JMLE JOURNAL OF MEDIA LITERACY EDUCATION

*Journal of Media Literacy Education,* 13(1), 1-13, 2021
https://doi.org/10.23860/JMLE-2021-13-1-1
ISSN: 2167-8715

# *Exploring adolescents' critical thinking aptitudes when reading about science in the news*

OPEN ACCESS

**Peer-reviewed article**

**Citation:** Bissonnette, M., Chastenay, P., & Francoeur, C. (2021). Exploring adolescents' critical thinking aptitudes when reading about science in the news. *Journal of Media Literacy Education, 13*(1), 1-13. https://doi.org/10.23860/JMLE-2021-13-1-1

**Corresponding Author**:
Marianne Bissonnette
bissonnette.marianne@uqam.ca



**Received:** March 3, 2020
**Accepted:** May 20, 2020
**Published:** May 24, 2021

**Data Availability Statement**: All relevant data are within the paper and its Supporting Information files.

**Disclosure statement**: The authors declare that they have no relevant material or financial interests that relate to the research described in this paper. Informed consent was obtained from all participants included in the study.

**Editorial Board**

Marianne Bissonnette

*Université du Québec à Montréal, Canada*

Pierre Chastenay

*Université du Québec à Montréal, Canada*

Chantal Francoeur

*Université du Québec à Montréal, Canada*

## ABSTRACT

This research studies the critical thinking skills of six teenagers in their final years of high school. It looks at the way those students use a set of cognitive skills in order to analyze scientific and pseudoscientific information available in online news articles. Semi-structured interviews were conducted with six students chosen according to their results in a questionnaire about interest in science topics. Results show a large gap between participants' use of critical thinking skills. Most of these skills were mainly used for text comprehension, evoking general knowledge, numeracy, arguments assessment and production, and life skills (open-mindedness and metacognition). The participants were often confused when they were asked to justify their stances, and when they had to compare arguments' value. This exploratory study could lead to a better understanding of teenagers' strengths and weaknesses in news media literacy, and the part that schools could play in helping students develop them.

**Keywords:** *media literacy, critical thinking, adolescents, science news, pseudoscience*.

## INTRODUCTION

Science is an information domain that can be difficult to work with, causing it to be regularly mistreated by news media. Oxman et al. (1993) reported four frequent errors in media science: false information transmission, the tendency to grant importance to minor discoveries, the tendency to aggravate dangers and the tendency to give credit to uncertain news. Media can also create misunderstandings because of their tendency to show multiple views of a story, in the name of balance, even if some of those views are irrelevant (Lewandowsky et al., 2012). Moreover, since the Internet has revolutionized the access to information, those multiple views are now available to everyone through blogs and other alternative news sources. People rely more and more on online news media when they want science information, especially regarding health-related issues (Lewandowsky et al., 2012). However, even though young people are closer to media than previous generations, they don't necessarily appear to be more critical towards the information they encounter, especially when it comes to science and technology (Gutiérrez-Martín & Tyner, 2012). The readers also seem to have difficulties finding good scientific information and asking adequate questions (Delagrave, 2008; Korpan et al., 1997).

Nowadays, science misinformation, such as pseudoscience, is found in every corner of the Internet, making self-education for decision-making unreliable at best, even dangerous in some cases. Although sometimes hard to distinguish from science, pseudoscience is disconnected from reality and not directly focused on science's quest for truth (Pigliucci & Boudry, 2013), which can cause disastrous consequences regarding citizens' health, security, and wellbeing (Maier et al., 2014). It has also been observed that a significant part of the population believes in paranormal (religious or not) phenomena and pseudoscience (National Science Board, 2018). For example, about half of science majors at the University of Arizona believed astrology to be at least 'sort of' scientific (Sugarman et al., 2011), and at least 25% of the public still believe that vaccines cause autism years after the article claiming such was retracted (Lewandowsky et al., 2012).

Between the vast amount of pseudoscience and other scientific fake news, and the increasing complexity of socioscientific issues, being science literate thus becomes both arduous and necessary at the same time. Besides, even if the precise definition of science literacy is still disputed, there is a general consensus in the scientific community that one of its fundamental characteristics is the ability to engage critically with science in the news (McClune & Jarman, 2012).

Since adequate media literacy can foster better science literacy (Maier et al., 2014), many countries all around the world included some news literacy content to their curricula, in order to encourage students to become "confident, connected, lifelong learners," (New Zealand Ministry of Education, 2007, p. 8). Media and science literacy also have a strong connection to democracy and civic responsibilities (Gingras, 2003), and many (Gutiérrez-Martín & Tyner, 2012; Maier et al., 2014) believe that school should provide adequate support on this matter. It is also important for students to understand that media have a role to play in the construction of social fabric, including socio-scientific issues, which can have huge impacts on norms and beliefs (Laramée, 1998). For the majority of adults, news media are the primary source of information about socio-scientific issues (McClune & Jarman, 2012) and learning to use critical thinking skills during compulsory school can help recognize incorrect beliefs or flawed reasoning, which is fundamental to both science and news media literacies (Guilbert et al., 1999; McClune & Jarman, 2012).

### Critical thinking

Critical thinking (CT), defined as a "reasonable, reflective thinking that is focused on deciding what to believe or do," (Ennis, 2015, p. 32), is an important component of media literacy. According to Ennis, CT is closely linked to the ability and the will to make reasonable decisions, which is also an aim pursued by media literacy education. Over the years, many experts suggested alternative definitions or proposed other criteria for CT, like metacognition (Paul, et al., 1993), the assessment of an information's value and reliability (Fisher & Scriven, 1997), and the will to find the *truth* (Fisher, 2001). CT is also seen as a higher level of thinking similar to creative thinking, problem solving, decision making, or the upper stages of Bloom's (1956) taxonomy of educational objectives (analysis, synthesis, evaluation). Recently, critical thinking has been more and more seen as a composite of dispositions (attitudes) and skills (abilities) (Davies & Barnett, 2015). Dispositions are 'habits of the mind' or 'affective states' that are needed to perform good critical thinking. As for skills, they are competences that can be of a lower or higher level of thinking and can be in relation to self, to

others, or to the world. Ennis (2015, p. 32-33) listed 12 dispositions and 18 skills of the critical thinker, which we will use in our methodology (see Table 2).

