"Fake News" or Real Science? Critical Thinking to Assess Information on COVID-19

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Few people question the important role of critical thinking in students becoming active citizens; however, the way science is taught in schools continues to be more oriented toward "what to think" rather than "how to think." Researchers understand critical thinking as a tool and a higher-order thinking skill necessary for being an active citizen when dealing with socio-scientific information and making decisions that affect human life, which the pandemic of COVID-19 provides many opportunities for. The outbreak of COVID-19 has been accompanied by what the World Health Organization (WHO) has described as a "massive infodemic." Fake news covering all aspects of the pandemic spread rapidly through social media, creating confusion and disinformation. This paper reports on an empirical study carried out during the lockdown in Spain (March–May 2020) with a group of secondary students ($N = 20$) engaged in diverse online activities that required them to practice critical thinking and argumentation for dealing with coronavirus information and disinformation. The main goal is to examine students' competence at engaging in argumentation as critical assessment in this context. Discourse analysis allows for the exploration of the arguments and criteria applied by students to assess COVID-19 news headlines. The results show that participants were capable of identifying true and false headlines and assessing the credibility of headlines by appealing to different criteria, although most arguments were coded as needing only a basic epistemic level of assessment, and only a few appealed to the criterion of scientific procedure when assessing the headlines.

Keywords: critical thinking, argumentation, socio-scientific issues, COVID-19 disease, fake news, epistemic assessment, secondary education

INTRODUCTION: CRITICAL THINKING FOR SOCIAL RESPONSIBILITY – AN URGENT NEED IN THE COVID-19 PANDEMIC

The COVID-19 pandemic is a global phenomenon that affects almost all spheres of our life, aside from its obvious direct impacts on human health and well-being. As mentioned by the UN Secretary General, in his call for solidarity, *"We are facing a global health crisis unlike any in the 75-year history of the United Nations — one that is spreading human suffering, infecting the global economy and upending people's lives."* (19 March 2020, Guterres, 2020). COVID-19 has revealed the

vulnerability of global systems' abilities to protect the environment, health and economy, making it urgent to provide a responsible response that involves collaboration between diverse social actors. For science education the pandemic has raised new and unthinkable challenges (Dillon and Avraamidou, 2020; Jiménez-Aleixandre and Puig, 2021), which highlight the importance of critical thinking (CT) development in promoting responsible actions and responses to the coronavirus disease, which is the focus of this paper. Despite the general public's respect of science and scientific advances, denial movements – such as the ones that reject the use of vaccines and advocate for alternative health therapies – are increasing during this period (Dillon and Avraamidou, 2020). The rapid global spread of the coronavirus disease has been accompanied by what the World Health Organization (WHO) has described as the COVID-19 social media *infodemic*. The term *infodemic* refers to an overabundance of information (real or not) associated with a specific topic, whose growth can occur exponentially in a short period of time [World Health Organization (WHO), 2020]. The case of the COVID-19 pandemic shows the crucial importance of socio-scientific instruction toward students' development of critical thinking (CT) for citizenship.

Critical thinking is embedded within the framework of "21st century skills" and is considered one of the goals of education (van Gelder, 2005). Despite its importance, there is not a clear consensus on how to better promote CT in science instruction, and teachers often find it unclear what CT means and requires from them in their teaching practice (Vincent-Lacrin et al., 2019). CT is understood in this study as a set of skills and dispositions that enable students and people to take critical actions based on reasons and values, but also as independent thinking (Jiménez-Aleixandre and Puig, 2021). It is also considered as a dialogic practice that students can enact and thereby become predisposed to practice (Kuhn, 2019). We consider that CT has two fundamental roles in SSI instruction: one role linked to the promotion of rational arguments, cognitive skills and dispositions; and the other related to the idea of critical action and social activism, which is consistent with the characterization of CT provided by Jiménez-Aleixandre and Puig (2021). Although research on SSIs has provided us with empirical evidence supporting the benefits of SSI instruction, particularly argumentation and students' motivation toward learning science, there is still scarce knowledge on how CT is articulated in these contexts. One challenge with promoting CT, especially in SSIs, is linked to new forms of communication that generate a rapid increase of information and easy access to it (Puig et al., 2020).

The study was developed in an unprecedented scenario, during the lockdown in Spain (March–May 2020), which forced the change of face-to-face teaching to virtual teaching, involving students in online activities that embraced the application of scientific notions related to COVID-19 and CT for assessing claims published in news headlines related to it. Previous studies have pointed out the benefits of virtual environments to foster CT among students, particularly asynchronous discussions that minimize social presence and favor all students expressing their own opinion (Puig et al., 2020).

