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Students' Attitudes to Information in the Press: Critical Reading of a Newspaper Article With Scientific Content

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Abstract This research analyses what happens when a critical reading activity based on a press article dealing with an energy-related problem is implemented with two groups of students of 13–14 years old and 16–17 years old in the same school (a total of 117 students). Specifically, the research analyses the students' profiles from the standpoint of their attitudes to the information given in the news story and the use they make of it when writing an argumentative text. It also analyses the difficulties the students have when it comes to applying their knowledge about energy in a real-life context. Lastly, some strategies are suggested for helping students to critically analyse the scientific content of a newspaper article. Three reader profiles were identified (the credulous reader, the ideological reader and the critical reader). No significant differences were found in reading profiles in terms of age or scientific knowledge. The findings show that the activity helped to link science learning in school with facts relating to an actual context, particularly in the case of students with more science knowledge.

Keywords Contextualisation · Energy · Argumentation · Critical reading · Newspaper

Introduction

One of the aims of science teaching at school is to help produce independent people who are capable of analysing information critically and applying the knowledge they have acquired in a diverse range of situations. Students have difficulties analysing and understanding texts with scientific content although they would seem to have the necessary scientific knowledge to understand them (McClune and Jarman 2011). Probably, our greatest challenge as educators is to ensure that students are able to transfer the knowledge learnt in the classroom to the analysis of situations that arise in a variety of contexts. Press articles can help students to connect their knowledge (school knowledge) to everyday situations (Oliveras et al. 2013). The ability to analyse and respond critically to the ideas expressed in newspaper articles with scientific content is a significant characteristic of scientific literacy (Korpan et al. 1997; Wellington 1991), and therefore, it is vital to help students to read and interpret this type of text. Scientific literacy means not just understanding what texts with scientific context are saying but also

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adopting a critical stance towards such texts. Reading means understanding, interpreting, analysing and criticising texts. This is the fundamental meaning of literacy (Norris and Phillips 2003).

The written press is the main source of scientific information for most adults (Jarman and McClune 2002; Korpan et al. 1997), and the opinions and actions presented in these media are often based on scientific knowledge that the reader must know how to analyse critically. There has been a variety of research work on teaching and learning science from newspapers (Halkia and Mantzouridis 2005; Korpan et al. 1997; Norris and Phillips 2003; Phillips and Norris 1999; Ratcliffe 1999; Ratcliffe and Grace 2003). McClune and Jarman (2010) identified five essential elements necessary to respond critically to science in the press (knowledge of science; knowledge of writing and language; knowledge about news, newspapers and journalism; skills; and attitudes).

We consider that the critical reading and analysis of a press article with scientific content is an activity that needs to be worked on at school. In a previous research study, we analysed the difficulties experienced by secondary school students when reading a newspaper article critically and designed an instrument to help students develop their capacity to analyse articles with scientific content critically (Oliveras et al. 2013). The research presented in this article focuses on identifying the various critical reading profiles for this type of article and also attempts to analyse students' difficulties when it comes to applying their knowledge of energy in a real-life context. The research was carried out with students beginning the study of energy at 13–14 years old and students who had worked on this subject for one or two school years (16–17 years of age) but who were studying different specialities, either the humanities or sciences option.

Theoretical Framework

Critical Reading of Press Articles With Scientific Content

We consider reading to be an active process of constructing meaning based on the text. The meaning of the text is reconstructed by the reader based on his or her own references. According to Norris and Phillips (1987), when the reader's world, meaning the ideas that the reader has before reading the text, and the paper world (Olson 1994), defined as the understanding of the world given in the text, meet, readers can adopt various epistemological positions with respect to the text by:

1. adopting a dominant position, enabling their previous ideas to affect the information in the text,
2. enabling the text to have an impact on their previous ideas and make interpretations against them, or
3. adopting a critical stance to begin an interactive negotiation between the text and their beliefs or opinions in order to reach an interpretation that is as consistent and complete as possible.

McClune and Jarman (2011) identified certain indicators to analyse students' critical reading level. According to these authors, 'students who have a higher critical reading ability are able to evaluate new information by comparing it to what they already know and to information from other sources and, at the same time, able to give reasons why they agree, disagree or would seek more evidence' (p. 698). We will adopt this idea of the critical reader in this research work. Therefore, we consider that in order to achieve critical reading, it is not sufficient for readers to compare their own ideas with those of the text (Norris and Phillips 1987), but they must also be able to compare the information in the text with other sources (McClune and Jarman 2011). Students will need to identify the relevant data and arguments given in the article to then be able to analyse their credibility by comparing them with other sources.

In addition, critical reading depends on the reader's previous knowledge and requires the reader to contextualise and infer the author's intentions and actively construct new knowledge (Yore et al. 1998). To read a science-related press article critically, students must have background knowledge of the science topic to which the article refers, and be able to activate and apply it in a real-life context. By focusing our research on identifying various reading profiles with respect to a press article, we analysed which relevant information in the text the students identified in order to analyse the news story, which knowledge on energy they activated and what position they adopted based on this information and its comparison with other sources. The final argumentative text which the students wrote enabled us to identify the different positions taken.

Difficulties With Applying Knowledge of Energy Learnt in the Classroom to a Real Problem

There is a general agreement among science teachers on the importance of choosing the teaching of energy as a focus of interest in the science curriculum, since this is a central idea which provides an important key to our understanding of the way things happen in the physical, biological and technological world (Duit 1986; Hinrichs and Kleinbach 2002; Papadouris et al. 2008). Furthermore, energy issues have personal, social and environmental implications that may help to enhance students' interest in learning. Understanding these implications is necessary in order to make informed decisions concerning the current situation of planetary emergency (Bybee 1991). However, we need to ask ourselves which ideas of energy we need to help students to construct so that they can make informed decisions.

Various approaches to the concept of energy have been used in the school context, ranging from the classic definition as the ability of a body or system to perform work (Warren 1983) to defining energy as a quasi-material substance that participates in the processes that happen around us (Duit 1987; Millar 2005; Schmid 1982). Like Duit (1986), we think that the construction of an appropriate idea of energy means taking into consideration three characteristics: conservation, transfer and degradation. On the other hand, students attribute energy to specific bodies and not to the system formed by objects that interact, and therefore it is important to present energy as distributed between objects of a system rather than simply located with certain individual objects (Domenech et al. 2007; Kaper and Goedhart 2002; Millar 2000).

There is a considerable consensus that in the classroom, the point is not to start talking about energy, trying to define it (Jiménez-Aleixandre and Gallástegui-Otero 1995; Sexl 1981; Trumper 1991), but rather to identify the changes in a system and explain them as the result of interactions (Papadouris et al. 2008; Pintó et al. 2005). The idea of energy can be introduced later, together with the search for links between the various changes and attempts to quantify them. A comprehensive approach to the concept requires applying this knowledge in a variety of situations where changes are identified, placing particular emphasis on relationships between science, technology, society and the environment. It means demonstrating the close link between problems with energy (its role in our lives, problems associated with obtaining and using energy resources) and the current planetary emergency, and the need to be prepared to take decisions in this regard. Therefore, it is important to design curricular material which explores energy in different contexts in order to be able to apply the key ideas of conservation, transfer and degradation.