Critical thinking is closely linked to numerous fundamental thinking skills, both in various work fields and in daily life, like decision making and metacognition. Decision making and critical thinking are so interdependent that some experts view decision making as the ultimate goal of critical thinking (Ennis, 2015). Indeed many critical thinking appraisal tools, including the famous Watson-Glaser critical thinking appraisal (Watson & Glaser, 1964), also assess decision-making. Critical thinking is also intertwined with metacognition, since one needs to reflect on their own thinking to be fairly critical and also needs to be critical towards oneself to achieve metacognition (Ennis, 2015).

Critical thinking can be influenced by many factors. First, cultural background, especially the language, appears to be related to critical thinking performance (Manalo & Sheppard, 2016). It seems that people tend to demonstrate fewer critical thinking skills when using a second language. That could be explained by a cognitive overload caused by the working memory being already busy with the difficult task of interacting with a language that is not fully mastered. In the classroom, many teaching strategies linked to language acquisition can influence the development of critical thinking, such as group discussion, concept mapping and analytical questioning (Wang & Seepho, 2017).

Teaching for critical thinking can, however, be very challenging and many complications can occur. For example, low achieving students can rapidly be overwhelmed and feel excluded. Moreover, very little help and instruction can be found to assist high school teachers who want to include critical thinking in their class (Marin & Halpern, 2011). This leads to a particularly poor level of critical thinking in youth. In a 2006 report by a consortium of US organizations, 92.1% of the employers surveyed considered colleges students "as being 'deficient' in critical thinking," (Davies & Barnett, 2015, p. 4).

### Research problem

There are as many ways to assess critical thinking as there are ways to define it. Some tests assess dispositional aspects of critical thinking, while other focus on quantifying cognitive skills (Ku, 2009). Few studies have investigated how teenagers use critical thinking from a skills-plus-dispositions point of view; we think that assessing both aspects could help us understand whether or not the media education provided in school is fruitful and, if not, which skills need improvement.

This leads to our research question: how do teenagers use critical thinking skills and dispositions when they are exposed to science-based and pseudoscience-based news media texts covering the same scientific issue?

## CONTEXT OF THE CURRENT STUDY

Media literacy education was included in Québec's curricula for elementary and high schools during the last school reform (early 2000s). This introduction has been made in both learning competences and *generic skills acquisition* (Ministère de l'Éducation, du Loisir et du Sport du Québec, 2017). Furthermore 'media literacy' was selected as one of the five broad areas of learning, with the explicit aim of encouraging students to "exercise critical, ethical and aesthetic judgment with respect to the media," (Ministère de l'Éducation, du Loisir et du Sport du Québec, 2017, p. 27). However, very few studies have investigated the implementation of teaching interventions based on these objectives and the few studies that did essentially exposed (1) teachers' difficulties in integrating media literacy in classes, (2) the heaviness of the task, and (3) the lack of time, funding, and specific training available to teachers (Landry & Basque, 2015). Furthermore, studies that have explored the acquisition of media literacy skills by Québec students since the implementation of the new curricula are exceptionally rare. Thus, it is safe to say that we don't really know what is actually going on in the classrooms regarding news media literacy and critical thinking. As for science literacy, researchers are witnessing an ongoing decrease in the interest shown by high school students towards science (Potvin & Hasni, 2014a). Interest is known to be closely tied to students' understanding of what science is, along with their willingness to engage with science-related issues (Rahm, et al., 2019), which is precisely what science literacy is all about.

The present research was conducted in a high school in the Greater Montreal Area with teenagers in their two final years of high school (15-17 years old). This age bracket was chosen because, in Québec, it corresponds to the last two years of compulsory schooling. Indeed, according to the 2006 Québec census (Institut de la statistique du Québec, 2006), approximately half of high school students will not attend post-secondary education. Therefore, it is compulsory school's last

chance to help these students develop critical thinking. The recruitment was completed with the help of three math teachers who distributed the consent form to their students.

## METHODS

A total of 74 students, aged 15 to 17 years old and enrolled in Year 4 and 5 of high school, agreed to participate in the first part of the study, in which they were asked to complete a 21-item questionnaire. Questions 1-4 were for identification purposes; the questions 5-21 were taken from the Chaire de recherche sur l'intérêt des jeunes à l'égard des sciences et de la technologie (CRIJEST) General Questionnaire (Potvin & Hasni, 2014b).

The questions assessed three main constructs related to interest about science and technology (S&T): school science interest (Questions 17 to 21, Cronbach's $\alpha$ = .87), self-concept (Questions 5 to 10, Cronbach's $\alpha$ = .78), and perceived importance of S&T (Questions 11 to 16, Cronbach's $\alpha$ = .80). Since these three constructs are intrinsically correlated to interest about S&T (Potvin & Hasni, 2014b), they were considered as one single construct (total Cronbach's $\alpha$ = .90).

Of all the students who answered the survey, 57 accepted to participate in a follow-up interview. After ranking these 57 participants from lowest to highest interest, five were chosen at regular positions on that scale (lowest and highest, then one at each quartile). Two more participants were selected for their odd results (the first with high self-concept and low interest; the second with high importance, and low interest). The former decided to withdraw from the study, which lead to a final number of six participants (Table 1). The questionnaire's purpose was for participants selection only, in order to obtain data about students with different levels of interest towards school science.

