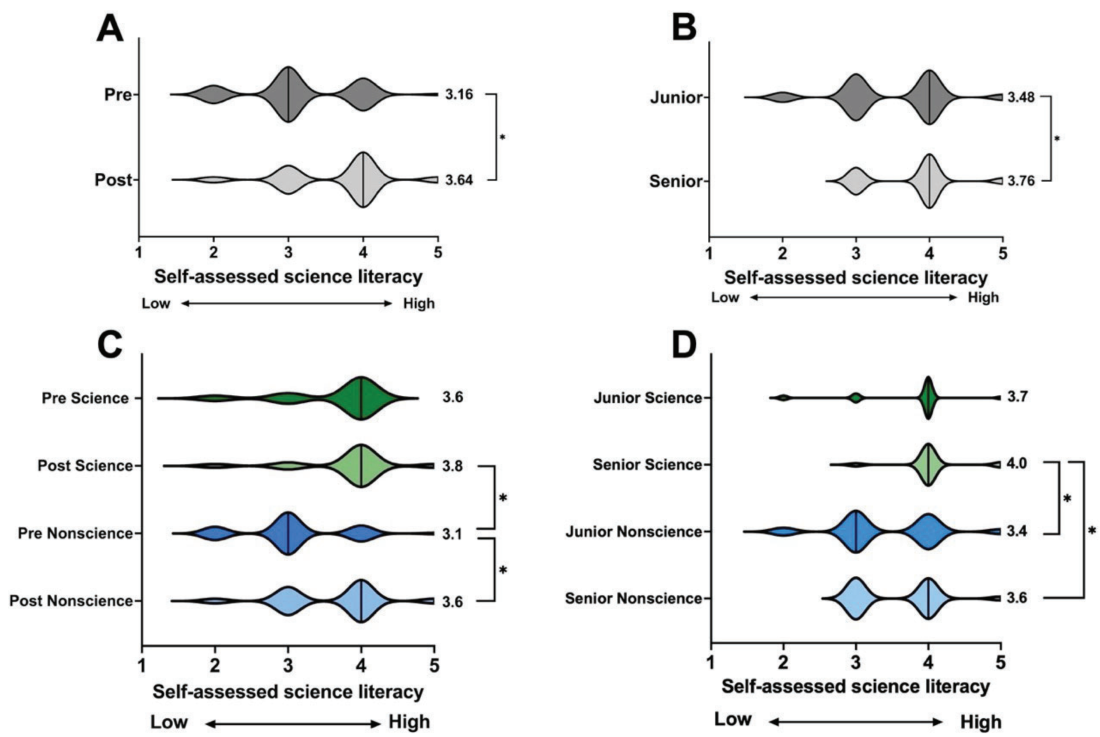
RESULTS

Self-Assessed Science Literacy

When students were asked to rate their self-assessed science literacy on a five-point scale of "Terrible, Poor, Fine, Good, or Excellent," there were differences related to level of study and between science and nonscience majors (Figure 1). Self-assessed science literacy was significantly higher in students at the end (post) compared to beginning (pre) of a general education science literacy course (P=0.0001) (Figure 1A). Senior students self-assessed their science literacy as higher than junior students (P=0.0029) (Figure 1B). Pre nonscience majors self-assessed their level of science literacy significantly lower than post science (P=0.0009) and post nonscience (P=0.0013) students (Figure 1C). Senior science students had the highest self-assessed science literacy, which was significantly higher than both junior and senior nonscience students (P<0.0001) (Figure 1D). Overall, we found science majors self-assessed their science literacy more favourably (Good or Excellent) compared to nonscience majors (Science: 89%, Nonscience: 46%), and senior students self-assessed higher compared to junior students (Senior: 69%, Junior: 51%).

Figure 1

Self-Assessed Student Science Literacy from 1 "Terrible" to 5 "Excellent"



Note. A) Self-assessed science literacy increased from pre to post (P=0.0001) and B) from junior to senior students (P=0.0029). C) Pre nonscience students self-assessed significantly lower than post science (P=0.0009) and post nonscience (P=0.0013) students. D) Junior and senior, science and nonscience majors. Senior science students self-assessed significantly higher than junior nonscience (P<0.0001) and senior nonscience (P<0.0001) students. Solid black lines indicate median values. Bold numbers represent the mean values.

Interest in Science

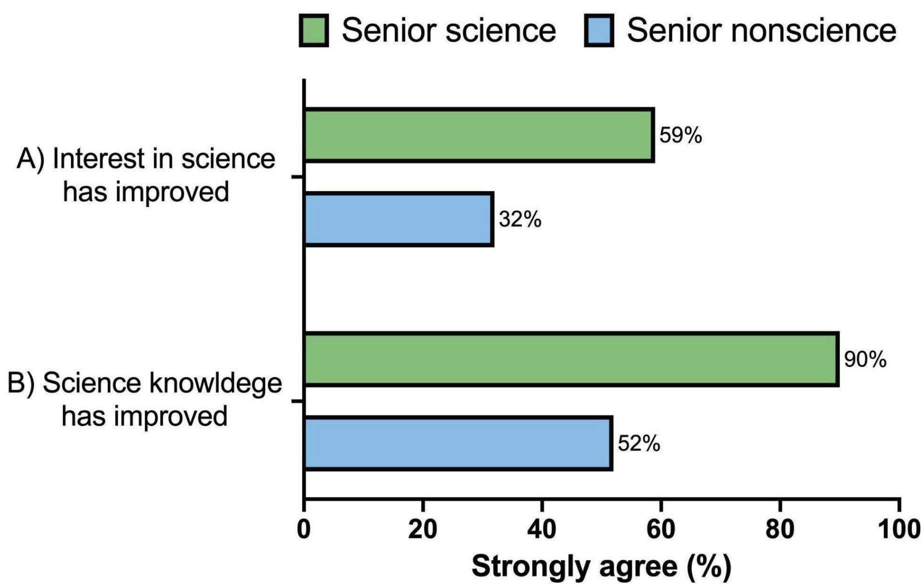
Overall interest in science was high, with 90% of students stating that they are "interested" or "extremely interested" in response to the question "How would you rate your interest in science and learning about scientific topics?" Responses were selected from a five-point scale, with 1 indicating "extremely uninterested" and 5 indicating "extremely interested." Figure 2 presents self-reported interest in science. No differences were found between pre and post, and junior and senior students (P>0.05). Pre and post science students self-reported more interest in

