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Dialogic Scientific Gatherings: The Promotion of Scientific Literacy Among Children

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Abstract

The participation of citizens in democratic societies depends on their ability to understand scientific knowledge and apply it to everyday life situations. Thus, promoting scientific literacy from an early age should be among the main priorities in democratic societies. Dialogic Scientific Gatherings (DSGs) have successfully promoted scientific literacy among adults. This research intends to take a step forward in studying DSG implementation's transferability in promoting scientific literacy in primary school children from a culturally diverse school placed in a low socioeconomic neighborhood in Spain. Drawing upon Communicative Methodology, this case study has collected data through semi-structured interviews and communicative observations. The results show that (1) DSG enhance scientific literacy, specifically instrumental learning, analytical and critical thinking and social abilities and (2) the promotion of scientific literacy has an impact on decision-making and participation in society. Furthermore, although this research is a case study implemented in one school, it shows that DSG can be transferred to a culturally diverse school.

Keywords

dialogic scientific gatherings, scientific literacy, science education, vulnerable children

Introduction

Nowadays, the spread of fake news and over-information must be addressed (Allen et al., 2020). According to Pulido et al. (2020), although news based on scientific evidence are more likely to be retweeted throughout social media, it is also true that fake news are more likely to be stated at the very first moment. Drawing on the analysis of the slip of fake news throughout social media, Pulido et al. (2020) conclude that sharing scientific knowledge on an open-access basis (namely, throughout social media apps and/or scientific platforms) provide individuals with the opportunity to differentiate between false versus truthful information. The ability to distinguish between fake news and evidence depends significantly on people's scientific literacy, including reading, understanding, and making sense of scientific concepts and applying them to their daily lives (Pandya & Dibner, 2019). In *The Sociology of Science*, Merton and Gaston (1977) discussed the importance of sharing scientific knowledge with people beyond the scientific community to open up real opportunities for individuals to participate in a more democratic and participative society. He suggested that promoting the interaction between scientists and non-academic individuals improves the scope of scientific knowledge, making it more reliable.

Further research has provided extensive evidence on the benefits for science and society of the dialog (interaction) between scientific community and non-academic individuals (Aiello et al., 2021; Flecha, 2020). In this line, we define *scientific literacy* as "the ability to engage with science-related issues, and with the ideas of science, as a reflective citizen" (OECD, 2013, p. 7). Scientific literacy has become fundamental in the last decades.

Even though scientific literacy is essential for individuals to participate in democratic societies fully, inequalities in accessing scientific knowledge still exist worldwide. The ones who suffer the most from these inequalities are people from vulnerable groups, such as ethnic minorities, migrants, children from non-academic contexts, and individuals from low socioeconomic status (European Commission, 2013; Pandya, 2012). These inequalities represent a problem for both citizens (especially people from these vulnerable

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groups) and scientists. On the one hand, citizens with lower scientific literacy levels face more obstacles accessing scientific innovations in their daily lives (Apter et al., 2008; Paasche-Orlow et al., 2018). On the other hand, the lack of diversity among scientists indirectly prompts a biased scientific production, bringing results that do not respond to everyone's needs (Soler & Gómez, 2020).

Previous studies suggest that scientific literacy inequalities exist since the beginning of the school trajectory, and they increase during school years if they are not appropriately addressed (Kähler et al., 2020; Morgan et al., 2016). These inequalities affect children's academic achievement, including language and reading skills (Capitelli et al., 2016; Thier, 2002). These gaps become visible in surveys such as PISA or TIMSS. Students of a migrant origin or low socioeconomic background tend to perform lower than their peers in these international assessments (EAPC, 2016; Instituto Nacional de Evaluación Educativa [National Institute of Educational Evaluation], 2015). One example in this regard is the case of Roma, who represent the most significant ethnic minority in Europe. According to FRA [European Union Agency for Fundamental Rights] (2014), Roma tend to fail more often than non-Roma students (89% vs. 38% respectively). Therefore, approximately 10% of Roma achieve secondary level of education, while among the general population this situation raises up to 73%.