Table 1. *Information about the interview participants*

| **Participants** (fictitious name) | **Gender** | **School level** | **Age** | **Mean result of the interest and self-concept questionnaire** (min 1; max 6) |
|---|---|---|---|---|
| Caroline | F | Secondary 5 | 17 | 2,3 |
| Sophie | F | Secondary 5 | 17 | 3,3 |
| Florence | F | Secondary 5 | 16 | 4,4 |
| Jacob | M | Secondary 4 | 16 | 4,9 |
| Juliette | F | Secondary 5 | 16 | 5,8 |
| Raphael | M | Secondary 5 | 17 | 3,5 (odd result) |

During the interviews, two short journalistic texts about electromagnetic (EM) waves and cell phones, picked from online news media (a blog and a Canadian traditional media) were presented to the six participants. The first text was pseudoscience-based and promoted a fearful and negative opinion towards wave-emitting technologies like radio and cell phones. The second text was science-based and presented a nuanced, fact-checked opinion about the different types of EM waves and their risks. The pseudoscientific article was written by André Fauteux, a blogger, and titled '*La mort sans fil*'[1] (Fauteux, 2006). It was published in the blog section of an organization called '*Conseil Régional Environnement Montréal*'. The scientific article was written by Ève Christian, a meteorologist and scientific columnist at CBC/Radio-Canada[2]. It was entitled '*Peut-on dormir en sécurité près de notre cellulaire*?'[3] (Christian, 2016). The texts were selected with the help of two Québec experts in scientific journalism (Ève Beaudin and Olivier Bernard) and a physics professor at Polytechnique Montréal (Thomas Gervais).

The interviews happened during students' lunch break and began with an introduction, during which participants received explanations about the task and

[1] The wireless death (free translation). Retrieved from http://cremtl.qc.ca/publication/entrevues/2006/mort-sans-fil-par-andre-fauteux-editeur-revue-maison-21e-siecle

[2] Canadian Broadcasting Corporation or Radio-Canada is the Canadian national public broadcaster.

[3] Can we safely sleep next to our cell phone? (free translation) Retrieved from https://ici.radio-canada.ca/nouvelle/774596/dormir-cellulaire-lit-oreiller-danger-sante

were informed of their right to quit the interview at any time and that their identity would be anonymized. Participants were first asked to read both texts with the think-aloud protocol, a data collection method where participants are asked to say whatever comes to their mind while performing a task (Falardeau et al., 2014). They were encouraged to speak openly about every thought the texts brought up and to ask questions if they needed clarification. Some participants needed a few reminders during the reading process in order to continue verbalizing their thinking.

A semi-structured interview based on Ennis' critical thinking skills and dispositions (Ennis, 2015; see Table 2) followed the think-aloud protocol. Each interview lasted between 30 and 45 minutes and was recorded with the permission of the participants (audio only). Transcripts were then analyzed thematically according to our interview grid, which was also based on Ennis' critical thinking skills and dispositions. The elements that emerged from analysis of the data are exposed in the following results section.

Table 2. *Themes that emerged from the data in relation with Ennis' (2015) critical thinking skills (S) and dispositions (D).*

| **Themes** | **Skills and dispositions** |
|---|---|
| Big picture | - Take into account the total situation (D5);<br>- Keep in mind the basic concern in the context (D6);<br>- Try to 'get it right' to the extent possible or feasible (D11);<br>- Have a focus and pursue it (S1). |
| Precision | - Seek as much precision as the situation requires (D10);<br>- Ask and answer clarification questions (S3). |
| Sources credibility | - Use credible sources and observations, and usually mention them (D4);<br>- Judge the credibility of a source (S5). |
| Background knowledge | - Try to be well informed (D3);<br>- Use their background knowledge, knowledge of the situation, and previously established conclusions (S7). |
| Mathematics and logic | - Understand and use graphs and maths (S4);<br>- Deal with things in an orderly manner (S17). |
| Rhetoric and argumentation | - Analyze argument (S2);<br>- Deduce, and judge deductions (S8);<br>- Make, and judge, inductive inferences and arguments (both enumerative induction and best-explanation reasoning) (S9);<br>- Make, and judge, value judgments (S10);<br>- Attribute and judge unstated assumptions (S13)<br>- Deal with fallacy labels (S15);<br>- Deal with rhetorical strategies (S18). |
| Comprehension and expression | - Seek and offer clear statements of the thesis or question (D1);<br>- Seek and offer clear reasons (D2).<br>- Define terms, and judge definitions (S11);<br>- Handle equivocation appropriately (S12). |
| Open-mindedness | - Be alert for alternatives (D7);<br>- Be open-minded (D8);<br>- Take a position and change a position when the evidence and reasons are sufficient (D9). |
| Metacognition | - Think suppositionally (S14);<br>- Be aware of and check the quality of their own thinking (metacognition) (S16). |

## RESULTS

The results brought to light by the analysis were sorted thematically so as to highlight the critical thinking skills or dispositions used or displayed by the participants (who were given fictious names). The results will be presented thematically. Table 2 shows the relationship between the skills and dispositions and the themes.

### Seeing both the big picture and the details

The *big picture* (D5, D6, D11, S1) theme was mainly about their understanding of the main ideas and issues presented in the articles. After reading the texts, half of our participants were able to affirm that the main theme connecting articles was EM waves. Another student suggested Alzheimer's disease as the main topic, which was only mentioned in the first paragraph of Fauteux's article. The two last participants, Jacob and Sophie, failed to provide an answer. All participants perceived a difference between the authors' opinions. Another student, Florence, while clearly stating that the authors' opinions diverged, thought that they were not incompatible. Three students, including the latter, also proposed the idea that Christian's science-based article was an attempt to minimize popular beliefs or to appease irrational fears.