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

science than post nonscience students, and both junior and senior science students were significantly more interested in science than junior and senior nonscience students (P<0.05).

Figure 2

Percent of Senior Students Who Strongly Agree That Their Science Interest and Knowledge Have Improved During Their Degree



Note. Senior students were asked to choose from a five-point scale (1 “strongly disagree” to 5 "strongly agree”) in response to two statements: A) My interest in scientific topics and engagement with science (documentaries, news articles, podcasts, etc.) has increased during my time as a student at Mount Royal University. B) My knowledge about scientific topics and ability to think scientifically about issues in my everyday life have improved during my time as a student at Mount Royal University.

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Science Attitudes

Table 2 presents the percentage of students who strongly agreed with four statements about the importance of science and science research funding. Overall senior science students had the most favourable views. The question about the use of tax dollars to fund basic science research was viewed the least favourably overall. For all questions, favourability was lower at the beginning (pre) compared to the end (post) of a first-year science literacy course (pre > post), which was most pronounced in nonscience students. The largest discrepancy between science and nonscience majors was found on the citizenship question. The percent of science students who strongly agreed that "being scientifically literate is an important part of responsible citizenship" was higher in the post compared to pre, and senior compared to junior groups. In contrast, pre and junior nonscience students held more favourable views about the importance of scientific literacy to responsible citizenship compared to post and senior students.

Table 2

Percentage of Pre-Post and Junior-Senior, Science and Nonscience Majors Who Strongly Agreed, on Five-Point Scale (1 "Strongly Disagree" to 5 "Strongly Agree") With Four Statements About Their Attitudes About Science

	Citizenship	Politics	Taxes	Value
Pre → Post	56% → 48%	71% → 46%	24% → 10%	51% → 46%
Science Pre → Post	30% → 50%	70% → 63%	10% → 13%	70% → 50%
Nonscience Pre → Post	61% → 47%	71% → 41%	27% → 10%	47% → 45%
Junior → Senior	54% → 52%	57% → 59%	18% → 24%	52% → 62%
Science Junior → Senior	44% → 61%	68% → 65%	16% → 31%	60% → 71%
Nonscience Junior → Senior	57% → 45%	56% → 55%	18% → 19%	48% → 56%

Citizenship: Being scientifically literate is an important part of responsible citizenship.
Politics: It is important to know where political leaders stand on scientific issues.
Taxes: Tax dollars should be spent on funding scientific research even if there is no clear or immediate societal benefit.
Value: Being scientifically literate has personal and cultural value for non-scientists.

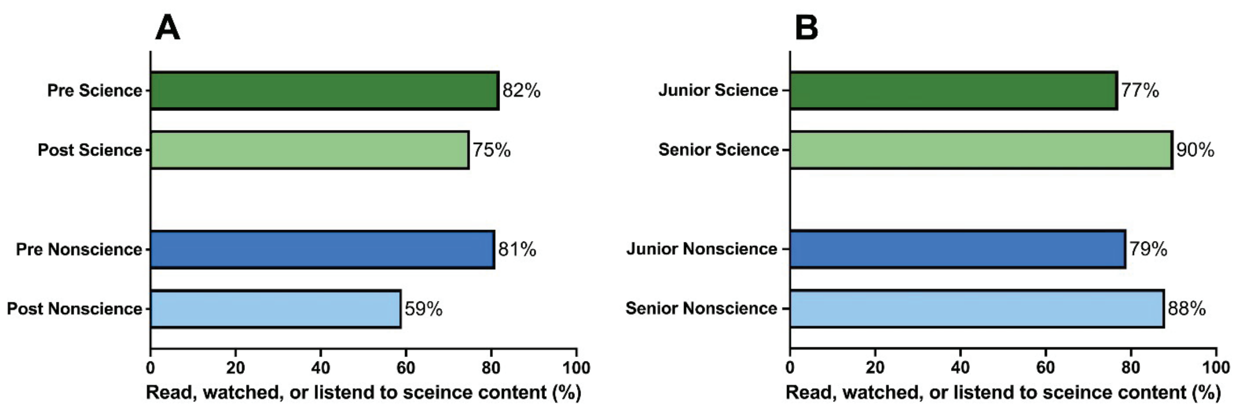
Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Science Engagement

Student engagement with science was assessed by the percentage of students who report reading, watching, or listening to something on a scientific topic in the last month unrelated to a course requirement (Figure 3, Table 3). Small decreases in engagement are seen pre to post, with small increases in engagement seen junior to senior (Table 3). Pre students had higher rates of engagement than post students while overall senior students had higher rates of engagement than junior students. No meaningful differences are seen between science and nonscience students. Overall fewer students were engaging with science content by listening (e.g., podcast, audiobook, radio programs) compared to reading or watching.