In this research, we aim to explore students' ability to critically engage in the assessment of the credibility of COVID-19 claims during a moment in which fake news disseminated by social media was shared by the general public and disinformation on the virus was easier to access than real news.

THEORETICAL FRAMEWORK

We will first discuss the crucial role of CT to address controversial issues and to fight against the rise of misinformation on COVID-19; and then turn attention to the role of argumentation in students' development of CT in SSI instruction in epistemic education.

Critical Thinking on Socio-Scientific Instruction to Face the Rise of Disinformation

SSIs are compelling issues for the application of knowledge and processes contributing to the development of CT. They are multifaceted problems, as is the case of COVID-19, that involve informal reasoning and elements of critique where decisions present direct consequences to the well-being of human society and the environment (Jiménez-Aleixandre and Puig, 2021). People need to balance subject matter knowledge, personal values, and societal norms when making decisions on SSIs (Aikenhead, 1985) but they also have to be critical of the discourses that shape their own beliefs and practices to act responsibly (Bencze et al., 2020). According to Duschl (2020), science education should involve the creation of a dialogic discourse among members of a class that focuses on the teaching and learning of "how did we come to know?" and "why do we accept that knowledge over alternatives?" Studies on SSIs during the last decades have pointed out students' difficulties in building arguments and making critical choices based on evidence (Evagorou et al., 2012). However, literature also indicates that students find SSIs motivational for learning and increase their community involvement (Eastwood et al., 2012; Evagorou, 2020), thus they are appropriate contexts for CT development. While research on content knowledge and different modes of reasoning on SSIs is extensive, the practice of CT is understudied in science instruction. Of particular interest in science education are SSIs that involve health controversies, since they include some of the challenges posed by the post-truth era, as the health crisis produced by coronavirus shows. The COVID-19 pandemic is affecting most countries and territories around the world, which is why it is considered the greatest challenge that humankind has faced since the 2nd World War (Chakraborty and Maity, 2020). Issues like COVID-19 that affect society in multiple ways require literate citizens who are capable of making critical decisions and taking actions based on reasons. As the world responds to the COVID-19 pandemic, we face the challenge of an overabundance of information related to the virus. Some of this information may be false and potentially harmful [World Health Organization (WHO), 2020]. In the context of growing disinformation related to the COVID-19 outbreak, EU institutions have worked to raise awareness of the dangers of disinformation and promoted the use of authoritative sources (European Council of the European Union, 2020). Educators and science educators have been increasingly concerned with what can be done in science

instruction to face the spread of misinformation and denial of well-established claims; helping students to identify what is true can be a hard task (Barzilai and Chinn, 2020). As these authors suggest, diverse factors may shape what people perceive as true, such as the socio-cultural context in which people live, their personal experiences and their own judgments, that could be biased. We concur with these authors and Feinstein and Waddington (2020), who argue that science education should not focus on achieving the knowledge, but rather on gaining appropriate scientific knowledge and skills, which in our view involves CT development. Furthermore, according to Sperber et al. (2010), there are factors that affect the acceptance or rejection of a piece of information. These factors have to do either with the source of the information – "who to believe" – or with its content – "what to believe." The pursuit of truth when dealing with SSIs can be facilitated by the social practices used to develop knowledge (Duschl, 2020), such as argumentation understood as the evaluation of claims based on evidence, which is part of CT development.

We consider CT and argumentation as overlapping competencies in their contexts of practice; for instance, when assessing claims on COVID-19, as in this study. According to Sperber et al. (2010), we now have almost no filters on information, and this requires a much more vigilant, knowledgeable reader. As these authors point out, individuals need to become aware of their own cognitive biases and how to avoid being victims themselves. If we want students to learn how to critically evaluate the information and claims they will encounter in social media outside the classroom, we need to engage them in the practice of argumentation and CT. This raises the question of what type of information is easier or harder for students to assess, especially when they are directly affected by the problem. In this paper we aim to explore this issue by exploring students' arguments while assessing diverse claims on COVID-19. We think that students' arguments reflect their ability to apply CT in this context, although this does not mean that CT skills always produce a well-reasoned argument (Halpern, 1998). Students should be encouraged to express their own thoughts in SSI instruction, but also to support their views reasonably (Puig and Ageitos, 2021). Specifically, when they must assess the validity of information that affects not only them as individuals but also the whole society and environment. CT may equip citizens to discard fake news and to use appropriate criteria to evaluate information. This requires the design and implementation of specific CT tasks, as this study presents.