The principle of the conservation of energy is quite different to students' everyday perception. They see how energy is constantly 'spent' around them (Chisholm et al. 1992). Therefore, teaching energy cannot just be restricted to discussing conservation but must also give equal importance to the idea of the degradation of energy to avoid this gap between students' everyday perceptions and the model of energy we would like them to construct. Energy is only conserved in isolated systems, and most of the systems in our surroundings (even in the physics laboratory) are open systems, and there are constant transfers of energy into the environment.

In general, a good command of knowledge involves the ability to use it to interpret a range of situations and to transfer it (Gilbert et al. 2011). Therefore, we agree with Nordine et al. (2011) that the teaching of energy must be based on daily objects and phenomena and must be considered in a qualitative manner. The objective is to ensure that students can learn about the concept of energy in a meaningful way that enables them to analyse and interpret real-life problems. However, real problems are complex, and their analysis from a scientific standpoint involves activating various types of knowledge, using and analysing evidence, constructing reasons and taking decisions (Jiménez-Aleixandre and Gallástegui-Otero 1995). In this research study, students were asked to approach the critical analysis of the content of a press article on a real social and environmental problem relating to energy, a complex problem where making decisions would require taking into account different knowledge about the sources, transfer and degradation of energy.

Argumentation, Scientific Data and Ideas

Argumentation aids scientific literacy (Driver et al. 2000; Duschl and Osborne 2002; Erduran et al. 2004). Current research indicates that when students engage in argumentation activities, they can develop complex reasoning and critical thinking skills (Lawson 2003; Sadler 2004), as they understand how knowledge is generated and validated in science (Driver et al. 2000; Osborne et al. 2004), and improve their communication skills (Kuhn and Udell 2003).

We can define argumentation from two points of view: an individual or structural meaning as well as a social or dialogic meaning (Jimenez-Aleixandre and Erduran 2008). In terms of the structural meaning, many science educators adapt Toulmin's (1958) model of argumentation in that a claim or explanation is justified using various supports such as evidence, logic, warrants and reasoning (McNeill and Krajcik 2008; Sampson and Clark 2008). The claim is the statement that answers the original question or problem. The evidence is a piece of scientific data that backs up the claim, which can consist of either quantitative or qualitative measurements that are used to answer a question, solve a problem or make a decision (Aikenhead 2005). Reasoning is a justification that connects the evidence to the claim and shows how or why the data count as evidence by using appropriate and sufficient scientific principles. Argument justifies a claim using either evidence or reasoning (McNeill 2011). A second aspect of argumentation focuses on a social meaning in which there is dispute or debate among individuals. From this point of view, arguing is seen as a social activity in which an individual tries to convince others either through talk or writing about the validity of a particular assertion (Sampson and Clark 2008).

Many studies suggest that students have difficulties with argumentation, particularly when it comes to evaluating assertions (Driver et al. 2000), identifying evidence (Clark and Slotta 2000; Kuhn 1991; Osborne et al. 2004; Yang 2004), justifying assertions with evidence and evaluating arguments (Sadler 2004). These difficulties become more acute when students are asked to construct arguments on the basis of press articles. The texts we can give students to read from newspapers are characterised by the fact that the theoretical model of reference used to interpret the facts they discuss is very implicit (Martins et al. 2001; Norris and Phillips 2003), and this means that students have to infer the arguments from the text. Therefore, for students to read newspaper articles with scientific content, science curricula used in schools must provide sufficient knowledge and be meaningful (Millar and Osborne 1998). The point is not so much to transmit a large amount of information but rather to encourage the construction of theoretical, general or abstract models that have the potential to be used to interpret very diverse facts and analyse topics that do not form part of the hard core of science (Duschl 1990).

Most of the studies on argumentation have been performed on the basis of school or academic events, but an increasing number deal with reasoning in areas of daily life (for example, Jiménez-Aleixandre et al. 2000; McNeill 2011; Osborne et al. 2004; Simmoneaux 2001; Yang 2004; Yang and Anderson 2003; Zohar and Nemet 2002). In one of these studies (Yang 2004), it was shown that the students had difficulty incorporating theory and evidence when it came to evaluating socio-scientific issues. According to Yang, students' reasons were based on their epistemological beliefs and personal opinions. In real-life contexts, even adults are insufficiently skilled at giving scientific arguments in relation to social issues (Kortland 1996; Kuhn 1991; Ratcliffe 1996), and both adults and children have difficulties relating evidence (data) and theory (claims), which is essential to creating a valid argument (Kuhn 1991). Yang and Anderson (2003) showed that high school students' use of scientific information in reasoning was often judged to be simple and could be easily affected by emotional factors that tinged the evaluation of the evidence. Therefore, a difficulty in transferring critical thinking skills when analysing of socio-scientific issues was identified and, as a result, students need to be supported to identify scientific justifications. To achieve this, classroom activities need to be designed in meaningful contexts (Yang 2004), and students need to understand the structure of an argument and have the necessary scientific concepts (McNeill and Krajcik 2008).

We believe that to construct robust arguments about real problems, students need to be able to identify and interpret all the evidence, as different assertions may be possible depending on the interpretation of the evidence (Osborne et al. 2004). Teachers need to create situations in which the students need to use data as evidence to solve a problem. Developing the skill and ability to argue effectively is a long-term process that comes only with recurrent opportunities to engage in argumentation throughout the curriculum. The main message is that all of these studies, including our own, show that improvement at argumentation is possible if it is explicitly addressed and taught (Osborne et al. 2004; Zoller et al. 2000).

Credibility of Data

Evaluating media reports requires the ability to assess whether the evidence is valid and reliable, to distinguish correlations from causes and observations from inferences, and to assess the degree of risk (Millar and Osborne 1998; Monk and Osborne 1997). According to Gott et al. (1999), a datum must have a known (or estimated) reliability and validity before it can be used in evidence. Some questions that could help students perform this datum analysis could be: Has the value of the appropriate variable been measured? Has the parameter been sampled so that the datum represents the population? Does the datum have sufficient precision?

The credibility of different sources of information can be defined as the consideration of the grounds for confidence through the use of interrogatory tools, such as the critical asking of 'reports about the origin of evidence, whether the evidence is simply correlational or whether there is a plausible theoretical mechanism, whether the results are reproducible, whether they are contested or about the authority of the scientific source' (Driver et al. 2000, p. 301). Students' difficulty with assessing the credibility of evidence is well documented in the related literature (Dawson &Venville 2009; Nicolaidou et al. 2011; Reiser 2004; Sandoval and Millwood 2005). Students are known to objectivise evidence, seeing data as factual rather than constructed and open to interpretation (Lemke 1990; Sandoval and Çam 2011), and when constructing their own explanations, students seem to take for granted the meaning of data and routinely fail to explain the relation of the data to the claims (McNeill et al. 2008; Sandoval and Millwood 2005). Research has shown that one of the important reasons students faced difficulties in evaluating the credibility of evidence was that they lacked the criteria needed to be able to evaluate evidence (Wu and Hsieh 2006). Students need to understand the way evidence is used in science to validate knowledge claims, because so many of the situations in which citizens interact with science involve judgments about evidence (Gott and Duggan 1996).