Figure 3

Percentage of Students Who Said That They Had Either Read, Watched, or Listened to Something on a Scientific Topic Outside of a Course Requirement in the Last Month



Note. A) Pre and post, science and nonscience students. B) Junior and senior, science and nonscience majors.

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Table 3

Percentage of Pre-Post and Junior-Senior Science and Nonscience Students Who Read, Watched, or Listened to Something Scientific in the Last Month Unrelated to Course Content

	Read	Watched	Listened
Pre → Post	58% → 56%	58% → 64%	23% → 22%
Science Pre → Post	64% → 56%	64% → 63%	27% → 13%
Nonscience Pre → Post	57% → 56%	57% → 65%	22% → 25%
Junior → Senior	55% → 79%	59% → 68%	24% → 26%
Science Junior → Senior	58% → 80%	58% → 70%	15% → 34%
Nonscience Junior → Senior	54% → 78%	60% → 65%	27% → 22%

Read: In the last month have you read a scientific book, article, or news story unrelated to a course you are taking?
Watched: In the last month have you watched a TV show or documentary on a scientific topic unrelated to a course you are taking?
Listened: In the last month have you listened to a podcast, audiobook, or radio program on a scientific topic unrelated to a course you are taking?

The interview sessions revealed that many interviewees were motivated to learn more about science topics covered in the GNED 1101 course outside of class time. The interview data suggests that the GNED 1101 course improved students' engagement, and we plan to further investigate the topics and classroom approaches that facilitated this motivation. Some statements mentioned by the interviewees about how GNED 1101 encouraged them to engage with science are presented in Table 4 below.

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Table 4

Student Interview Quotes About Their Engagement With Science Outside of the Classroom

Interviewee	Major	Year	Statement
Zara	Science	4	*"When I took that course, yeah, it did because it exposed me to like new areas of science that I'd never like seen before. So, for example, there's this one unit, it had to do with a bunch of like numbers and converting those numbers into a different set of numbers. I had never done that before and then after the course ended, I could see why it would be helpful in reading like different numbers and understanding like the ways numbers evolved. So, yeah, that did, like, it did help to learn more about."*
Mariam	Nonscience	1	*"The scientific research part of [GNED1101] with hypothesis and that I really paid attention to and searched to learn more about it."*
Bob	Nonscience	4	*"They were kind of surface level glances, and my family and I discussed things like that. We kind of have already gotten to the surface level of radiation."*

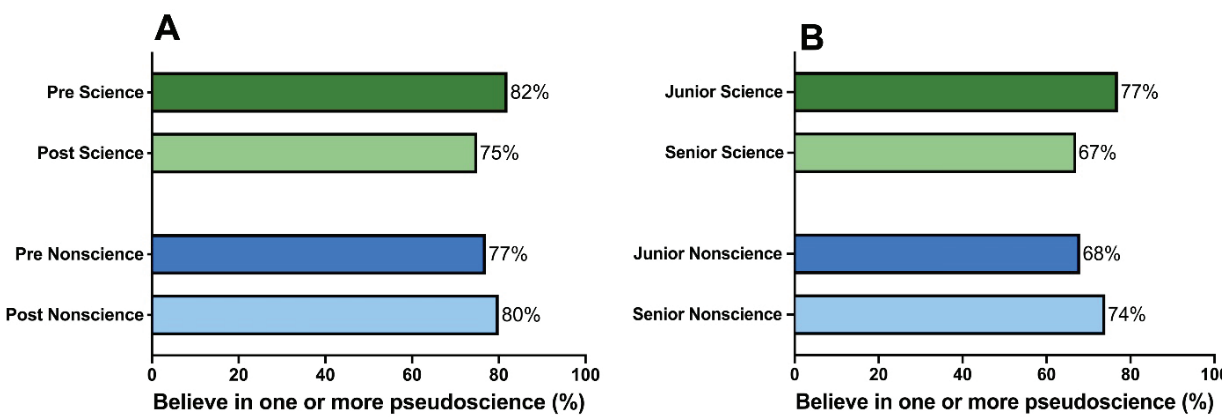
Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Pseudoscience Belief

Participants were asked if they believed in four different pseudosciences (astrology, numerology, psychic powers, and reflexology), and, as a follow-up question, they were asked how scientific they thought each of these topics are (not scientific, sort of scientific, very scientific, or not sure). The word pseudoscience did not appear on the questionnaire to avoid biasing responses. The percentage of participants who believed in at least one of the four pseudosciences is presented in Figure 4. Across all participant groups, the rates of belief in at least one of these four pseudosciences is over 50% and over 80% in pre students. Both science and nonscience students had higher rates of belief in pseudoscience at the beginning of GNED1101 compared to students at the end of the course. Senior science students had lower rates of belief in pseudoscience (67%) compared to junior science students (77%), but not lower than post nonscience students (59%). Of the four pseudosciences addressed, reflexology was the most likely to be believed with 56% of all participants saying they believed in reflexology and 65% agreeing that reflexology is "sort of" or "very scientific" (Table 5). Reflexology was also the least familiar, with 24% of participants indicating that they had never heard of reflexology before. In contrast, only 2 of 265 (0.8%) participants reported that they had never heard of astrology before, while fewer students reported believing in astrology (37%) compared to reflexology (56%).

Figure 4

Percentage of Students Who Believe in at Least one of Four Pseudosciences (Astrology, Numerology, Psychic Powers, Reflexology)



Note. A) Pre and post, science and nonscience students. B) Junior and senior, science and nonscience majors.