Argumentation to Enhance Critical Thinking Development in Epistemic Education on SSIs

While the concept of CT has a long tradition and educators agree on its importance, there is a lack of agreement on what this notion involves (Thomas and Lok, 2015). CT has been used with a wide range of meanings in theoretical literature (Facione, 1990; Ennis, 2018). In 1990, The American Philosophical Association convened an authoritative panel of forty-six noted experts on CT to produce a definitive account of the concept, which was

published in the Delphi Report (Facione, 1990). The Delphi definition provides a list of skills and dispositions that can be useful and guide CT instruction. However, as Davies and Barnett (2015) point out, this Delphi definition does not include the phenomenon of action. We concur with these authors that CT education should involve students in "CT for action," since decision making – a way of deciding on a course of action – is based on judgments derived from argumentation using CT. Drawing from Halpern (1998), we also think that CT requires awareness of one's own knowledge. CT requires, for instance, insight into what one knows and the extent and importance of what one does not know in order to assess socio-scientific news and its implications (Puig and Ageitos, 2021).

Critical thinking and argumentation share core elements like rationality and reflection (Andrews, 2015). Some researchers suggest understanding CT as a *dialogic practice* (Kuhn, 2019) has implications in CT instruction and development. Argumentation on SSIs, particularly on health controversies, is receiving increasing attention in science education in the post-truth era, as the coronavirus pandemic and denial movements related to its origin, prevention, and treatment show. Science education should involve the creation of a dialogic discourse among members of a class that enable them to develop CT. One of the central features in argumentation is the development of epistemic criteria for knowledge evaluation (Jiménez Aleixandre and Erduran, 2008), which is a necessary skill to be a critical thinker. We see the practice of CT as the articulation of cognitive skills through the practice of argumentation (Giri and Paily, 2020).

This article argues that science education needs to explore learning experiences and ways of instruction that support CT by engaging learners in argumentation on SSIs. Despite CT being considered a seminal goal in education and the large body of research on CT supporting this (Dominguez, 2018), debates still persist about the manner in which CT skills can be achieved through education (Abrami et al., 2008). Niu et al. (2013) remark that educators have made a striking effort to foster CT among students, showing that the belief that CT can be taught and learned has spread and gained support. Therefore, CT has slowly made its way into general school education and specific instructional interventions. Problem-based learning is one of the most widely used learning approaches nowadays in CT instruction (Dominguez, 2018) because it is motivating, challenging, and enjoyable (Pithers and Soden, 2000; Niu et al., 2013). We see active learning methodologies and real-word problems such as SSIs as appropriate contexts for CT development.

The view that CT can be developed by engagement in argumentation practices plays a central role in this study, as Kuhn (2019) suggested. However, the post-truth condition poses some challenges to the evaluation of sources of information and scientific evidence disseminated by social media. According to Sinatra and Lombardi (2020), the post-truth context raises the need for critical evaluation of online information about SSIs. Students need to be better prepared to assess science information they can easily find online from a variety of sources. Previous studies described by these authors emphasized the importance of source evaluation instruction to equip students toward this goal

(Bråten et al., 2019), however, this is not sufficient. Sinatra and Lombardi (2020) note that students should learn how to evaluate the connections between sources of information and knowledge claims. This requires, from our view, engaging students in CT and epistemic performance. If we want students to learn to think critically about the claims they will encounter on social media, they need to practice argumentation as critical evaluation.

We draw on research on epistemic education (Chinn et al., 2018) which considers that learning science entails students' participation in the science epistemic goals (Kelly and Licona, 2018); in other words, placing scientific practices at the center of SSI instruction. Our study is framed in a broader research project that aims to embed CT in epistemic design and performance. In Chinn et al. (2018) AIR model, epistemic cognition has three core elements that represent the three letters of the acronym: epistemic Aims, goals related to inquiry; epistemic Ideals, standards and criteria used to evaluate epistemic products, such as explanations or arguments; and Reliable processes for attaining epistemic achievements. Of particular interest for our focus on CT is that the AIR model also proposes that epistemic cognition has a social nature, and it is situated. The purpose of epistemic education (Barzilai and Chinn, 2017) should be to enable students to succeed in epistemic activities (*apt epistemic performance*), such as constructing and evaluating arguments, and to assess through meta-competence when success can be achieved. This paper attends to one aspect of epistemic performance proposed by Barzilai and Chinn (2017), which is cognitive engagement in epistemic assessment. Epistemic assessment encompasses in our study the evaluation of the content of claims disseminated by media. Aligned with these authors we understand that this process requires cognitive and metacognitive competences. Thus, epistemic assessment needs adequate disciplinary knowledge, but also meta-cognitive competence for recognizing unsupported beliefs.