Not many studies have been done on how to help students improve their analysis of the credibility of evidence. A study performed by Nicolaidou et al. (2011) used an instructional framework to support students' assessment of the credibility of evidence. According to these authors, in order to help students assess the credibility of evidence, there must be a good learning context. This context must be relevant to the students' lives, it must produce socio-scientific dilemmas, contain complex tasks in meaningful ways and make students need to assess the evidence, while working in a group, and provide opportunities for public discussions of the final decisions. But most importantly, students must compare different types of sources (data, reports, opinions, interviews) of various credibility levels, reflect on who the author of the evidence is, the author's background and what was the source of funding for producing each piece of evidence (Nicolaidou et al. 2011; Oliveras et al. 2013). The teacher and textbooks are the most important sources of information to which students have access, and they are used to being taught to accept the information from these sources without questioning them (Clark and Slotta 2000). However, increasingly, the Internet is now being used as a source of information (Butler 1995; Clark and Slotta 2000) and, therefore, students need to learn to check the data they find on this medium as it is the source they will use most in their lives outside school.

Students react in the same way as adults to sources of information. For some students, a source may be more credible if the source is only slightly more informed than the student. Students might prefer lower credibility sources closer to their own level (Clark and Slotta 2000). Another factor influencing students assessing the credibility of evidence is images. Relevant illustrations aid learning from text, and illustrations may help poor readers more than good readers. Images help students in various ways, evoking prior domain knowledge and establishing a preliminary mental model of the situation (Clark 2000). Students often choose to take one position or another completely at random and, therefore, it is very important to teach them the skills required to critique and analyse information sources in a reasoned manner (Linn 2000).

Schools certainly spend very little time on analysing and interpreting data but, on the other hand, in the curriculum, students are explicitly or implicitly expected to handle data and not raise concerns over the credibility of the evidence (Driver et al. 2000). The school science curriculum should include practice in questioning and manipulating different sorts of real data in a variety of ways (Tytler et al. 2001). There is no question that the assessment of the credibility of data requires explicit development of skills that help students to critically analyse data and evidence (Nicolaidou et al. 2011).

Objectives of the Research

1. To analyse which scientific ideas students use in their arguments and identify whether there are any differences according to their knowledge of science and age.
2. To analyse which data students use in their arguments and identify whether there are any differences according to their knowledge of science and age.
3. To identify various profiles of press article readers and detect whether there are any differences according to the students' scientific knowledge and age.

Project Description

Selection of the Article

The first stage of the research consisted of selecting a newspaper text[1] with scientific content. The article dealt with a study performed by Harvard University that showed that Google contributed to global warming. According to the author of the news article, Google's searches are of such a high quality because it uses several databases situated in different countries at the same time. As these powerful servers need a considerable amount of energy to function and cool down, they contribute to CO_2 emissions into the atmosphere to a greater extent than its competitors' servers. The article provided a lot of quantitative and qualitative data to back up the information. The article also contained the arguments put forward by Google to defend itself. The article did not at any point argue how Google contributed to the emission of CO_2 into the atmosphere.

The article was chosen because it dealt implicitly with many aspects discussed in the classroom on the concept of energy and also enabled students to perform a critical analysis. When this news story was published, it created a great deal of controversy, and contradictory information and data also appeared in various media, particularly on the Internet. This news story had previously appeared in 'The Times' newspaper although the same paper had subsequently corrected the story, stating that the assertions it contained had been interpreted incorrectly. As the information given in the text was the subject of much debate, the idea was for the students to check the information against other sources so that they could question it and be able to adopt a position on it. Another aim was to analyse whether the students with the most scientific knowledge (students of between 16 and 17 years old taking the science option) were best able to detect the key ideas on energy that appeared in the article and also conduct a better critical analysis of the information.

Subject Selection

The research was carried out at a secondary school in Catalonia (Spain). The school is in Barcelona and its students are from a medium to high sociocultural level. A total of 117 students aged 13–14 and 16–17 years old took part. The students came from four different classes: two classes of 13–14-year-olds (61 students), a class of 30 16–17-year-olds taking the humanities option and 26 16–17-year-olds taking the science option (a total of 56 16–17-year-olds). The 16–17-year-old students were in post-compulsory secondary education, and this

[1] http://grupsderecerca.uab.cat/liec/content/does-google-cause-pollution

was the first year they had chosen to follow a science or humanities study option. The four classes were taught by four different teachers. These ages were chosen because the topic of energy is dealt with for the first time in the curriculum at 13–14 years old and for the last time at 16–17 years old for students who choose the science option (26 students in our case). The activity was carried out in science class in the case of the 13–14-year-olds and as part of a science course within the core curriculum for all students in the case of the 16–17-year-olds. This course covers the study of current scientific problems or events with an emphasis on argumentation and is basically a course that imparts scientific information.

A meeting was held with the teachers of the classes involved in the research to present the proposal for the work. It should be noted that this type of activity had never been conducted in any of the classes and, therefore, it was something new for the teachers and students involved. The methodology to be applied in the classes was discussed in depth, but there was no detailed discussion of the scientific content of the article or of the research objectives. The activity was to be undertaken in the same way as any other classroom activity in diverse cooperative groups of four students.

In particular, there was a discussion on the need to encourage cooperative reading to aid comprehension of the text, and different cooperative reading strategies were suggested. It was emphasised to the teachers that it was important to encourage communication between the students and teachers and that this communication should facilitate self-regulation with respect to difficulties that would arise. Each teacher subsequently applied the activity to his/her class and collected all the students' written work generated throughout the activity. This written work made up the data used to analyse the findings.

Activity Design

To help the students with critical reading, a critical reading activity was designed based on the proposal of Oliveras et al. (2013). The activities were designed taking into account the three phases of the reading process (before reading, during reading and after reading). In the first phase, *before reading*, the students' preliminary ideas on the key information in the lead paragraph and the scientific knowledge were activated. The questions proposed to activate these ideas were 'Read the title and look at the picture. What do you think the news story is about? Which newspaper was it published in? Who wrote it?' The students were then given two questions to activate their scientific knowledge before reading the article: 'Write the content that you think you need to know in order to understand this news story. Does it have anything to do with what you have studied and with your knowledge?' Lastly, they answered the question in the title: 'Does Google cause contamination?' in accordance with their initial point of view.