About the *precision* (D10, S3) theme, only Sophie and Juliette asked clarification questions during the think-aloud protocols. Students were, however, unanimous about their interest in learning more by searching information on the Internet, but the object of their interest varied. Some wanted to get a better understanding of EM waves, another wished to find solutions to the problems related to wave-emitting technologies. One participant, Jacob, even wanted to see what people in general thought of that issue to help him build his opinion. Providing precise arguments seemed to be difficult to most participants. Half of them generally provided quick judgements at first. The two students who were the most spontaneously precise in their answers (Florence and Sophie) were also those who appeared to be the most comfortable with the think-aloud protocol.

### Students' understanding of statistics

The statistics presented in the media articles clearly sparked interest in the participants and were the main topic of the *mathematics and logic* (S4, S17) theme. Jacob and Juliette said the statistics were easy to understand and that everyone could figure out what they meant in the context. Caroline admitted that she found them confusing and hard to visualize. Two others, Florence and Sophie, had a more nuanced opinion, saying that some numbers were hard to comprehend, but that the majority of them were accessible to people their age or older. The last participant, Raphael, stated that there were more of them in Fauteux's pseudoscientific article and that it made it easier to ascertain the veracity of the author's claims. Florence had the opposite view on the matter and thought that the pseudoscientific article presented too many numbers and not enough explanations, making her more sceptical of the text's trustworthiness. She thought it was useless to flaunt so many numbers if they do not clarify or complement the information.

Jacob, who thought the statistics were easy to understand, and Florence, being more nuanced, asserted that many of the numbers seemed exaggerated, but the former was unable to explain why he had such a strong reaction and could not mention any sources that lead him to think that way. Raphael, the participant who was enthusiastic about the high presence of statistics in Fauteux's pseudoscientific text, changed his opinion slightly when he saw that some of these statistics were more than 10 years old. That observation lessened his appreciation for the text since, he said, "statistics have an expiration date".

Although only one student acknowledged her misunderstanding of statistics, it appears that some numbers were not well interpreted by the participants. The following sentence of Fauteux's text confused a few of them: "the authors noticed that mortality due to Alzheimer's disease increased by 106% between 1997 and 2002 in less populated areas and by 71% in high density regions". Some students had trouble imagining how something could increase by more that 100%. One of them even took it as a figure of speech intended to depict a very important increase.

The participants also shared their thoughts about their perceived importance of statistics in media in general. They were unanimous in saying how "statistics give meat to an argument," how it "helps convince the opposition". Some teenagers were less convinced than others and thought that "too many was as bad as not enough," since it could become "confusing" or "repetitive and boring". The "transparency" of statistics in journalistic texts seemed to concern Raphael, who was particularly loquacious on the way some authors tend to "choose the facts and numbers that will impress

or shock the readers, sometimes leading to show only one side of a story".

**Students' perception of the quality of a news article**

The *sources credibility* (D4, S5) theme showed great variations between what the participants described as a good article. What made a source reliable seemed unclear for most of them. But the majority nevertheless admitted that Ève Christian's science-based text appeared to be more trustworthy than André Fauteux's. Some said that Radio-Canada was a renowned media outlet and that they 'tend to trust sources they already know'. A few, on the other hand, did not really know CBC/Radio-Canada and thought the other source was more reliable.

The sources used by the authors and the way they were presented was also discussed by three of the students. Florence and Caroline appreciated the fact that Eve Christian asked an expert and that she mentioned her sources directly after the related information. Raphael, however, believed that the expert was not 'a good enough source', but had trouble explaining why.

Some criteria were widely shared like "a clear and interesting title," "classical aesthetics for the fonts and the colours," "the extensive use of statistics to support the author's claims" and "the year the text was written".

The main source of information that was used to justify their stances was personal experiences.

> When I entered secondary school, I had to begin to wear glasses and I think it is because I used my cell phone too much. (Sophie)

> My grandmother watches TV a lot and she believes everything she sees. Maybe older people are more at risk to believe everything they hear. (Jacob)

> They say radio antennas can cause pressure on the hands and skin cancer. It is weird because I have never encountered those symptoms when I was close to an antenna. (Raphael)

The previous statements show that the participants tend to corroborate their opinion with events that did or did not occur in their life. Personal experiences were also the first type of *background knowledge* (D3, S7) used by half of the students. Jacob and Sophie justified their initial mistrust towards cell phones with such knowledge, saying that 'their friend's phone overheated in their bed' or that 'they began to forget things when they got a phone'. The third one, Raphael, rather thought that if what he read in the texts never happened to him then it must somehow be false.

Among the four participants who used concepts or information learned in their science classes during the interview, only one, Florence, made her final opinion based on what she had learned in school about the electromagnetic spectrum. The other three mentioned their science class as the reason why they did not have problems understanding the articles. Television and YouTube were also frequently cited as sources of information. Unlike the others, Juliette said that her interest was triggered more by the pseudoscientific text, since she thought that we rarely hear such information in the media.

**Students' reading comprehension and verbal expression**

While analysing interview results under the *comprehension and expression* (D1, D2, S11, S12) theme, it appeared rather quickly that some students' understanding of the texts was limited by their level of reading comprehension. If they had no problem with the act of reading itself, they however found that some sentences of Fauteux's text were "too long" or that they contained "too many complicated scientific words", and "too few details to properly understand them". Surprisingly, only one participant, Sophie, asked for vocabulary clarification during her reading, even if more than half of them eventually admitted hesitating about the meaning of some words or sentences. Three teenagers asserted that they used their background knowledge and the context surrounding the complicated words to understand them. The participants mentioned no other reading strategy.