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Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Table 5

Percentage of Students Who Believe in Astrology, Numerology, Psychic Powers, and Reflexology, as well as the Percentage Who Think These Are Either Sort of Scientific or Very Scientific

	Astrology		Numerology		Psychic Powers		Reflexology	
	% Believe	% Scientific	% Believe	% Scientific	% Believe	% Scientific	% Believe	% Scientific
Pre Science	37%	45%	9%	36%	45%	18%	55%	45%
Post Science	38%	56%	13%	31%	31%	19%	63%	75%
Pre Nonscience	38%	42%	23%	25%	31%	19%	63%	67%
Post Nonscience	37%	47%	22%	30%	29%	22%	45%	63%
Junior Science	35%	46%	12%	35%	35%	15%	58%	62%
Senior Science	47%	49%	18%	27%	35%	10%	51%	59%
Junior Nonscience	34%	45%	22%	27%	29%	22%	53%	66%
Senior Nonscience	31%	45%	19%	23%	45%	30%	58%	67%

The interviewees justified their beliefs in different ways. Four broad categories emerged for both science and nonscience students that help explain their pseudoscience beliefs: *scientific terms, interest, personal experience,* and *authority.*

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Scientific Terms

The use of invented terms that sound “scientific” or real science terms applied incorrectly in pseudoscience are used to fool the audience, intentionally or unintentionally, into believing their ideas have scientific status. Some examples mentioned by the interviewees about why they believed in astrology are provided in Table 6.

Table 6

Student Interview Quotes About How the Use of Scientific Terms Inform Their Science Beliefs

Interviewee	**Major**	**Year**	**Statement**
Alice	Nonscience	2	*“I think that the way that they come up with this [astrology] because it has a lot to do with the planets and stuff. I think that has some true thing of science.”*
Ahmed	Nonscience	4	*“I feel like I think that just like more to Earth than like the Milky Way. So, I think that like just looking, learning about, you know, different planets or different universes around outside.”*
Rose	Science	1	*“I think that there has been a lot of research, especially with technology evolving with all of the, like, stuff in the space station and everything. Like people have a lot more understanding of planets and stars, and space, and all of that. So, it definitely is a scientific thing.”*

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Interests

Most interviewees who believed in astrology or reflexology mentioned personal interest as the main reason. Interview data about how personal interest impacted pseudoscience belief is presented in Table 7.

Table 7

Student Interview Quotes About How Personal Interests Inform Their Science Beliefs

Interviewee	Major	Year	Statement
Lili	Science	4	*"I very much, you know, alongside my very rational scientific brain, I also tend to really, like, just very strange phenomenon that I think are, you know, really interesting…. I know it might not be real, but the thing with, you know, astrology as well, where, you know, certain planets or orbits kind of manipulate people's emotions and thoughts are to me, that's really interesting."*
Jonas	Nonscience	5	*"[I have] interest in such things as well. You also don't find a lot of evidence or results from religion or astrology being done from hypothesis and different research studies or anything like that."*
Rose	Science	1	*"I probably am an interested participant in hearing about it [astrology]. But I would not think it is very scientific. And it follows more personal belief."*

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Personal Experience

Some interviewees claimed that they had personal experience of astrology and/or reflexology. Examples showing how personal experiences can affect students' beliefs in pseudoscience are provided in Table 8.

Table 8

Student Interview Quotes About How Personal Experience Informs Their Science Beliefs

Interviewee	**Major**	**Year**	**Statement**
Kate	Nonscience	4	*"Yeah, I love reflexology. It's like my very favourite thing… a long time ago I tried to quit smoking and I got acupuncture for that on those spots, and did it help me? Yeah, I'd say that there was something to it… I do think that there was something to that and reflexology, just how it makes me feel after I have it."*
Nina	Science	4	*"Just from like personal experience when I was very young, my dad had to get his appendix removed. So, none of, like, his family doctor or anyone, like, emergency knew what happened with him, or what was going on with him because he was in severe pain. But someone just like, based on I don't know I forget the details of the story but literally in like two seconds was able to figure this out. So it's more also from personal experience I guess."* *"I did a lot like I practiced it a lot, a lot of, like, my pressure points, like, on my hands or on my face typically. I don't know what the word is for that… the word like massage, I'll like pressure."*
Lili	Science	4	*"I probably am an interested participant in hearing about it [astrology]. But I would not think it is very scientific. And it falls, more personal belief."*

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

AUTHORITY

Students may believe something based on the authority of others. This could be something someone has told them and/or something they have observed. Believing things on authority usually means believing them because they have been told about them by someone they think trustworthy, or they have observed someone trustworthy believing in them, or they have found them in the resources they think are trustworthy. Some examples are provided in Table 9.

Table 9

Student Interview Quotes About How Authority Figures Inform Their Science Beliefs

Interviewee	Major	Year	Statement
Kate	Nonscience	4	*"And you know, my father-in-law was Hindu and loved astrology. He would consult astrologers, and he had a PhD, and it's like, okay, so this super great person with this high education and scientific mind consults an astrologer, you know, to find out what's going on with his family."*
Nina	Science	4	*"I'm subject to chronic migraines, and I don't like taking, you know, I take Tylenol, and I don't really want to take anything stronger than that. And my doctor suggested that I get Botox to numb the nerves. Well, I really don't want to do that and then, yeah, more of a holistic position. [My doctor] said, well, there are certain pressure points that actually help with migraines. And so, I tried it, and it was actually really beneficial. So, there's, you know, certain points here or on your hand. So, for me, more of a positive experience with reflexology.*
Rose	Science	1	*"My roommate is in medicine and we're like, we're both doing sciences, but it's so different. That's definitely more, like the medical side of sciences or I'm definitely in the environment side of sciences… It's just like the way that your muscles move react to things… Yeah, it's just like a medical thing. So, in my head it is a scientific thing, I guess, because people are testing it. Yeah, there's so many scientists so broad, like, thinking about it now."*