In the second phase (*during reading*), the aim was to emphasise the regulation of the reading process based on cooperative reading in small groups. After reading the article, the students answered a series of questions, first individually and then they compared what they had written with their classmates to reach a final joint written piece of work. The purpose of the questions was to help the students reflect on the content of the news story and analyse the various points of view and arguments given by both sides in the article, as well as the data and evidence provided (Fig. 1).

The students then had to do some research on the Internet and were asked to check the information given in the text against other sources of information and select the most reliable source on the basis of certain criteria of credibility discussed earlier (Fig. 2). Once they had

Question to answer based on the reading	1st. individual piece of writing	2nd. piece of writing after comparing with classmates in the group
a. What is the first claim made in the article? What did the person say?		
b. What is the main argument given in the article to back up this initial claim?		
c. What data or evidence is given in the article to support the argument?		
d. Which arguments are given by Google to counter those given by Harvard University?		
e. What data or evidence is given by Google to support its arguments?		
f. What conclusion is reached in the article?		

Fig. 1 Questions designed for students to think about the content of the news story and analyse the various points of view and arguments

finished this part, they then pooled their work. They discussed the new information they had found on the Internet and compared it with the data given in the article.

The third phase, *after reading*, required the students to assess the scientific basis for the news stories and draw up a text arguing their viewpoint. Before writing the final discussion text, the students discussed the issues raised in the text, first in small groups and then with the whole class. They wrote their texts individually, answering the initial question posed in the article (Does Google cause pollution?). To help them write the text, they could follow the guidelines proposed. They wrote the text-based guidelines encouraging them to consider

- Look on the internet for information on two different websites on how many grams of CO_2 are emitted in each Google search to confirm or refute the data given in the article. Also make a note of any other arguments you find.

a. To do the research think of the key words to write down to do the search. Write them here first.

b. Results of the search:

Sources	mg or g of CO_2
Harvard University (La Vanguardia article)	7 mg
Google/(La Vanguardia article)	
Website: www.	
Website: www.	

c. Who says so? Write down the name(s) of the author(s) of the websites.

d. Which of the information is more credible? What helps you to decide?

e. Find other arguments on the internet (for or against Google's statements):

a)

b)

- Once you have found out the arguments given by Harvard University, Google or others, who do you think provides the most convincing evidence or proof? What is it?

- Do you think the author of the article supports one opinion over another? What evidence can you find in the text about what the author's opinion is?

- Realistically, what would we have to take into account to save energy when we search for information on the internet? And when we use computers?

Fig. 2 Internet research to verify the data given in the article their idea, formulate reasons supporting it and think of possible arguments against their idea and the evidence they could use to convince others (Osborne et al. 2004).

The activity was carried out over 5 days and took 5 h of class time.

Data Analysis

To analyze the data gathered in this study, three categories were defined. Category 1 analysed the scientific ideas that students used in their arguments. Category 2 analysed which relevant data the students selected in their final argumentative text. Category 3 analysed the profiles of press article readers. We assigned each category various levels. The levels were designed on the basis of the students' answers and were validated by two teachers with considerable professional experience.

To define the levels of category 1, 'identification of the main scientific ideas', we looked at whether the students connected their scientific ideas with the statements they had read in the news story. We took the lowest level (1) to correspond to students who only remarked that Google used energy without being more specific. We took the highest level of description to relate to students who made the connection between energy and CO_2 emissions (a connection that did not come up in the article).

To define the levels of the category 2, 'use of data from the text and other sources', we took as the basis the information that the students wrote in the final argumentative text. We believe that in order to evaluate media, students need to have the skills to select the evidence and then judge the credibility of sources. We took the lowest level (1) to correspond to students who did not use any information or data (either qualitative or quantitative) to make their arguments and the highest level to be students who knew how to identify all the relevant data, both in the text and on the Internet and to express it in the correct units.

In relation to category 3, 'to identify various profiles of press article readers', to define the types of critical reading profiles, we used as a basis the proposal of Norris and Phillips (1987) in relation to the different stances taken by readers with respect to a text and the definition given by McClune and Jarman (2011) of a critical reader. Three reader profiles were identified:

1 The credulous reader. Students who do not read critically and who validate the information based on whether a great deal of numerical data is included or copy sentences from the text without justifying or analysing them. They do not activate their ideas on science. They only focus on the information given in the newspaper article. They validate the information on the basis of whether the text includes a great deal of numerical data or of the prestige of Harvard University.

2 The ideological reader. Students who, despite finding different numerical data, take an initial ideological stance (ecologists, defenders of new technologies) and justify their arguments on that basis. These students adhere to their original position, some argue the benefits of new technologies although they may have side effects, and others, on the other hand, just concentrate on the possible effects on the environment.

3 The critical reader. Students who compare between the data, evidence or information given in the text, the information found on the Internet and their own scientific knowledge to reach a conclusion that takes into account various viewpoints. We consider students who carry out this process to be critical readers.

To assess the students' answers, the argumentative texts written by the students in the before-reading phase (first day) and in the after-reading phase (fifth day) were analysed.

Results and Discussion

The results of the research have been organised into sections in accordance with the objectives:

Results in relation to objective 1: analyse which scientific ideas the students used in their arguments and detect whether there are any differences depending on the students' knowledge of science and age

The results of applying the levels of category 1 (see Table 1) to the analysis of the texts written in the before- and after-reading phases are shown as frequency distributions in Table 2. To evaluate the association between the class group (13–14-year-olds, 16–17-year-olds, humanities option; and 16–17-year-olds, science option) and levels of category 1, Pearson's chi-square was used. This comparison was made before (pre) and after (post) reading the news story (see also Table 3).

Before reading (Table 2, column 'pre'), identification of the main scientific ideas does not depend on what school year the students have reached or their scientific knowledge ($p=0.0586$). Therefore, we did not detect any significant differences between the 13- to 14-year-old students and the 16–17-year-olds, or the 16–17-year-old students studying science and the 16–17-year-olds studying humanities. In this before-reading phase, most of the

Table 1 Levels of category 1: 'identification of the main scientific ideas'

Levels	Researcher interpretation	Representative statement
1	The student does not identify that it is a problem to do with energy or identifies the problem to do with energy without mentioning any scientific ideas.	'*Yes because we use energy when we connect to the Internet*'
2	The student identifies some of the scientific ideas (sources of energy, transformation of energy, and transfer of energy in the form of heat or degradation of energy) but does not provide scientific justification of the relationship between CO_2 and energy.	'*I think that Google causes pollution through the Joule effect which is when electrical charges move, they create electricity because a part of the electricity is converted into heat*'
3	The student identifies some of the scientific ideas (sources of energy, transformation of energy, and transfer of energy in the form of heat or degradation of energy) and provides scientific justification of the relationship between CO_2 and energy (emission of CO_2 relating to the burning of fossil fuels…).	'*Yes, because the equipment that makes it work uses energy and, depending on where the energy comes from, it causes more or less pollution when it is produced…*'
4	The student identifies all the scientific ideas (sources of energy, transformation of energy, and transfer of energy in the form of heat or degradation of energy) and provides scientific justification of the relationship between CO_2 and energy.	'*…they use energy obtained from power stations that need coal to heat water and make the water vapour to generate electricity. These processors also heat up and need to be cooled down, and energy is also needed to refrigerate them.* *Another important point that shows us that Google causes pollution is the speed of the searches it makes. A search is not just sent to one server but to thousands spread all over the world, and the first server to find the answer sends it to us. Therefore, it does not use just one but several servers for the same search and works quickly and effectively.…*'