According to the analysis of the *rhetoric and arguments* (S2, S8, S9, S10, S13, S15, S18) theme, very few students commented on the texts' rhetoric, except for a quick judgement about the way the author of the pseudoscience text stated a lot of facts without giving examples. However, students could not guess how it would impact the reader. Two students nevertheless put forward the idea that the writing style could affect the reader's interest. Florence said that the title of the scientific text reminded her of the "click-baiting" technique because it was "intriguing, sensationalized and emotional". She nonetheless thought of it as a good way to prompt the reader to read through the long explanatory introduction, which is essential to really understand Christan's position on the matter. The second student who thought the writing style was important was appreciative of the pseudoscientific text author's style.

> The first text (Fauteux's) basically doesn't let the reader think. It throws a fact, after the other. The author bombards the reader with facts to convince him that he's right. I think it is a good technique because if the reader is a person who has mixed feelings about the issue, it is an advantage to not let them think it through and to throw information at them until they are on your side. (Raphael)

After being asked how he reacted to that technique, the participant said that he personally did not feel that the text had an influence on him since he thought he had "good critical thinking skills".

All participants were able to share their views about the strength of the articles' arguments. The most often-cited "weak" arguments were the links made between EM waves and Alzheimer's disease, EM waves and the Asian flu, and cell phones and chronic fatigue, which were all found in the pseudoscientific text. However, the chronic fatigue and the Asian flu arguments were also mentioned as "strong" by other students, showing the difference of perception in the participants.

While evaluating the authors' arguments, some participants noticed a few sophisms in Fauteux's text. Two of them were particularly noted. The first one concerned the section that pretended that the use of cell phones caused young Japanese to isolate from their family and to suffer from chronic fatigue.

> [Fauteux] says that more and more young Japanese lock themselves in their bedroom to avoid their family. They say these people suffer from chronic fatigue and frequently use their cell phone, but it is not necessarily because of it! (Caroline)

The second most observed sophism was about the claim that the Asian flu was caused by the EM waves emitted by the boat on which the epidemic started.

> I don't really see a connection between the flu epidemic and the boat where it started. For me it looks more like a strange coincidence than a cause to effect kind of event. (Florence)

Half of the students thus showed signs they understood induction and deduction without, however, using any vocabulary related to it. They found those arguments "weird," "coincidental," or "blurry". Although the interview exercise did not especially ask them to take a stand on the issue, they all did, mostly citing personal experiences, teachers, and family members' opinions to justify their stance.

**Life skills use**

The questions and interactions with interviewees about *open-mindedness* (D7, D8, D9) indicate that participants were generally quite receptive when it came to knowledge and arguments emanating from authority figures like parents and teachers, especially when they warned of potential dangers. At first, at least two thirds of the participants believed that those warnings were legitimate.

When the interview ended, half of the students admitted to being influenced one way or the other by the articles, leading to a radical change in the opinion of two of them. Both felt that the science-based article reassured them regarding the alleged dangers of EM wave-emitting technology. Caroline was convinced by the explicative tone of Christian's article, which made her feel like "she really was trying to make you understand". The science-based article also persuaded Florence, who thought it was in line with what she learned in her science class. In the end, only two participants (Sophie and Juliette) still believed that cell phones were dangerous, three (Jacob, Caroline and Raphael) were convinced they were not, and one (Florence) was more nuanced, saying that maybe they were only dangerous in some special cases. Only one student mentioned open-mindedness as an important quality to understand science.

> Back in the days, the earth was flat, and then they found out that in fact it wasn't. Even if I'm a catholic I believe what science says. I'm kind of a religious person but I think it is important to listen to the views or the explications that bring you new perspectives. (Sophie)

One of the two students (Jacob and Raphael) that thought there were no health threats related to EM waves before and after reading the articles did not feel compelled by Fauteux's arguments, saying they were "too far from his reality" and that "only a proof of death or serious disease [as a consequence of the use of EM wave-emitting technology] could change his mind".

We observed clear evidence of *metacognitive skills* (S14, S16) in two of the participants. Florence reflected on her own thinking during the think-aloud phase, explaining how her background knowledge was helping her understand the texts. Most students found the think-aloud part really difficult, sometimes even saying that "they did not have anything to say because it called nothing to mind". The other student, Raphael, made an interesting statement in terms of metacognition.

> Let's say there's a person who is against taking the bus. If you show him an argument in favour of buses, he will be far less convinced than someone who already likes taking the bus. In this case, I already believe that [EM wave-emitting technologies] aren't harmful for humans. I have a bias so I will be more easily convinced by the text that says that cell phones don't cause DNA changes. (Raphael)

Totally aware of his confirmation bias, this student also understood that people could have a different comprehension of a similar issue.

## DISCUSSION

Many students interviewed in this research project presented some limitations in their critical thinking skills when they showed difficulties related to text comprehension. These limitations are not surprising since more than a few skills and dispositions depend on reading ability when applied to written media. Although teenagers watch a lot of photos and videos (Tan, 2013), reading is still very much needed to interact with the majority of online media, traditional or not. The participants identified sentence length, the complexity of the vocabulary, and the lack of detail as the main factors that negatively impacted their comprehension and evaluation of the articles. While they did not mention other elements, like common knowledge, prior opinions, emotions, and the use (or the non-use) of reading strategies, we noticed that these also influenced participants' comprehension and ability to evaluate the articles, as previous studies also reported (Bingle & Gaskell, 1994; Bowyer et al., 2017; Leopold & Leutner, 2012).