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Discussion

Key findings of this work revealed that students' self-assessed science literacy improved over a first-year science literacy course and undergraduate degree; however, student interest in learning science topics did not change over the course or students' degree programs. Students held generally favourable views about science; however, on average, students at the end of a first-year general education science literacy foundation course (post) held less favourable views about science compared to students at the beginning of the course (pre). This indicates that both interest in science and positive attitudes towards science did not improve when taking a first-year general education science literacy course. When senior students were asked about their science knowledge and interest over a four-year degree, senior science students were more likely to strongly agree that their interest in and knowledge about science increased compared to senior nonscience students. Regardless of program or level of study, students reported regularly engaging with science content outside of the classroom through reading or watching, and to a lesser extent listening. Despite high science engagement, pseudoscience belief was prevalent, with 75% of students believing in at least one of four pseudoscience examples given in the questionnaire. Interview data indicated that student belief in pseudoscience topics was driven by four primary reasons, which included i) the use of scientific terms, ii) their interest in the topics, iii) their personal experience with the topics, and iv) authority figures who motivated their beliefs. These findings indicate areas where undergraduate general education is advancing positive science views and engagement in undergraduate students, while also offering areas for concern, pedagogical improvement, and future research.

Science literacy is necessary for full participation in democratic and cultural discourse and to make informed personal and economic decisions that are so often influenced by scientific issues (Snow & Dibner, 2016). Liberal education curriculum strives to enhance undergraduate student science literacy across programs and levels of study. We found that students' self-reported science literacy increased over a single general education science literacy course. This finding aligns with Vandergrift et al. (2020), who report a similarly modest increase in self-reported science literacy over a general education science course. Vandergrift et al. also found a weak but significant correlation between students' self-reported science literacy and instructors' assessments of their students' science literacy as well as academic proficiency. These results suggest that students' perceptions of their own science literacy may align with other measures of science literacy; however, this has not been found in all cases. Cartwright et al. (2020) found that over the duration of a fourth-year science course, students' perceptions of their science literacy improved while practical science literacy scores decreased. These studies suggest that students' perceptions of their science literacy and competencies

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

may not be aligned in all cases, highlighting an area for further investigation. Comparing self-assessed science literacy to objective measures is beyond the scope of the current project but remains an interesting area for future research.

Despite increases in self-reported science literacy over a single course and four-year undergraduate degree, students' self-reported interest in learning about science did not change. Interest in science was generally high among most students and, therefore, this lack of difference between pre-post and junior-senior groups may be due to a ceiling effect, where measurable increases are not possible. Engagement in science activities outside of course requirements was also found to be high and likewise did not increase pre-post while increasing slightly over a four-year degree (junior to senior). It is possible that engagement was higher in the pre compared to post group due to different demands for students at the beginning compared to the end of the semester. In both the fall and winter semesters, students are coming off a break where they may have had more time and interest to engage with science content. In contrast, at the end of the semester, students are more likely to be busy with coursework and have less time and interest to engage with science outside of course requirements. When comparing junior to senior, however, it is notable that reading scientific content was 24% higher in senior compared to junior students. This highlights the importance of teaching science concepts that are interesting and relevant to students, to promote relevance and interest in science topics. Future work is needed to understand how students' perceptions of their own science literacy may influence their interest and confidence to engage with science concepts and vice versa.

Given the rapid pace of science advancement, science literacy education should strive to provide a modern, relevant view of science to general science students. Scientific issues of the day should be front and centre within an evolving science curriculum. These issues can have personal, democratic, economic, or cultural implications highlighting the range of value that science literacy has for individuals and broader society (Snow & Dibner, 2016). Science literacy education should balance foundational knowledge because you can't think critically about nothing (Anelli, 2011; Trefil, 2008) with practical scientific reasoning, skills, and competencies individuals can use to make scientifically informed decisions about their daily lives (Feinstein, 2010). The role of science education should not be to establish a balance of these components, but rather to provide access to the requisite scientific content for students to learn enough and the motivation to engage with science so that they can become confident, competent outsiders (Feinstein, 2010). Our data demonstrated generally high interest among undergraduate students in learning about science, which is unsurprisingly higher in science compared to nonscience majors. It is important that general education curriculum strives to engage nonscience majors, demonstrating the value that science literacy can have in their lives, and motivate students to continue to learn about science topics beyond the classroom.

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

One goal of science literacy education is to prepare citizens who are sympathetic to science (DeBoer, 2000; Snow & Dibner, 2016). This educational goal accepts that science has been a net good for humanity, despite its limitations and examples of misuse over time. In preparing a citizenry with positive views about science, scientific endeavours will continue to be supported and science expertise valued. We evaluated students' attitudes towards science by asking them how strongly they agreed with four statements about the importance of science and science research funding. Overall, we found senior students held slightly more favourable views than junior students, while positive attitudes were lower in all cases in the post compared to pre groups sampled from a general education science literacy course. This finding, that students held less favourable views about science at the end compared to the beginning of the course is surprising and concerning given that this course aims to increase students' understanding of and respect for science. It may be that, for a majority of students, the science topics were not presented as relevant to their daily lives and thus favourable attitudes towards science decreased.