Table 2 Category 1: identification of the relevant scientific ideas used to construct arguments before ('pre') and after reading ('post') depending on the students' age and knowledge of science (*N*=117)

	Level 1		Level 2		Level 3		Level 4	
	Pre	Post	Pre	Post	Pre	Post	Pre	Post
13–14-year-olds	93.5	55.7	1.6	18	4.9	24.6	0	1.6
16–17-year-olds, humanities option	86.6	7.7	10	46.2	3.3	23.1	0	23.1
16–17-year-olds, science option	84.6	30	0	30	15.4	30	0	10

students were at the lower end of the scale. These students had difficulties activating their knowledge of science and did not realise that the article dealt with an energy problem. These students raised different kinds of arguments in order to justify the question. For instance, they used irrelevant arguments such as '*Google is necessary for looking for information you can't find in the encyclopaedia*', authority criterion like '*Google causes pollution because the studies done at Harvard showed that and they made a detailed study of the situation*', socialisation criterion such as '*Google can't create pollution because a lot of people use it*' or no link was made between energy and computer use: '*No, because Google is a search engine and is not a tangible thing and, therefore, an intangible thing can't create pollution*'. In level 2, students identified one of the relevant scientific ideas (the cooling of the servers), but they did not make a link between pollution and CO_2 emissions. Only a few students identified some of the relevant scientific ideas and justified, using a scientific basis, the link between CO_2 emissions and the burning of fossil fuels (level 3), and no students identified or made a scientific link between all the scientific ideas studied (level 4).

It should be noted that before reading the text, the students adopted different attitudes with respect to the text. There were students who thought that just by reading the title and subtitle, they had sufficient information to answer the question, both for and against: '*Google causes pollution because the studies conducted by Harvard have shown this and they did a detailed*

Table 3 Contingency table, category 1 (before, pre) versus category 1 (after, post) depending on age and scientific knowledge (*N*=117)

Category 1, before (pre) (%)	Category 1, after (post) (%)			
	Level 1	Level 2	Level 3	Level 4
13–14-year-olds (*N*=61)				
Level 1	59.6	17.5	22.9	0
Level 2	0	100	0	0
Level 3	0	0	66.7	33.33
16–17-year-olds, humanities option (*N*=30)				
Level 1	30.76	30.76	26.9	11.53
Level 2	0	33.3	66.7	0
Level 3	0	0	100	0
16–17-year-olds, science option (*N*=36)				
Level 1	9.1	45.45	18.18	27.27
Level 2	0	50	50	0
Level 3	0	50	50	0

study of the situation' (13–14-year-olds and 16–17-year-olds) or '*Google cannot cause pollution because many people use it*' (13–14-year-olds and 16–17-year-olds), and others thought that they did not have enough information to form a judgment and preferred not to give an opinion: '*I do not know because I have not read the article yet and I do not know anything about how Google affects global warming*' (16–17-year-olds) or '*Lack of information to decide*'. We detected that the same argument was sometimes used to confirm the claim that Google caused pollution ('*Google is a connection to Internet and therefore it causes pollution*') and at other times to refute it ('*Google does not cause pollution because it is a computer program*'). All the students answered the question with very short texts of a maximum of three sentences to back up their ideas.

After reading (Table 2, column 'post'), it was observed that the identification of the main scientific ideas differed significantly depending on age ($p<0.001$), which indicates that reading the article helped the older students to use the ideas in their arguments.

Most of the 13–14-year-old students are included in levels 1 and 2 (73.7 %) and did not understand the relationship between energy and CO_2 emissions: '*My idea is that Google causes pollution…. When someone does a search, the contents of that search go to different servers around the world, many kilometres away, a lot of energy is used and CO_2 is generated. Proof of the use of many servers is the high speed at which a search is made…*' (level 2, 13–14-year-olds). The texts of the 13–14-year-old students in most cases showed that their scientific knowledge was not entirely assimilated, and they confused ideas or did not verbalise them and, therefore, it was not clear whether they had understood them. Some students confused efficiency (little degradation of energy) and efficacy (high-speed searches): '*…In order to work efficiently, Google has to use a lot of energy. Because the servers need a lot of energy….*' (13–14-year-olds). Some students mentioned some of the scientific ideas they had studied, such as CO_2 pollution and the transfer of energy but they had not assimilated them very well, and when it came to describing them, they were confused: '*My idea is to confirm that Google contributes to global warming and the reasons why are that the computer heats up with each search and that generates CO_2…*' (13–14-year-olds, level 2). Some students were not clear that CO_2 only originates from the burning of fossil fuels and talked about CO_2 coming from nuclear power stations: '*Google causes pollution due to the quantity of energy used by its servers to perform each search, as well as the energy they need for cooling. In this way, they contribute to CO_2 emissions into the atmosphere because the energy that the servers use comes from nuclear power stations that emit this gas…*' (13–14-year-olds, humanities option). Only 26.3 % of the 13–14-year-old students are included in levels 3 and 4 and were able to make a link between energy consumption and CO_2 emissions.

When comparing the results of the 16–17-year-old students taking the science versus humanities options, no significant differences were detected ($p=0.101$), but if we focus on the level 3 and 4 answers, we can see that in the case of the science students, half (50 %) are included in the highest level, 4 (see Table 5), and were able to identify all the key concepts relating to the topic (energy sources, energy transfer in the form of heat, transformation of energy and degradation of energy) and relate them to the relevant scientific ideas. On the other hand, in the case of the students taking the humanities option, most of them (75 %) are included in level 3 (they identified some of the key ideas relating to the topic but not all of them, and they justified the relationship between CO_2 and energy on the basis of the burning of fossil fuels). An example is: '*The answer in my opinion is yes. Google uses powerful servers to offer results for each search. As everyone knows, all machines, whether they are computers or trains, need energy to function. And where do they get that energy from—power stations…*' (level 3, 16–17-year-olds, humanities option). This student did not mention the energy needed for cooling.

In the final argumentative text, the level 4 students identified all the relevant claims made in the article and backed them up using their knowledge of energy. One example of the arguments used is: '*Google causes pollution and this is a fact. I will not focus so much on the quantity of CO_2 it emits into the environment but more on other factors which definitely make Google a polluter. Google has servers and large processors spread all around the world. They use energy obtained from power stations that need coal to heat water and make the water vapour to generate electricity. These processors also heat up and need to be cooled down, and energy is also needed to refrigerate them. Another important point that shows us that Google causes pollution is the speed of the searches it makes. A search is not just sent to one server but to thousands spread all over the world, and the first server to find the answer sends it to us. Therefore, it does not use just one but several servers for the same search and works quickly and effectively.…*' (level 4, 16–17-year-olds, science option).