GOAL AND RESEARCH QUESTIONS

This paper examines students' competence to engage in argumentation and CT in an online task that requires them to critically assess diverse information presented in media headlines on COVID-19. Competence in general can be defined as "a disposition to succeed with a certain aim" (Sosa, 2015, p. 43) and epistemic competence, as a special case of competence, is at its core a dispositional ability to discern the true from the false in a certain domain. For the purposes of this paper, the attention is on epistemic competence, being the research questions that drive the analysis of the following:

1. What is the competence of students to assess the credibility of COVID-19 information appearing in news headlines?
2. What is the level of epistemic assessment showed in students' arguments according to the criteria appealed while assessing COVID-19 news headlines?

MATERIALS AND METHODS

Context, Participants, and Design

A teaching sequence about COVID-19 was designed at the beginning of the lockdown in Spain (Mid-March 2020) in response to the rise of misinformation about coronavirus on the internet and social media. The design process involved collaboration between the first and second author (researchers in science education) and the third author (a biology teacher in secondary education).

The participants are a group of twenty secondary students (14–15 years old), eleven of them girls, from a state public school located in a well-known seaside village in Galicia (Spain). They were mostly from middle-class families and within an average range of ability and academic achievement.

Students were from the same classroom and participated in previous online activities as part of their biology classes, taught by their biology teacher, who collaborated on previous studies on CT and learning science through epistemic practices on health controversies.

The activities were integrated in their biology curriculum and carried out when participants received instruction on the topics of health, infectious diseases, and the immune system.

Google Forms was used for the design and implementation of all activities included in the sequence. The reason to select Google Forms is that it is free and a well-known tool for online surveys. Besides, all students were familiar with its use before the lockdown and the teacher valued its usefulness for engaging them in online debates and in their own evaluation processes. This online resource provides anonymous results and statistics that the teacher could share with the students for debates. It needs to be highlighted that during the lockdown students did not have the same work conditions; particularly, quality and availability of access to the internet differed among them. Thus, all activities were asynchronous. They had 1 week to complete each task and the teacher could be consulted anytime if they had difficulties or any question regarding the activities.

The design was inspired by a previous one carried out by the authors when the first case of Ebola disease was introduced in Spain (Puig et al., 2016), and follows a constructivist and scientific-based approach. The sequence began with an initial task, in which students were required to express their own views and knowledge on COVID-19 and health notions related with it, before then being progressively involved in the application of knowledge through the practice of modeling and argumentation. The third activity engaged them in critical evaluation of COVID-19 information. A more detailed description of the activities carried out in the different steps of the sequence is provided below.

Stage 1: General Knowledge on Health Notions Related to COVID-19

An individual Google Forms survey around some notions and health concepts that appear in social media during the lockdown, such as "pandemic", "virus," etc.

Stage 2: Previous Knowledge on Coronavirus Disease

This stage consisted of three parts: (2.1) Individual online survey on infectious diseases; (2.2) Introduction of knowledge about infectious diseases provided in the e-bugs project website[1] and activities; virtual visit to the exhibition "Outbreaks: epidemics in a connected world" available in the Natural History Museum website (blinded for review); (2.3) Building a poster with the chain of infection of the COVID-19 disease and some relevant information to consider in order to stop the spread of the disease.

Stage 3: COVID-19, Sources of Information

This stage consisted first of a virtual forum in which students shared their own habits when consulting scientific information, particularly coronavirus-related, and debated on the main media sources they used to consult for this purpose. Secondly, students had to analyze ten news headlines on COVID-19 disseminated by social media during the outbreaks; six corresponded to fake news and four were true. They were asked to critically assess them and distinguish which they thought were true, providing their arguments. Media sources were not provided until the end of the task, since the act of asking for the source was considered as part of the data analysis (see **Table 1**). The second part of this stage is the focus of our analysis.

Stage 4: Act and Raise Awareness on COVID-19

The sequence ended with the creation of a short video in which the students had to provide some tips to avoid the transmission of the virus. The information provided in the video must be supported and based on established scientific knowledge.