Foundational science knowledge is an important dimension of science literacy (Anelli, 2011; Trefil, 2008). However, without demonstrating why content matters to students, they may develop less favourable views. Motivation to learn about science has been shown to correlate with the perceived relevance to career goals (Glynn et al., 2009). It is important that science instructors, especially in general education courses, recognize and utilize the extrinsic motivations of students. The relevance of science topics to students should be presented along with the core foundational concepts. These findings indicate that a four-year undergraduate general education may broadly increase the extent to which students perceive the value of science; however, these gains were not due to a specific science literacy course. Science students held more favourable views than nonscience students, highlighting the need to promote the value of science to nonscience majors in general education courses. Our work aligns with others who reject the deficit model of science communication, which supposes that exposure to science content is enough to increase public support and science literacy (Simis et al., 2016). To increase student and public support for science, it is important that instructors and communicators contextualize content, demonstrating relevance in ways that motivate students to learn.

One dimension of science literacy is the ability to use evidence-based reasoning in decision making. It is reasonable to believe that science education would improve an individual's ability to make scientifically based decisions in their everyday lives and to distinguish science from pseudoscience. This assumption is complicated by research that has shown that people tend to make meaning of science they encounter in their lives using culturally based narratives that often do not include science (Baram-Tsabari, 2022; Carrion, 2018). A 20-year survey conducted in the United States and completed in 2011 investigated undergraduate science literacy and found high rates of pseudoscience belief (Impey et al., 2011). Of the students surveyed, over 40% believed that the positions of the planets affect everyday life (e.g., astrology) and over 15% stated that aliens visited ancient human civilizations (Impey et al., 2011). These striking findings are replicated in the current study where we found 38% of undergraduates report believing in astrology and 75% of respondents believed in at least one for the four pseudosciences included in the questionnaire. Most striking in respect to these data is how many students believe that these pseudoscience topics are somewhat or very scientific. For example, 49% of senior science students thought astrology was scientific, 4% more than senior nonscience students. We believe science students are learning scientific language, prevalent in pseudoscience, without gaining the deeper scientific reasoning skills necessary to detect pseudoscientific claims. This explanation is supported by our interview data where science students frequently used scientific jargon to explain their pseudoscience beliefs. British physicist James Clerk Maxwell believed that "such indeed is the respect paid to science, that the most absurd opinions may become current, provided they are expressed in language, the sound of which recalls some well-known scientific phrase" (as cited in Davenport & Rosenthal, 2013, p.139). The Impey et al. (2011) survey found that pseudoscience belief rates did not correlate with level of science literacy, and we similarly did not find differences between science and nonscience majors. We did find pseudoscience belief rates to be lower at the end (post) compared to the beginning (pre) of a first- year general education science literacy course; however, on average, belief rates in senior students were found to be close to belief rates in junior students. These data suggest that a four-year degree, at our institution, which includes a general education component, is not protective against believing in pseudoscience, although short-lived gains over a single science literacy course may be present. We believe that the increased scientific vocabulary of science students may increase rather than decrease their belief in pseudoscience, which is supported by our findings. More work is needed to explore strategies that may improve pseudoscience awareness and scientific reasoning skills in our general education curriculum.

The concept of science literacy has been suggested to be more of a slogan to rally educators to support science instruction than a measurable education outcome (DeBoer, 2000). Given the pace of scientific and technological advancement and the relevance these concepts have for individual and democratic decision making, as well as cultural significance, we echo the rallying cry and encourage more effort to adapt and optimize science education for the modern world and the modern student. Our findings suggest that at our institution more work is needed to increase student interest in science among nonscience students and to engage in more classroom discussions about the value science brings to everyday life to enhance positive science attitudes. Exposure to scientific concepts is often not enough to increase student engagement or positive views about science. We found pseudoscience belief to be high among all students, and more focus is needed to provide students the competencies required to differentiate science from

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

pseudoscientific claims.

Understanding students'—especially nonscience students'—perceptions of their science literacy, their attitudes and engagement with science, and their pseudoscience beliefs is important in designing general education courses that aim to empower scientific thinking (Vandegrift et al., 2020). There is no single solution to enhance undergraduate student scientific literacy and reduce pseudoscience beliefs. Teaching critical thinking through approaches like the FLICC model is one approach science educators could try to protect against science denialism (Cook, 2020). The FLICC model presents five science denial techniques scientifically literate people should know: fake experts, logical fallacies, impossible expectations, cherry picking, and conspiracy theories. As the internet increases the spread of misinformation and conspiracy theories, it is vital that a scientifically literate public understands and can defend against these five techniques of denialism (Diethelm & McKee, 2009; Peters & Besley, 2020). Another approach to limit pseudoscientific belief is to pre-expose and reveal weak pseudoscientific arguments to students. Known as inoculation theory, pre-exposure has been shown to confer resistance to persuasion across different issues including scientific misinformation (Compton et al., 2021). It is important that instructors have the freedom to organize their general education science courses around science content that they feel comfortable with (DeBoer, 2000), while promoting a shared vision of science literacy that enhances student interest, confidence, and engagement. In addition to presenting foundational science content, science literacy curriculums should also strive to combat pseudoscience belief through techniques such as the FLICC model and inoculation theory. Undergraduate science courses are often the last formal science instruction students receive, and they play an important role in promoting science trust and support in the community.