It was observed that the students had difficulties identifying all the claims contained in the news story and activating their scientific ideas on energy in order to be able to write the final argumentative text. Table 4 shows the claims that arose in this final text and the frequency detected. The ideas that the students found the most difficult to integrate into their arguments were those relating to the energy needed to cool the servers and energy efficiency and efficacy, despite the fact that they appear in the news story.

The fact that the students identified the main claims in the article does not necessarily mean that they activated the scientific ideas it contained. For example, in the case of the first claim '*Google needs a lot of energy to function*', the students had to think that the energy used by Google is used both for the functioning of the computer and the servers and is obtained from sources which, for the most part, involve the burning of fossil fuels, which results in CO_2 being produced. Regarding the second claim, students had to activate the idea of energy transfer in the form of heat. For the third claim, they had to detect that the faster the searches, the more effective they were. The students in level 4 were those that identified all the claims in the article and linked them to the scientific ideas they contained.

When comparing the students' presentation of their scientific ideas before (pre) and after reading the text (post), an evolution of the scientific ideas could be observed (Table 3). There were students for which no evolution was observed. This was particularly true among the 13–14-year-olds, 59.6 % of whom were still in level 1 for the final argumentative text, presumably due to the fact that the ideas in the text were not meaningful for them and they did not have sufficient knowledge to be able to justify their relevance. It was also observed that the students taking the science study option showed the greatest evolution of scientific ideas.

It is interesting to note that of the 16–17-year-olds in the science group that scored level 3 on the pre-reading activity, half of them dropped to level 2 on the post-reading argument (Table 3). Although these students had the scientific knowledge needed, they did not apply it in their final argumentative text. A detailed reading of these texts allowed us to identify how the students prioritised the use of numeric data over the use of scientific arguments. Also, we found that these students gave priority to figures, either to back up the information they had read

Table 4 Claims arising in the news story and frequency detected (N=117)

Claims	Frequency (N=117)
Google needs a lot of energy to function	109
Google needs energy to cool down the servers	18
Google's headquarters are very energy-efficient	4
Searches are rapid	11

or to criticise it by comparing the data in the text with data that they had found on the Internet.

Results in relation to objective 2: analyse the use of data from the text and other sources and detect whether there are any differences depending on the students' knowledge of science and age

This analysis was performed on the basis of the argumentative text. The results of applying the levels of category 2 (see Table 5) to the final argumentative texts written by the students are shown as frequencies in Table 6. To evaluate the association between the class group (13–14-year-olds; 16–17-year-olds, humanities option; and 16–17-year-olds, science option) and the use of data, we used Pearson's chi-square test. This comparison was made before (pre) and after (post) reading the piece of news.

The results indicate that use of the data in the final argumentative text varied depending on the age and scientific knowledge of the students ($p=0.0066$). Most of the 13–14-year-old students (73.8 %) either did not use any type of data or quoted irrelevant information (levels 1 and 2). These students did not mention the grams of CO_2 emissions per search and based their arguments on other data in the news story based on analogies with everyday events, such as '*Google causes as much pollution as 9,333 cars travelling 1 km*' or '*Google causes pollution because it produces as much CO_2 as when a kettle is boiled'*. Therefore, we can infer that the students had difficulty identifying the relevant data relating to amounts and units.

For the 16–17-year-old students, if we compare the results of the students taking the science and humanities options, significant differences can be detected. If we focus on the answers in level 4, we can see that 15.4 % of science students were in the highest level and able to use the information in the text and on the Internet, compared with 6.7 % of the students studying the humanities option in this situation. One example of level 4 can be found in this student who is able to (1) use the data in the text: '*According to the study mentioned in the La Vanguardia newspaper, a search causes the emission of 7 mg of CO_2. This quantity is not at all large if we*

Table 5 Levels of category 2: 'use of data from the text and other sources'

Levels	Researcher interpretation	Representative statement
1	The student does not use any information.	'*Google is a huge enterprise that gets every day thousands of visits a day. Every visit pollutes a little bit…*'
2	The student uses qualitative and/or quantitative data with inappropriate units or uses data in the text that are not relevant.	'*Google emits the same amount of CO_2 every day as 9,333 cars travelling a whole kilometre*'
3	The student uses relevant qualitative and/or quantitative data from the text with the appropriate units.	'*A search causes the emission of 7 mg of CO_2…*'
4	The student uses relevant qualitative and/or quantitative data from the text and other sources with the appropriate units.	'*…a search causes the emission of 7 mg of CO_2. This quantity is not at all large if we are talking about only a few searches. However, the website receives about 200 million hits per day. You do not need to do the maths to see that this gives a very high number of grams of CO_2 …we found Internet sites that talked about emissions of 7 g of CO_2 per search but others talked about milligrams.…*'

Table 6 Category 2: use of data from the text and other sources to create arguments after reading depending on age and scientific knowledge (N=117)

	Level 1 (%)	Level 2 (%)	Level 3 (%)	Level 4 (%)
13–14-year-olds	57.4	16.4	24.6	1.6
16–17-year-olds, humanities option	30	13.3	50	6.7
16–17-year-olds, science option	23	27	34.6	15.4

are talking about only a few searches. However, the website receives about 200 million hits per day. You do not need to do the maths to see that this gives a very high number of grams of CO_2*…*", and (2) compare data from different sources:'.... *we found Internet sites that talked about emissions of 7 g of* CO_2 *per search but others talked about milligrams. Also, we are given Google's opinion, which reduces to less than one-third the figure mentioned by the study carried out by the prestigious University for the* CO_2 *emissions as the result of a search….*' (level 4, 16–17-year-olds, science option).

We detected that although some of the 16–17-year-old level 2 students could identify the relevant data in the text, i.e. the grams of CO_2 emissions into the atmosphere, they expressed it in different units to those used in the news story. When doing the research on the Internet, these students found that the figure that appeared in different websites was 7 g per search (compared to the 7 mg stated in the news story), and they put that figure in the final text, without specifying that the source was not the article or assessing critically whether 7 g per search was a very high number. Therefore, in the case of the 16–17-year-old students, a difficulty was not so much identifying the relevant data but knowing how to analyse the value of that data critically and specify the source of the information they found.

It is worth noting that the students gave relatively little importance to the use of data to back up their ideas in the final text. Despite at first thinking that the students would use a lot of numerical data to support their ideas, since figures appear in the article on CO_2 emissions, only 53.6 % of the 16–17-year-olds and 26.2 % of the 13–14-year-olds used the data properly in their arguments (levels 3 and 4).