Two of the participants in this study were unable to identify the general idea of the articles (D5, D6) and two others chose minor ideas or arguments as being the main topic. This supports observations made by Bowyer et al. (2017), who assessed teenagers' comprehension of political arguments presented in YouTube videos, and noticed that background knowledge and prior opinions played an important part in the understanding of a message. In line with these findings, the student who was afraid of what EM waves could do to her brain cells thought the main idea of Fauteux's article was that cell phones caused Alzheimer's disease. The capacity to discern important ideas seemed to have improved during the conversation, with students talking more and more about EM wave-emitting technologies. This evolution could be explained by the fact that people develop a better understanding of issues the longer they discuss them, which is included in the concept of verbal comprehension-knowledge (Reynolds & Turek, 2012).

As seen in the literature, the way the interviewed teenagers got in touch with the news (D3, D7, D10) seemed to have consequences on their ability to assess source credibility (D4, S5). The third millennium brought new ways to access information—notably, social media—that come with their own distorting lens. This new way of coming across the news created a peculiar phenomenon that Boczkowski et al. (2017) called *incidental news*. Since news content is mixed up with entertainment videos and family matters, it gets lost in the information flow and the value of each component tends to become uniformized. As shown in previous research (Gray et al., 2005; Notley et al., 2012), students referred to their parents or their teacher as credible sources and tended to be less refractory to sources they had previously encountered. Apart from people close to them, the other sources mentioned varied greatly between the participants and they seemed to have difficulty deciding what makes a source valuable. Some suggestions' evaluations reflected what is seen in the literature, like the value of a text's visual aspect and the fact that the authors had sources of their own to validate their information (Liu, 2004).

Since they spent so much time talking about statistics during the interviews, we think that numeracy (S4) is quite important to master in order to understand an article about any scientific issue, especially when it is about health topics (Reyna et al., 2009). Students will grant great importance to numbers and if they don't have the numeracy skills to understand them; it could have a huge impact on the value they give (positive or negative) to arguments and opinions based on statistics. Numeracy also appears to be closely related to text comprehension (Delagrave, 2008; Ennis, 2015), a connection we definitely saw during the interviews. It is indeed logical to be better at understanding numbers in a context if one understands clearly the said context.

The teenagers interviewed in this study showed as much suspicion towards scientific argument as they did pseudoscientific arguments, which raises an issue about the way they are shown to treat evidence. Our study was not about how critical thinking and media literacy are taught. We can, however, conclude that students are encouraged to be generally skeptical without being told what to be skeptical about. It seems to bring them to sometimes be overly critical of good evidence. Subsequent research should investigate how critical thinking and media literacy are taught – because they are – and what part of it seems to be misguiding students

into being blindly skeptical. A line of thought that we gathered from the data is that our participants seemed to be more skeptical towards arguments that contradicted their previous ideas and opinions. They were also stricter towards arguments of others, sometimes not noticing that these arguments were similar to theirs – a phenomenon Trouche et al. (2015) called *selective laziness of reasoning*. It could also be due to a confirmation bias (Nickerson, 1998), which encourages people to believe in things that reinforce their initial opinions. It could explain why many participants described some of Fauteux's arguments as weak while also agreeing with them. We can't ignore the fact that part of this confusion could also come from a desire for approval (DeWaelsche, 2015) since a few of the participants asked the interviewer if they correctly answered the questions.

Open-mindedness (D7, D8, D9) enters more into the broad category of critical thinking dispositions, since they are more like a state of mind than an actual ability or skill. To modify a personal opinion is, however, an arduous task that can be slowed down by various factors like family values or religious beliefs, as we saw with Juliette, the participant who stuck with her mother's opinion that cellphones were dangerous. Metacognitive skills (S14, S16) were observed in two participants, who also happened to be the two who seemed the most comfortable with numeracy and argument analysis. This interesting connection is yet to be investigated since our sample was very small. While we can't draw conclusions on that matter, it is certainly worth studying further.

## CONCLUSIONS

Many studies investigated how to foster critical thinking in high school students and some of them even precisely targeted pseudoscience (Adam & Manson, 2014; Marin & Halpern, 2011; McLean & Miller, 2010; Schmaltz & Lilienfeld, 2014; Yang & Wu, 2012). However only a few were interested in the skills and dispositions needed for critical thinking in the context of science news, which was the objective of this research. How did the interviewed teenagers use and express their critical thinking skills? From the answers provided by the participants, we could observe that they possessed very different sets of strengths and weaknesses as critical thinkers, despite all going to the same school and attending the same classes. They were, however, all capable of skepticism even though it was not always directed at the right target, causing insecurity about choosing sides and defending their opinions. While not generalizable, these results are relevant because they give clues on where to begin in order to engage in a discussion about our youth's media and scientific literacies education (literacy levels and metacognitive skills, among others). It also paves the way for more extended research work with the aim of improving teenagers' critical thinking about scientific and pseudoscientific information. If Ennis' (2015) abilities and dispositions are certainly helpful, there is a whole other field of aptitudes that our research did not tackle: domain-specific competences. Whether they are science related or media related, domain-specific competences tend to be more easily learnt and applied to contexts (Tiruneh et al., 2016) since the abstract learning of a generic skill can make its contextualization more difficult.

The results of this study show that, while students are taught some elements of media literacy, it is likely that those elements are misunderstood or rarely contextualized in a scientific setting. Helping teenagers foster sensible critical thinking skills and dispositions in this information era should be an educational priority, especially regarding topics that will affect citizens' daily lives, like science-related issues.

## REFERENCES


Adam, A. & Manson, T. (2014). Using a pseudoscience activity to teach critical thinking. *Teaching of psychology*, *41*(2), 130-134. https://doi.org/10.1177/0098628314530343

Bingle, W. H. & Gaskell, P. J. (1994). Scientific literacy for decisionmaking and the social construction of scientific knowledge. *Science Education*, *78*(2), 185-201. https://doi.org/10.1002/sce.3730780206

Bloom, B. S., Krathwohl, D. R., & Masia, B. B. (1956). *Taxonomy of educational objectives: the classification of educational goals*. Longmans.