Data Corpus and Analysis

Data collection includes all individual surveys and activities developed in Google Forms. We analyzed students' individual responses ($N = 28$) presented in Stage 3. The research is designed as a qualitative study that utilizes the methods of discourse analysis in accordance with the data and the purpose of the study.

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[1]https://www.e-bug.eu

Discourse analysis allows the analysis of the content (implicit or explicit) of written arguments produced by students, and so the examination of the research questions. Our analysis focuses on students' arguments and criteria used to assess the credibility of COVID-19 headlines (ten headlines in total). It was carried out through an iterative process in which students' responses were read and revised several times in order to develop an open-coded scheme that captures the arguments provided. To ensure the internal reliability of our codes, each student response was examined by the first and the second author separately and then contrasted and discussed until 100% agreement was achieved. The codes obtained were established according to the following criteria, summarized in **Table 2**.

For Research Question 1, we distributed the arguments in two main categories: (1) *Arguments that question the credibility of the information*; (2) *Arguments that do not question the credibility of the information.*

For Research Question 2, we classify arguments that question the credibility of the headline in accordance with the level of epistemic assessment into three levels (see **Table 2**). The level of epistemic assessment (basic, medium, and high) was established by the authors based on the criteria that students applied and expressed explicitly or implicitly in their arguments. These *criteria* emerged from the data, thus the categories were not pre-established; they were coded by the authors as the following: content (using the knowledge that each student has about the topic), source (questioning the origin of the information), evidence (appealing to empirical evidence as real live situations that students experienced), authority (justifying according to who supports or is behind the claim) and scientific procedure (drawing on the evolution of scientific knowledge).

TABLE 1 | COVID-19 News Headlines provided to students.

	COVID-19 News headlines
True	1. "It is possible to get COVID-19 by contact with a person who does not present symptoms"
	2. "The COVID-19 virus can be transmitted in areas with hot and humid climates"
	3. "People with asthma are more vulnerable to the effects of coronavirus"
	4. "Skin manifestations (urticaria, chilblains, rashes,...) could be included among the mild symptoms of coronavirus"
False	5. "It is possible to completely eliminate the coronavirus from the body by wetting it with alcohol or chlorine"
	6. "Antibiotics are effective in preventing and treating coronavirus infection"
	7. "The coronavirus only affects people over 70 years old"
	8. "Making Steam is advisable as a cure against COVID-19"
	9. "The pneumonia vaccine protects against the coronavirus"
	10. "Drinking alcohol protects against coronavirus"

TABLE 2 | Code scheme for research questions 1 and 2.

Arguments	Levels of epistemic assessment	Criteria appealed in their arguments
Questioning the credibility of the claim	Non-epistemic assessment	None
	Basic epistemic assessment (assessing the content of the claim, providing arguments to question it)	At least one of them: Appeals to content (C) Appeals to empirical evidence (E)
	Medium epistemic assessment (assessing the content of the claim, questioning the source trustworthiness, providing arguments to question the claim)	At least one of them: Appeals to the source (S) Appeals to authority (A)
	High epistemic assessment (questioning the content of the claim, the source trustworthiness and the scientific procedure behind providing well-reasoned arguments to question the claim)	At least:
		Or two or more criterion
No questioning the credibility of the claim	No epistemic assessment (accept the content of the claim, not questioning or asking for the source, providing their own arguments aligned with the claim)	Appeals to scientific procedure (SP)

RESULTS

Students' Competence to Critically Assess the Credibility of COVID-19 Claims

In general, most students were able to distinguish fallacious from true headlines, which was an important step to assess their credibility. For those that were false, students were able to question their credibility, providing arguments against them. On the contrary, for true news headlines, as it was expected, most participants developed arguments supporting them. Thus, they did not question their content. In both cases, the arguments elaborated by students appealed to different criteria discussed in the next section of results.

As shown in **Table 3**, 147 arguments were elaborated by students to question the false headlines; they created just 22 arguments to assess the true ones. This finding was expected by the authors, as arguments for questioning or criticality appear more frequently when the information presented differs from students' opinions.

Students showed a higher capacity for questioning those claims they considered false or *fake news*, which can be related to the need to justify properly why they consider them false and/or what should be said to counter them.