Conflict of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

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References

Allum, N., Sturgis, P., Tabourazi, D., & Brunton-Smith, I. (2008). Science knowledge and attitudes across cultures: A meta-analysis. *Public Understanding of Science*, *17*(1), 35–54. https://doi.org/10.1177/0963662506070159

Anelli, C. (2011). Scientific literacy: What is it, are we teaching it, and does it matter? *American Entomologist*, *57*(4), 235–244. https://doi.org/10.1093/ae/57.4.235

Baram-Tsabari, A. (2022). The relevancy of science education to public engagement with science. In K. Korfiatis & M. Grace (Eds.), *Current research in biology education: Contributions from biology education research* (pp. 3–17). Springer. https://doi.org/10.1007/978-3-030-89480-1_1

Benjamin, T. E., Marks, B., Demetrikopoulos, M. K., Rose, J., Pollard, E., Thomas, A., & Muldrow, L. L. (2017). Development and validation of scientific literacy scale for college preparedness in STEM with freshmen from diverse institutions. *International Journal of Science and Mathematics Education*, *15*(4), 607–623. https://doi.org/10.1007/s10763-015-9710-x

Buehl, M. M., & Alexander, P. A. (2005). Motivation and performance differences in students' domain-specific epistemological belief profiles. *American Educational Research Journal*, *42*(4), 697–726. https://doi.org/10.3102/00028312042004697

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Carrion, M. L. (2018). "You need to do your research": Vaccines, contestable science, and maternal epistemology. *Public Understanding of Science*, *27*(3), 310–324. https://doi.org/10.1177/0963662517728024

Cartwright, N. M., Liddle, D. M., Arceneaux, B., Newton, G., & Monk, J. M. (2020). Assessing scientific literacy skill perceptions and practical capabilities in fourth-year undergraduate biological science students. *International Journal of Higher Education*, *9*(6), 64–76. https://doi.org/10.5430/ijhe.v9n6p64

Compton, J., Linden, S., Cook, J., & Basol, M. (2021). Inoculation theory in the post-truth era: Extant findings and new frontiers for contested science, misinformation, and conspiracy theories. *Social and Personality Psychology Compass*, *15*(6), 1–16. https://doi.org/10.1111/spc3.12602

Cook, J. (2020, March 31). *A history of FLICC: The 5 techniques of science denial*. https://skepticalscience.com/history-FLICC-5-techniques-science-denial.html

Corbin, J., & Strauss, A. (2008). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (3rd ed.). SAGE Publishing. https://doi.org/10.4135/9781452230153

Davenport, W. H., & Rosenthal, D. (Eds.). (2013). *Engineering: Its role and function in human society*. Elsevier.

DeBoer, G. E. (2000). Science literacy historical and contemporary meanings. *Journal of Research in Science Teaching*, *37*(6), 582–601. https://doi.org/10.1002/1098-2736(200008)37:6<582::AID-TEA5>3.0.CO;2-L

Diethelm, P., & McKee, M. (2009). Denialism: What is it and how should scientists respond? *European Journal of Public Health*, *19*(1), 2–4. https://doi.org/10.1093/eurpub/ckn139

Ding, L., Wei, X., & Mollohan, K. (2016). Does higher education improve student scientific reasoning skills? *International Journal of Science and Mathematics Education*, *14*(4), 619–634. https://doi.org/10.1007/s10763-014-9597-y

Feinstein, N. (2010). Salvaging science literacy. *Science Education*, *95*(1), 168–185. https://doi.org/10.1002/sce.20414

Glynn, S. M., Taasoobshirazi, G. & Brickman, P. (2007). Nonscience majors learning science: A theoretical model of motivation. *Journal of Research in Science Teaching*, *44*(8), 1088–1107. https://doi.org/10.1002/tea.20181

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching*, *46*(2), 127–146. https://doi.org/10.1002/tea.20267

Gormally, C., Brickman, P., & Lutz, M. (2012). Developing a Test of Scientific Literacy Skills (TOSLS): Measuring undergraduates' evaluation of scientific information and arguments. *CBE-Life Sciences Education*, *11*(4), 364–377. https://doi.org/10.1187/cbe.12-03-0026

Holbrook, J., & Rannikmae, M. (2009). The meaning of scientific literacy. *International Journal of Environmental & Science Education*, *7*(3), 275–288.

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Holden, I. I. (2012). Predictors of students' attitudes toward science literacy. *Communications for Information Literacy*, *6*(1), 107–123. https://doi.org/10.15760/comminfolit.2012.6.1.121

Impey, C., Buxner, S., Antonellis, J., Johnson, E., & King, C. (2011). A twenty-year survey of science literacy among college undergraduates. *Journal of College Science Teaching*, *40*(4), 31–37.

Lederman, N. G., & Lederman, J. S. (2019). Teaching and learning nature of scientific knowledge: Is it déjà vu all over again? *Disciplinary and Interdisciplinary Science Education Research*, *1*(6), 1–9. https://doi.org/10.1186/s43031-019-0002-0

Levine, D. L. (2018, July 19). *Science Denialism in the 21st Century*. https://blogs.scientificamerican.com/observations/science-denialism-in-the-21st-century/

Lewandowsky, S., Ecker, U. K. H., & Cook, J. (2017). Beyond misinformation: Understanding and coping with the "post-truth" era. *Journal of Applied Research in Memory and Cognition*, *6*(4), 353–369. https://doi.org/10.1016/j.jarmac.2017.07.008

Meinwald, J., & Hildebrand, J. G. (2010). Science and the educated American: A core component of liberal education. *American Academy of Arts and Sciences*. https://www.amacad.org/publication/science-american-liberal-education

Miller, J. D. (1998). The measurement of civic scientific literacy. *Public Understanding of Science*, *7*(3), 203–223. https://doi.org/10.1088/0963-6625/7/3/001

Packer, M. (2010). *The science of qualitative research*. Cambridge University Press.