Boczkowski, P., Mitchelstein, E. & Matassi, M. (2017, January). Incidental News: How Young People Consume News on Social Media. In T.X. Bui, & R.H. Sprague, (Dir.), *Proceedings of the 50th Hawaii International Conference on System Sciences* (pp. 1785-1792). https://doi.org/10.24251/HICSS.2017.217

Bowyer, B., Kahne, J. and Middaugh, E. (2017). Youth comprehension of political messages in YouTube videos. *New media and society*, *19*(4), 522-541. https://doi.org/10.1177/1461444815611593

Christian, È. (2016, April 7). Peut-on dormir en sécurité près de notre cellulaire? *Radio-Canada*. https://ici.radio-canada.ca/nouvelle/774596/dormir-cellulaire-lit-oreiller-danger-sante

Davies, M. & Barnett, R. (2015). *Introduction*. In M. Davies et al. (Eds.), *The Palgrave Handbook of Critical Thinking in Higher Education* (pp. 1-26). Palgrave Macmillan US.

Delagrave, E. (2008). *Évaluation de la capacité des futurs enseignants en sciences à interpréter adéquatement les nouvelles scientifiques portant sur des études épidémiologiques* [Masters thesis, Université du Québec à Montréal]. Université du Québec à Montréal. https://archipel.uqam.ca/1174/

DeWaelsche, S. A. (2015). Critical thinking, questioning and student engagement in Korean university English courses. *Linguistics and education, 32*(B), 131-147. https://doi.org/10.1016/j.linged.2015.10.003

Ennis, R. H. 2015. *Critical thinking: a streamlined conception*. In M. Davies et al. (Eds.), *The Palgrave Handbook of Critical Thinking in Higher Education* (pp. 31-47). Palgrave Macmillan.

Falardeau, É., Pelletier, C. & Pelletier, D. (2014). La méthode de la pensée à voix haute pour analyser les difficultés en lecture des élèves de 14 à 17 ans. *Éducation et Didactique, 8*(3), 43-54. https://doi.org/10.4000/educationdidactique.2022

Fauteux, A. (2006). La mort sans fil. *Conseil régional de l'environnement de Montréal*. https://cremtl.org/publication/entrevues/2006/mort-sans-fil-par-andre-fauteux-editeur-revue-maison-21e-siecle

Fisher, A. (2001). *Critical thinking: An introduction*. Cambridge University Press.

Fisher, A. & Scriven, M. (1997). *Critical Thinking: Its Definition and Assessment.* University of East Anglia, Centre for Research in Critical Thinking.

Gingras, A. (2003). *Médias et démocratie: le grand malentendu*. Presses de l'Université du Québec.

Gray, N. J., Klein, J. D., Noyce, P. R., Sesselberg, T. S. & Cantrill, J. A. (2005). Health information-seeking behaviour in adolescence: The place of the internet. *Social science & medicine, 60*(7), 1467-1478. https://doi.org/10.1016/j.socscimed.2004.08.010

Guilbert, L., Boisvert, J. & Ferguson, N. (1999). *Enseigner et comprendre: le développement d'une pensée critique*. Les Presses de l'Université Laval.

Gutiérrez Martín, A. & Tyner, K. (2012). Media education, media literacy and digital competence. *Comunicar, 38*(19), 31-39. https://doi.org/10.3916/C38-2012-02-03

Institut de la statistique du Québec. (2006). *2006 Census: Population aged 25 and older without a diploma, and population with a university certificate or diploma, by sex, mother tongue and age group*.http://www.stat.gouv.qc.ca/statistiques/education/diplomation/tab2_niv_sco_2006.htm

Korpan, C. A., Bisanz, G. L., Bisanz, J. & Henderson, J. M. (1997). Assessing literacy in science: evaluation of scientific news briefs. *Science Education, 81*(5), 515-532. https://doi.org/10.1002/(SICI)1098-237X(199709)81:5<515::AID-SCE2>3.0.CO;2-D

Ku, K. Y. L. (2009). Assessing students' critical thinking performance: Urging for measurements using multi-response format. *Thinking Skills and Creativity, 4*(1), 70-76. https://doi.org/10.1016/j.tsc.2009.02.001

Landry, N. and Basque, J. (2015). L'éducation aux médias dans le Programme de formation de l'école québécoise: intégration, pratiques et problématiques. *Revue canadienne de l'éducation, 38*(2), 1-33.

Laramée, A. (1998). *L'éducation critique aux médias*. TELUQ.

Leopold, C. & Leutner, D. (2012). Science text comprehension: Drawing, main idea selection, and summarizing as learning strategies. *Learning and instruction*, *22*(1) 16-26. https://doi.org/10.1016/j.learninstruc.2011.05.005

Lewandowsky, S., Ecker, U. K. H., Seifert, C. M., Schwarz, N., & Cook, J. (2012). Misinformation and Its Correction: Continued Influence and Successful Debiasing. *Psychological Science in the Public Interest*, *13*(3), 106-131. https://doi.org/10.1177/1529100612451018

Liu, Z. (2004). Perceptions of credibility of scholarly information on the Web. *Information processing & management, 40*(6), 1027-1038. https://doi.org/10.1016/S0306-4573(03)00064-5

Maier, M., Rothmund, T., Retzbach, A., Otto, L. & Besley, J. (2014). Informal learning through science media usage. *Educational Psychologist*, *49*(2), 86-103. https://doi.org/10.1080/00461520.2014.916215

Manalo, E. & Sheppard, C. (2016). How might language affect critical thinking performance? *Thinking skills and creativity, 21*(1), 41-49. https://doi.org/10.1016/j.tsc.2016.05.005