The headlines that were most controversial, meaning they created diverse positions among students, were these three: *"The COVID-19 virus can be transmitted in areas with hot and humid climates," "Skin manifestations (urticaria, chilblains, rashes…) could be among the mild symptoms of coronavirus"* and *"Antibiotics are effective in preventing and treating coronavirus infection."*

The first two were questioned by 11 students out of 28, despite being real headlines. According to students' answers, they were not familiar with this information, e.g., *"I think the heat is not good for the virus."* On the contrary, 17 students did not question these headlines, arguing for instance as this student did: *"because it was shown that both in hot climates and in cold climates it is contagious in the same way."*

A similar situation happened with the third headline, which is false. A proportion of students (9 out of 28) accepted that antibiotics could help to treat COVID-19, showing in their answers some misunderstanding regarding the use of antibiotics and the diseases they could treat. The rest of the participants (19 out of 28) questioned this headline, affirming that *"because antibiotics are used to treat bacterial infections and coronavirus is a virus,"* among other justifications for why it was false.

Levels of Epistemic Assessment in Students' Arguments on COVID-19 News Headlines

To analyze the level of epistemic assessment showed in students' arguments when dealing with each headline, attention was focused on the criteria students applied (see **Table 2**). As **Table 4** summarizes, almost all arguments included only one criterion (139 out of 169), and 28 out of 169 did not incorporate any criterion. These types of arguments can be interpreted as low epistemic assessment, or even without epistemic assessment if no criterion is included.

In the category of *Basic Epistemic Assessment*, we include all students' arguments that included one criterion: *Content* or *Empirical Evidence*. Students assessed the content of the claim appealing to their own knowledge about that piece of information or to empirical evidence, without posing critical questions for assessing the credibility of the source of information. These two criteria, content and evidence, were included in students' arguments with a frequency of 86 and 23, respectively, with this category the most common (109 out of 169) when questioning false and true headlines. In the case of true headlines, arguments under this category were identified in relation to headlines 2 and 4, whose credibility were questioned by appealing to the content, such as: *"those are not the symptoms* (skin manifestations)*"*. Examples of arguments assessing the content of false headlines are provided below:

"Because the virus is inside the body, and even if you injected alcohol into the body it would only cause intoxication"

This student rejects headline 5, appealing to the fact that alcohol causes intoxication rather than the elimination of coronavirus.

"I know a person who had coronavirus and they only gave him paracetamol"

TABLE 3 | Number of students who questioned or not each news headline on COVID-19.

COVID-19 News headlines		Questioning	No questioning
True	1. "It is possible to get COVID-19 by contact with a person who does not present symptoms"	–	28
	2. "The COVID-19 virus can be transmitted in areas with hot and humid climates"	11	17
	3. "People with asthma are more vulnerable to the effects of coronavirus"	–	27
	4. "Skin manifestations (urticaria, chilblains, rashes,…) could be included among the mild symptoms of coronavirus"	11	17
False	5. "It is possible to completely eliminate the coronavirus from the body by wetting it with alcohol or chlorine"	26	2
	6. "Antibiotics are effective in preventing and treating coronavirus infection"	19	9
	7. "The coronavirus only affects people over 70 years old"	27	1
	8. "Making Steam is advisable as a cure against COVID-19"	24	4
	9. "The pneumonia vaccine protects against the coronavirus"	24	2
	10. "Drinking alcohol protects against coronavirus"	27	1

TABLE 4 | Arguments used by students to assess the credibility of each COVID-19 headline.

COVID-19 News Headlines	Arguments to question each headline	Criteria appealed in arguments	Level of epistemic assessment
Headline 1. "It is possible to get COVID-19 by contact with a person who does not present symptoms"	–		
Headline 2. "The COVID-19 virus can be transmitted in areas with hot and humid climates"	11	C: 6	Basic
		A: 1	Medium
		S: 1	
		None: 3	No
Headline 3. "People with asthma are more vulnerable to the effects of coronavirus"	–		
Headline 4. "Skin manifestations (urticaria, chilblains, rashes,.) could be included among the mild symptoms of coronavirus"	11	C: 8	Basic
		S: 3	Medium
Headline 5. "It is possible to completely eliminate the coronavirus from the body by wetting it with alcohol or chlorine"	26	C: 15 E: 4	Basic
		A: 2	Medium
		S: 2	
		SP: 2	High
Headline 6. "Antibiotics are effective in preventing and treating coronavirus infection"	19	C: 8 E: 2	Basic
		S: 2	Medium
		SP: 5	High
		C + SP: 1	
		None: 1	No
Headline 7. "The coronavirus only affects people over 70 years old"	27	C: 19 E: 8	Basic
		A: 1	Medium
Headline 8. "Making Steam is advisable as a cure against COVID-19"	24	C: 8 E: 3	Basic
		S: 2	Medium
		SP: 1	High
		None: 10	No
Headline 9. "The pneumonia vaccine protects against the coronavirus"	24	C:10 E:5	Basic
		S:3	Medium
		SP: 3	High
		None: 3	No
Headline 10. "Drinking alcohol protects against coronavirus"	27	C: 12 E:1	Basic
		S:3	Medium
		None: 11	No
Total number of arguments		169	