Peters, M. A., & Besley, T. (2020). Education and the new Dark Ages? Conspiracy, social media and science denial. *ACCESS: Contemporary Issues in Education*, *40*(1), 5–14. https://doi.org/10.46786/ac20.3082

Scientific misinformation: A perfect storm, missteps, and moving forward. (2021). *Cell*, *184*(6), 1402–1406. https://doi.org/10.1016/j.cell.2021.02.025

Simis, M. J., Madden, H., Cacciatore, M. A., & Yeo, S. K. (2016). The lure of rationality: Why does the deficit model persist in science communication? *Public Understanding of Science*, *25*(4), 400–414. https://doi.org/10.1177/0963662516629749

Snow, C. E., & Dibner, K. A. (2016). *Science literacy: Concepts, contexts, and consequences*. The National Academies Press. https://doi.org/10.17226/23595

Trefil, J. (2008). *Why Science?* Teachers College Press.

Udo, M. K., Ramsey, G. P., & Mallow, J. V. (2004). Science anxiety and gender in students taking general education science courses. *Journal of Science Education and Technology*, *13*(4), 435–446. https://doi.org/10.1007/s10956-004-1465-z

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Vandegrift, E. V. H., Beghetto, R. A., Eisen, J. S., O'Day, P. M., Raymer, M. G., & Barber, N. C. (2020). Defining science literacy in general education courses for undergraduate non-science majors. *Journal of the Scholarship of Teaching and Learning*, *20*(2), 15–30. https://doi.org/10.14434/josotl.v20i2.25640

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Appendix

Questionnaire

Questions included in the present study

Personal Characteristics

Question	Response Options
How would you rate your level of science literacy at the current time?	• Excellent • Good • Fine • Poor • Terrible
Which of the following best represents your program?	*List of all programs as well as open response option*
Which best describes your current year of study at MRU?	• First year • Second year • Third year • Fourth year • Fifth year • Sixth year or higher

Attitudes and Engagement

Question	Response Options
Being scientifically literate is an important part of responsible citizenship.	• Strongly agree • Somewhat agree • Neither agree nor disagree • Somewhat disagree • Strongly disagree
It is important to know where political leaders stand on scientific issues.	• Strongly agree • Somewhat agree • Neither agree nor disagree • Somewhat disagree • Strongly disagree
Tax dollars should be spent on funding scientific research even if there is no clear or immediate societal benefit.	• Strongly agree • Somewhat agree • Neither agree nor disagree • Somewhat disagree • Strongly disagree

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Being scientifically literate has personal and cultural value for non-scientists.	• Strongly agree • Somewhat agree • Neither agree nor disagree • Somewhat disagree • Strongly disagree
How would you rate your interest in science, and learning about scientific topics?	• Extremely interested • Somewhat interested • Neither interested nor uninterested • Somewhat uninterested • Extremely uninterested
In the last month have you **read** a scientific book, article, or news story unrelated to a course you are taking?	• Yes • No
In the last month have you **watched** a TV show or documentary on a scientific topic unrelated to a course you are taking?	• Yes • No
In the last month have you **listened** to a podcast, audiobook, or radio program on a scientific topic unrelated to a course you are taking?	• Yes • No

Science (*Pseudoscience*) Beliefs

Question	Response Options
Part A: Do you believe in **astrology**, that the study of the movements and positions of celestial bodies can be interpreted to have an influence on human affairs and the natural world? Part B: Would you say **astrology** is very scientific, sort of scientific, not at all scientific, or you are not sure?	• Yes • No • I've never heard of astrology • Very scientific • Sort of Scientific • Not at all scientific • Not sure
Part A: Do you believe in **numerology**, that events in one's life can be interpreted and better understood by studying the meaning and relationships between numbers? Examples include life path numbers, numerological forecasts, and personality numbers among others.	• Yes • No • I've never heard of numerology

Imagining SoTL, Volume 3(2) (2023)
ISSN 2563-8289

Part B: Would you say **numerology** is very scientific, sort of scientific, not at all scientific, or you are not sure?	• Very scientific • Sort of Scientific • Not at all scientific • Not sure
Part A: Do you believe some people possess **psychic powers**, that they can perceive information hidden from normal sense or can use their mind to influence the world physically? Examples include clairvoyance, telepathy, psychic readings, and dowsing among others.	• Yes • No • I've never heard of psychic powers
Part B: Would you say **psychic powers** are very scientific, sort of scientific, not at all scientific, or you are not sure?	• Very scientific • Sort of Scientific • Not at all scientific • Not sure
Part A: Do you believe in the premise of **reflexology** (or zone therapy), a type of massage that applies pressure to the feet, hands, and ears to treat ailments in connected organs and body systems?	• Yes • No • I've never heard of reflexology
Part B: Would you say **reflexology** is very scientific, sort of scientific, not at all scientific, or you are not sure?	• Very scientific • Sort of Scientific • Not at all scientific • Not sure

Senior Student Questions

Question	**Response Options**
How strongly do you agree with the following statement: *My knowledge about scientific topics and ability to think scientifically about issues in my everyday life have improved during my time as a student at Mount Royal University.*	• Strong agree • Somewhat agree • Neither agree nor disagree • Somewhat disagree • Strongly disagree
How strongly do you agree with the following statement: *My interest in scientific topics, and engagement with science (documentaries, news articles, podcasts etc.) has increased during my time as a student at Mount Royal University.*	• Strong agree • Somewhat agree • Neither agree nor disagree • Somewhat disagree • Strongly disagree