Marin, L. & Halpern, D. (2011). Pedagogy for developing critical thinking in adolescents: Explicit

instruction produces greatest gains. *Thinking skills and creativity*, *6*(1), 1-13. https://doi.org/10.1016/j.tsc.2010.08.002

McClune, B., & Jarman, R. (2012). Encouraging and equipping students to engage critically with science in the news: what can we learn from the literature? *Studies in Science Education*, *48*(1), 1-49. https://doi.org/10.1080/03057267.2012.655036

McLean, C. & Miller, N. (2010). Changes in Critical Thinking Skills Following a Course on Science and Pseudoscience: A Quasi-Experimental Study. *Teaching of psychology*, *37*(2), 85-90. https://doi.org/10.1080/00986281003626714

Ministère de l'Éducation, du Loisir et du Sport du Québec. (2017). *Programme de formation de l'école québécoise, deuxième cycle du secondaire*. http://www.education.gouv.qc.ca/fileadmin/site_web/documents/education/jeunes/pfeq/PFEQ_presentation-deuxieme-cycle-secondaire.pdf

New Zealand. Ministry of Education. (2007). *The New Zealand curriculum*. https://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum

National Science Board (2018). *Science and Engineering Indicators 2018*. https://www.nsf.gov/statistics/2018/nsb20181/

Nickerson, R. S. (1998). Confirmation bias; A ubiquitous phenomenon in many guises. *Review of General Psychology, Educational Publishing Foundation, 2*(2), 175-220. https://doi.org/10.1037/1089-2680.2.2.175

Notley, C., Scaife, V., O'brien, M., Mceune, R., Biggart, L. & Millings, A. (2012). Vulnerable young people and substance-use information-seeking: perceived credibility of different information sources and implications for services. *Journal of substance use*, *17*(2), 163-175. https://doi.org/10.3109/14659891.2010.540297

Oxman, A. D., Guyatt, G. H., Cook, D. J., Jaeschke, R., Heddle, N. & Keller, J. (1993). An index of scientific quality for health reports in the lay press. *Journal of Clinical Epidemiology*, *46*(9), 987-1001. https://doi.org/10.1016/0895-4356(93)90166-X

Paul, R., Fisher, A. & Nosich, G. (1993). *Workshop on critical thinking strategies.* Foundation for Critical Thinking, Sonoma State University.

Pigliucci, M. & Boudry, M. (2013). *Philosophy of pseudoscience: reconsidering the demarcation problem*. University of Chicago Press.

Potvin, P. & Hasni, A. (2014a). Analysis of the decline in interest towards school science and technology from grades 5 through 11. *Journal of Science Education and Technology*, *23*(6), 784-802. https://doi.org/10.1007/s10956-014-9512-x

Potvin, P. & Hasni, A. (2014b). Interest, motivation and attitude towards science and technology at K-12 levels: a systematic review of 12 years of educational research. *Studies in Science Education*, *50*(1), 85-129. https://doi.org/10.1080/03057267.2014.881626

Rahm, J., Potvin, P., & Vazquez-Abad, J. (2019). Science Education in Québec. In C. D. Tippett & T. M. Milford (Eds.), *Science education in Canada: Consistencies, commonalities, and distinctions* (pp. 129-150). Springer.

Reyna, V. F., Nelson, W. L., Han, P. K. & Diekmann, N. F. (2009). How numeracy influences risk comprehension and medical decision making. *Psychological bulletin*, *135*(6), 943-973. https://doi.org/10.1037/a0017327

Reynolds, M. & Turek, J. (2012). A dynamic developmental link between verbal comprehension-knowledge (Gc) and reading comprehension: Verbal comprehension-knowledge drives positive change in reading comprehension. *Journal of school psychology*, *50*(6), 841-863. https://doi.org/10.1016/j.jsp.2012.07.002

Schmaltz, R. & Lilienfeld, S. (2014). Hauntings, homeopathy, and the Hopkinsville Goblins: Using pseudoscience to teach scientific thinking. *Frontiers in Psychology – Educational Psychology*, *5*, 1-5. https://doi.org/10.3389/fpsyg.2014.00336

Sugarman, H., Impey, C., Buxner, S., & Antonellis, J. (2011). Astrology Beliefs among Undergraduate Students. *Astronomy Education Review*, *10*(1), 010101. http://dx.doi.org/10.3847/AER2010040

Tan, E. (2013). Informal learning on YouTube: exploring digital literacy in independent online learning. *Learning, Media and Technology*, *38*(4), 463-477.

Tiruneh, D., Weldeslassie, A., Kassa, A., Tefera, Z., De Cock, M. & Elen, J. (2016). Systematic design of a learning environment for domain-specific and domain-general critical thinking skills. *Educational technology research and development*, *64*(3), 481-505. https://doi.org/10.1080/17439884.2013.783594

Trouche, E., Johansson, P., Hall, L. & Mercier H. (2015). The selective laziness of reasoning. *Cognitive science*, *40*(8), 2122-2136. https://doi.org/10.1111/cogs.12303

Wang, S. & Seepho, S. 2017. Facilitating Chinese EFL Learners' Critical Thinking Skills: The Contributions of Teaching Strategies. *SAGE open*, *7*(3), 1-9. https://doi.org/10.1177%2F2158244017734024

Watson, G. & Glaser, E.M., (1964). *Watson-Glaser Critical Thinking Appraisal Manual*. Psychological Corporation.

Yang, Y. & Wu, W. (2012). Digital storytelling for enhancing student academic achievement, critical thinking, and learning motivation: A year-long experimental study. *Computers and education*, *59*(2), 339-352. https://doi.org/10.1016/j.compedu.2011.12.012