In this example, the student rejects headline 6 and appeals to his/her own experience during the pandemic, particularly a close person who had coronavirus, as evidence against the use of antibiotics for coronavirus disease treatment.

The category *Medium Epistemic Assessment* gathers arguments that make critical questions, particularly those asking for information about the authority or the source of information. For us, these criteria reflect a higher level of epistemic performance since they imply questioning beyond the veracity of the headline

itself to its sources and authorship. There are 20 out of 169 arguments coded within this category.

The assessment of true headlines includes arguments that question the authority and source, e.g., *"because they said it on the news"* (headline 2), *"that news does not seem very reliable to me"* (headline 4). It is also an ordinary category in questioning false headlines, since students appealed to the source (16), *"because in the news they clarified that it was a fake news and because it is not credible either"* (headline 10) or the authority (4), *"because the professionals said they were more vulnerable (people over 70 years old) but not that it only affected them"* (headline 7).

For the highest category, *High Epistemic Assessment*, we consider those arguments (12 out of 169) in which students appealed to the scientific procedure (11) to justify why the headline is false, which manifests students' reliance on epistemic processes, e.g., *"because treatments that protect against coronavirus are still being investigated"* (headline 9). Also, under this category we include arguments that combined more than one criterion, content and scientific procedure *"Because antibiotics don't treat those kinds of infections. In addition, no medication has yet been discovered that can prevent the coronavirus"* (headline 6). Students' arguments included in this category were elaborated to assess false headlines.

Lastly, a special mention is afforded to those arguments that did not include any criteria (28), which are contained in the category *Non-Epistemic Assessment*. It appears more frequently in students' answers to headlines 8 and 10, as these examples show: *"I don't think it's true because it doesn't make much sense to me"* (headline 8) or *"I never heard it and I doubt it's true"* (regarding drinking alcohol, headline 10).

DISCUSSION

The findings of our study indicate that students were able to deal with *fake news,* identifying it as such. They showed capacity to critically assess the content of these news headlines, considering their inconsistencies in relation to their prior knowledge (Britt et al., 2019). As Evagorou (2020) pointed out, SSIs are appropriate contexts for CT development and to value the relevance of science in our lives.

The examination of RQ1 shows that a proportion of students were able to perceive the lack of evidence behind them or even identified that those statements contradict what science presents. This is a remarkable finding and an important skill to fight against attempts to diminish trust in science produced in the post-truth condition (Dillon and Avraamidou, 2020). CT and argumentation are closely allied (Andrews, 2015) but as the results show, knowledge domain seems to play an important role in assessing SSIs news and their implications. Specific CT requires some of the same skills as generalizable CT, but it is highly contextual and requires particular knowledge (Jones, 2015).

Students' prior knowledge influenced the critical evaluation of some of the COVID-19 headlines provided in the activity. This is particularly relevant in responses to headline 6 (false) *"Antibiotics are effective in preventing and treating coronavirus infection."* A previous study on the interactions between the

CT and knowledge domain on vaccination (Ageitos and Puig, 2021) showed that there is a correspondence between them. This points to the importance of health literacy for CT development, although it would not be sufficient to provide students with adequate knowledge only, as judgment skills, in this case regarding the proper use of antibiotics, are also required.

We found that the level of epistemic assessment (RQ2) linked to students' CT capacity is low. A big majority of arguments were situated in a basic epistemic assessment level, and just a few in a higher epistemic assessment. One reason that might explain these results could be related to the task design and format, in which students worked autonomously in a virtual environment. As CT studies in e-learning environments have reinforced (Niu et al., 2013), cooperative or collaborative learning favors CT skills, particularly when students have to discuss and justify their arguments on real-life problems. The circumstances in which students had to work during the outbreak did not allow them to work together since internet connections were not good for all of them, so synchronous activities were not possible. This aspect is a limitation for this research.