We did not find a link between the students' level of activation of the scientific ideas and the type of data they used (p=0.191) (see Table 7). At first we thought that the students with the highest level in science would also use the most relevant quantitative and qualitative data in the article and compare it with the data obtained from other sources, but there were quite a few students in the highest science level who appeared in the lowest level for data, i.e. they wrote the final argumentative text without using any data. It would appear that for these students, ideas were more important than supplying evidence. It is also true, however, that no student in the highest science level used qualitative or quantitative data with inappropriate units or used

Table 7 Contingency table, category 1 (identification of relevant scientific ideas, after reading) versus category 2 (use of data from the text, after reading) (N=117)

Category 1: main ideas (%)	Category 2: data (%)			
	Level 1	Level 2	Level 3	Level 4
Level 1	36.4	18.2	36.4	9.1
Level 2	23.8	28.6	42.9	4.8
Level 3	13.3	20	60	6.7
Level 4	44.4	0	22.2	33.3

irrelevant data from the text (level 2).

Results in relation to objective 3: identify different newspaper article reader profiles

To analyse the results of the research with respect to the third objective, we applied the category 3 levels to the analysis of the final argumentative texts written by the students (see Table 8). The frequency distribution for the various profiles defined is shown in Table 9. To evaluate the association between the class group (13–14-year-olds; 16–17-year-olds, humanities option; and 16–17-year-olds, science option) and the reader profiles, we used a Pearson's chi-square test. This comparison was made before (pre) and after (post) reading the piece of news.

The results show that the type of reader profile does not depend on school year or science knowledge, and all show similar distributions ($p=0.564$) (see Table 9). Most of the students come under profile 1, the 'credulous reader', and only 10.3 % of the students can be described as being profile 3, critical readers. However, it appears that in the group of 16–17-year-old science students, there was a greater percentage of students in level 3, although the number was not significant due to the size of the sample.

The profile 1 or credulous reader students, despite some of them activating their science knowledge of energy, did not compare the data from the text with other sources. To write their final argumentative text, these students trusted the information and data given in the news story that theoretically came from Harvard University, even though they found different data on the Internet. One example of this type of text is as follows: '*The answer to the above question can be found in this text. Maybe it seems a bit strange that Google causes pollution but it should be remembered that Harvard University* (*the United States*) *has carried out a study that shows that the popular search engine contributes to global warming.… The main item of information given by Harvard is that the standard search produces 7 mg of* CO_2*…*' (13–14-year-olds).

Despite finding different numerical data on the Internet, the profile 2 ideological reader students took a very strong initial ideological stance and based their arguments around it. These students activated their scientific ideas when reading the text but did not compare them with the data from other sources, and formed conclusions based on their ideas. We identified two types of ideological stances which we called 'ecologists' and 'defenders of new technologies'. In their arguments, the ecologists claimed that Google was guilty of global warming. When doing the Internet research, these students only looked for ecology websites to find arguments to confirm their initial point of view. We show below an example of a text of a profile 2 ecologist student. Although this student gives a clear opinion, she also identifies and accepts arguments from the opposing point of view: '*I think*

Table 8 Levels of category 3 'reader profiles'

Levels	Profiles of newspaper article readers	Representative statement
1	Credulous reader	The student reproduces the information he/she reads in the newspaper without comparing it with other sources or his/her own ideas.
2	Ideological reader	The student bases his/her arguments on his/her beliefs without taking into account the information he/she has read.
3	Critical reader	The student compares the information read with his/her own knowledge of science and with the information found in other sources.

Table 9 Category 3: reader profiles by age and science knowledge (N=117)

	Credulous reader (%)	Ideological reader (%)	Critical reader (%)
13–14-year-olds	73.8	19.7	6.6
16–17-year-olds, humanities option	73.3	16.7	10
16–17-year-olds, science option	61.5	19.2	19.2

that Google is one of the companies causing the greenhouse effect, destroying the atmosphere by emitting CO_2 because its servers need a large amount of energy to function and cool down. As I think that Google causes pollution I believe more in the figure of 7 mg of CO_2 given by Harvard University that the figure given by Google. An ecology website also confirms this (www.ecologiaverde.com). *Google causes the same amount of pollution as 9,333 cars in 1 day per kilometre. The arguments against my idea could be that Google has plans for the future such as cooling its servers using sea water and that, before the Internet existed, more pollution was caused by using public transport and more time was lost*'(13–14-year-olds).

The other profile 2 group of students are the defenders of new technologies who defend new technologies regardless of the information they read. For example, one said: '*I think that although Google causes some degree of pollution it is a very useful tool today and, perhaps, for each search we do we create pollution, but many other things that are not so useful cause pollution and nobody accuses them. Therefore, I think we could reduce the useless searches we do every now and then but in order to reduce pollution we need to reduce pollution in other places as well. Also, I think that one of the arguments given by Google is very convincing which is that last year the company invested 33.6 million euros in renewable energy projects and a company does not spend that much money on something in which it does not believe or is against*' (16–17-year-olds). This student did not compare the data on emissions in the article with other sources or analyse the intentions of the author of the news story but concentrated on her own arguments to defend Google.

Only 14.7 % of the 16–17-year-old students and 6.6 % of the 13–14-year-olds were critical readers (profile 3). These students compared data or evidence given in the newspaper with information they found on the Internet and reached their opinion taking into account their scientific knowledge. These students realised that there were differences between the data on CO_2 emissions that appeared in the article, theoretically provided by Harvard University, and the data from other sources, and in the final argumentative text they commented on these differences. Nine 16–17-year-old students found the original news story on the Internet, and in the final argumentative text, they noted that it was 'The Times' newspaper that started the controversy. This newspaper interpreted a study by the university in a way in which its author's statement was not entirely correct. The following is an example of a text written by a critical profile student: '*It seems the Californian giant, "Google Corporation TM", whose products we use every day, is accused of being responsible for the emission of over 7 g of CO_2 into the environment per Google search. However, the study performed by Harvard does not even mention Google, let alone that it produces 7 g of CO_2 per search. It would appear that the prestigious London newspaper, "The Times", wants to attack Google Corporation TM for reasons known only to them. According to Google, only 0.02 g of CO_2 are emitted per search and not 7 g as stated in the prestigious newspaper in question. Wissner-Gross, the scientist to whom the statements were attributed, stated as follows to CNET: "Harvard carried out a general study of Internet searches but at no time was Google mentioned or investigated". "The Times" defended these accusations claiming that what it had published had been misinterpreted, but the way in which the articles were written did not leave much room for* *any other interpretation. In fact, "Google Corporation" is well known for its involvement in ecological campaigns to reduce emissions of the pollutant gas. So yes, Google does cause pollution but not as much as some would claim. However, if we multiply the 0.02 g by all the searches made every day, by the servers used for each search, by the number of sources of electricity used by each computer, the figure is enormous*' (16–17-year-olds).