There were differences in the use of criteria, and thus in the level of epistemic assessment, when students dealt with true and false headlines. This could be related to diverse factors, such as the language. The claims are marred by language and they are formulated in a different way. Particularly, it is quite nuanced in true statements while certain and resolute in false headlines. The practice of CT requires an understanding of the language, the content under evaluation and other cognitive skills (Andrews, 2015).

In the case of false headlines, most arguments appealed to their content and less to the criteria of source, authority, and the scientific procedure, whereas in the case of true headlines most of them appealed to the authority and/or source. According to the AIR model (Chinn and Rinehart, 2016), epistemic ideals are the criteria used to evaluate the epistemic products, such as claims. In the case of COVID-19 claims, students need to have an ideal of high source credibility (Duncan et al., 2021). This means that students acknowledge that information should be gathered from reliable news media that themselves obtained information from reliable experts.

Only few students used the criterion of scientific procedure when assessing false headlines, which shows a high level of epistemic assessment. Promoting this type of assessment is important since online discourse in the post-truth era is affected by misinformation and by appeals to emotions and ideology.

CONCLUSION AND IMPLICATIONS

This research has been conducted during a moment in which the lives of people were paralyzed, and citizens were forced to stay at home to stop the spread of the coronavirus disease. During the lockdown and even after, apart from these containment measures, citizens in Spain and in many countries had to deal with a huge amount of information about the coronavirus disease, some of it false. The outbreak of COVID-19 has been accompanied by dissemination of inaccurate information spread at high speed, making it more difficult for the public to identify

verified facts and advice from trusted sources (World Health Organization (WHO), 2020). As the world responds to the COVID-19 pandemic, many studies have been carried out to analyze the impact of the pandemic on the life of children from diverse views (Cachón-Zagalaz et al., 2020), but not from the perspective of exploring students' ability to engage in the epistemic assessment of information and disinformation on COVID-19 under a situation of social isolation. This is an unprecedented context in many aspects, where online learning replaced in-person teaching and science uncertainties were more visible than ever.

Participants engaged in the epistemic assessment of coronavirus headlines and were able to put into practice their CT, arguing why they considered them as true or false by appealing to different criteria. We are aware that our results have limitations. Once such limitation is that students performed the activity independently, without creating a collaborative virtual environment, understood by the authors as one of the e-learning strategies that better promote CT (Puig et al., 2020). Furthermore, despite the fact that teachers were available for students to solve any questions regarding the task, the remote and asynchronous process did not allow them to guide the activity in a way that helped the students to carry out a deeper analysis. CT development and epistemic cognition depends on many factors, and teachers have an important role in achieving these goals (Greene and Yu, 2016; Chinn et al., 2020).

The analysis of arguments allows us to identify some factors that are crucial and directly affect the critical evaluation of headlines. Some of the students did not question the use of antibiotics for coronavirus disease. This result highlights the importance of health literacy and its interdependency with CT development, as previous studies on vaccine controversies and CT show (Puig and Ageitos, 2021). Although it is not the focus of this paper; the results point to the importance of making students aware of their knowledge limitations for critical assessment. A key instructional implication from this work is making e-learning activities more cooperative, as we have noted, and epistemically guided. Moreover, CT dimensions could be made explicit in instructional materials and assessments. If we want to prepare students to develop CT in order to face real/false news spread by social media, we need to engage them in deep epistemic assessment, namely in the critical analysis of the content, the source, procedures and evidence behind the claims, apart from other tasks. Promoting students' awareness and vigilance regarding misinformation and disinformation online may also promote more careful and attentive information use (Barzilai and Chinn, 2020), thus activities oriented toward these goals are necessary.

Our study reinforces the need to design more CT activities that guide students in the critical assessment of diverse aspects behind controversial news as a way to fight against the rise of disinformation and develop good knowledge when dealing with SSIs. Students' epistemological views can influence their performance on argumentation thus, if uncertainty of knowledge is explicitly address in SSI instruction and epistemic activities, students' epistemological views may be developed, and such development may in turn influence their argumentation competence and consequently their performance on CT.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Written informed consent was obtained from the participants' legal guardian/next of kin to participate in this study in accordance with the National Legislation and the Institutional Requirements.

AUTHOR CONTRIBUTIONS

BP conducted the conceptual framework and designed the research study. PB-A conducted the data analysis and collaborated in manuscript preparation. JP-M implemented the didactical proposal and collected the data. All authors contributed to the article and approved the submitted version.

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