Before reading the news story, this student had not adopted any opinion with respect to the question, 'Does Google cause pollution?' saying that he needed information to decide. After reading, he took a critical stance. Except in one case, all the students who upon reading the title and subtitle at the beginning of the activity did not adopt a position, claiming that they lacked information, in the argumentative text at the end could be classified as having the critical profile. Therefore, we can deduce that the predisposition with which students start reading a news story can have an effect on the final opinion they adopt.

Overall, we have seen that there is a link between the level of activation of scientific ideas and critical reading, both among the 13–14-year-old students (p=0.036) and the 16–17-year-olds (p=0.032). The students in a higher science level tended to be more critical (see Table 10).

Conclusions and Implications

The results of this study show that the reading activity relating to this press article helped the students to connect science at school with the real world. We believe that the reading of texts with scientific content from different sources has a fundamental role to play in science learning, not only to improve the understanding of scientific phenomena but also to help students develop a series of skills for use in the world outside school and be able to debate problems of social relevance using scientific arguments in a critical manner. This connection is not made automatically and, therefore, activities need to be designed to connect the scientific ideas discussed in the texts with their scientific basis. We consider that working on reading activities based on newspaper articles (Oliveras et al. 2013) can be another way to help students internalise the scientific concepts they have learned in the classroom, and the topic of energy, which comes up in many articles, should also be explored from this perspective.

The students' answers show that just reading the title and subtitle and looking at the pictures of a news story are not enough to help them activate their knowledge of science. We did not detect any significant differences between the 13–14-year-olds and the 16–17-year-olds or between students taking the humanities and science options. However, we think that this initial contact with the text, followed by group work, can predispose students to read the article and relate it to their ideas on energy.

We detected significant differences in the level of science of the texts written by the 13–14-year-old students and the 16–17-year-olds after reading the article. In the final argumentative text, quite a number of 16–17-year-old students justified scientifically the link between CO_2

Table 10 Contingency table, category 1 (identification of relevant scientific ideas, after reading) versus category 3 (reader profiles) (N=117)

Category 1: main ideas (%)	Category 3: newspaper article reader profiles (%)		
	Level 1	Level 2	Level 3
Level 1	71.1	24.4	4.5
Level 2	87.5	3.1	9.4
Level 3	63.3	23.3	13.3
Level 4	40	30	30

emissions and energy consumption, which is not a relationship expressly mentioned in the article. Most of the students in the highest science level were the 16–17-year-olds who had chosen the science study option. Some of these students were able to identify all the key concepts of the topic (sources of energy, energy transfer in the form of heat, energy transformation and the degradation of energy) and relate them to the relevant scientific ideas. Therefore, it was observed that it was necessary for the students to have studied energy throughout their time at school because, despite the key ideas presented to the 13–14-year-olds, it was the older students taking the science option who were able to apply them to a real-life context.

The scientific ideas activated by the students were identified using the argumentative text. It was observed that only a few arguments relating to the efficiency and effectiveness of the servers appeared in the final argumentative text. The idea of energy transfer through heat was also absent. This made us think that the students had not constructed these scientific ideas and, therefore, they were not able to identify the claims made in the article on these issues. We would agree with Papadouris et al. (2008) that it is necessary to work on the topic of energy as the transfer of one part of the system to another and not take the traditional approach that concentrates exclusively on forms of energy.

We detected that many students only identified one statement in the news story, 'Google uses energy', and used this as the basis for their arguments, without looking for connections with the related scientific ideas or with other claims in the text to back up their ideas. Students need to be helped to find connections between the claims and the related scientific ideas as they do not make this connection automatically (McNeill 2008). Accordingly, a didactic implication is that when working on texts in class, in addition to looking for the relevant claims they contain, there should also be a class discussion on which scientific ideas are associated with each of these claims.

It was seen that the students had difficulties using relevant data in the final argumentative text. Significant differences were observed between the 13–14-year-olds and the 16–17-year-olds. While the 13–14-year-olds could not identify the relevant data in the text, the 16–17-year-olds were able to identify it but not use it in the final argumentative text. We observed that the 16–17-year-olds gave great importance to the type of text they were writing and not much to using numerical data to back up their ideas. This could be due to the fact that the text was not written as part of the physics class but as part of the scientific information course. It would be necessary to explore in greater depth the importance of using quantitative arguments to express a scientific basis. According to McNeill (2011), in a good argument, the data must be appropriate and sufficient to back up the argument. It should be noted that when the students used data in the final argumentative text, it mainly came from the article, and very few students used data and arguments from the Internet.

One suggestion for improving the identification of relevant claims and data in a text is for the students, interacting in cooperative group work, to verbalise, discuss and agree on the information they considered to be relevant. Once all the information and claims appearing in the news story have been identified and agreed upon, they should be compared with other sources to find evidence to back up the claims. According to Nicolaidou et al. (2011), cooperation between students improves the identification and analysis of evidence. In this research, a step was made in this direction but this cannot be achieved through a single activity (Oliveras et al. 2013).

With respect to the reader profiles, it should first be noted that various viewpoints were expressed (in favour of Harvard, in favour of Google and points of view in between). Most of the students believed the information that appeared in the press even though they may have found other information on the Internet or information that did not agree with their knowledge of science (the credulous reader). This finding coincides with other research studies (Phillips and Norris 1999; Oliveras et al. 2013). Only 10.3 % of the students were critical with respect to the information (critical reader); other students (18.8 %) gave priority to their ideas on ecology or the benefits of new technologies over the information they read and, therefore, they are readers we classified as ideological readers. It should be noted that the critical students in the before reading stage mostly said that they did not have enough information to answer the question and, therefore, they adopted an open attitude to the reading. According to Yang (2004), it seems that most students believe knowledge can provide certain answers to all problems. It is very important to read texts from newspapers and other sources to help students to analyse real-life problems from an open and thoughtful perspective.

It was detected that in the final argumentative text, most of the students, except for the critical students, gave arguments from the text, and few students commented on the need for other information to verify the news story and therefore have the evidence on which to base their point of view. It is very important for students to compare information from the press with other information, in this case, from the Internet, in order to be able to validate the information they read. We think that this aspect needs to be worked on much more in science classes. It is not sufficient merely to look for information on the Internet, but students must also compare, analyse and discuss the data they find with their classmates and teachers, because discussion helps them to reflect on these differences.

In our research, we observed that there is an association between the type of argumentative text written by students and the level of activation of scientific ideas. The students with the highest demonstrated scientific reasoning powers were the ones who constructed the best written texts and vice versa. We think it would be interesting to examine this association in depth in further research.

To summarise we believe that in order to apply knowledge of energy to a text, students must have a well-constructed concept of energy. Students who had assimilated this concept in all its complexity were able to identify the relevant claims and information in the text and, thereby, activate their ideas on science. However, it is not sufficient to interpret the text scientifically; students must also be supported to adopt a critical stance on the information they read (McClune and Jarman 2011; Nicolaidou et al. 2011). Teaching them to analyse a press article critically is essential if our students are to acquire the facets of a critical reader. At the same time, they are able to learn more about science and become more competent at using scientific knowledge.

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