Considering how these inequalities have been present since early ages, the school becomes essential for promoting scientific literacy for all children, especially for students from ethnic minorities, migrant origin, or low socioeconomic status. In this context, Dialogic Scientific Gatherings (DSGs) are a type of evidence-based action that can be implemented to promote scientific literacy (Buslón et al., 2020; ScienceLit Project, 2018). DSGs have been implemented with adults for more than 40 years and have successfully promoted their scientific literacy. However, no studies have addressed the transferability of DSGs to school-aged children yet. Hence, this article aims to discuss how Dialogic Scientific Gatherings (DSGs) may encourage children's scientific literacy in an elementary school. Participating in the DSGs, 10-year-old children may engage with sophisticated scientific vocabulary, deal with specialized concepts, and develop a sense of critical thinking concerning scientific matters. Furthermore, drawing on their dialogue, children may expand their scientific knowledge and their understanding regarding those concepts and scientific ideas emerging from the readings drawing on the shared dialogue with all the participants in the gathering, since everyone shares his/her understanding of the reading using validity claims to justify his/her contributions.

State-of-the-art

Skills related to scientific literacy (such as reading with understanding, analyzing, and thinking critically) have become essential for citizens to actively participate in our society (based on the access and management of large amounts of information and data). Miller (2012) claims that "the health of democratic societies will depend in part on the ability of citizens to read, hear, understand and make sense of scientific and technical issues of the day" (p. 217) because these abilities promote empowerment and democratic participation of citizens in decision-making processes.

According previous studies, higher levels of scientific literacy are related to a better health condition (Rowlands et al., 2015; Rudd, 2010; educational levels and attainment (Morgan et al., 2016), empowerment and democratic participation (Miller, 2012; Rudolph & Horibe, 2016; Vanegas Muñoz et al., 2019), employment (Austin & Arnott-Hill, 2014), and decision-making (Süerdem & Çağlıyor, 2016), among other significant benefits.

Given the importance of scientific literacy for current societies, promoting scientific literacy and overcoming existing gaps would be a priority for schools and educational stakeholders in the coming years. However, to promote scientific literacy, it is crucial to start working the sooner, the better, starting from the early school years if possible (Cavagnetto, 2010; Papadakis et al., 2021; Vieira & Tenreiro-Vieira, 2016).

Different approaches can be followed when designing interventions to promote scientific literacy successfully. Several studies point to the impact of interventions focused on argumentation, including written and oral argumentation (Archila et al., 2018; Casado-Ledesma et al., 2021; Cavagnetto, 2010). For example, Cigdemoglu et al. (2017) conducted an intervention based on argumentative practices around acids and bases, finding that argumentation boosted scientific literacy, especially in the domains of knowledge and competency. In the same vein, Hand et al. (2018) found that argumentative practices significantly impacted children's critical thinking in science classrooms, especially those from low socioeconomic status and migrant origin. Dai et al. (2021) also concluded that argumentative practices around historic scientific narratives brought significant improvement in terms of science learning and understanding of the nature of science.

However, most of these interventions involve written argumentation practices instead of oral argumentation, despite the benefits of oral argumentation and dialog for science learning. Booth et al. (2020) studied the impact on the emerging scientific literacy of talks between parents and children. They found that scientific literacy emerged when parents raised questions and invited children to think critically and not when parents provided scientific explanations. Therefore, implementing evidence-based actions based on oral argumentation and egalitarian dialog effectively promotes children's scientific literacy.

According to previous research, DSGs implemented for more than 40 years in adult education schools (Soler, 2015) may be an example of actions promoting scientific literacy

being successful in the sense that they increase participants' scientific understanding (García-Carrión, 2015). In the same vein, further research provides evidence on the fact that DSGs have achieved social impact promoting the scientific literacy of the participants (Buslón et al., 2020; ScienceLit Project, 2018).

DSGs have been successfully implemented in several and diverse school contexts (López de Aguileta et al., 2020; Ruiz-Eugenio et al., 2020; Salceda et al., 2020). However, unlikely to studies conducted with adult learners (Díez-Palomar, 2020; Garcia Yeste et al., 2018), there is still a gap in reporting research contributions from implementing DSGs with children.

In this sense, they appear to be a great educational action to promote scientific literacy among students. This study discusses how DSGs work when transferring them into primary education in a culturally diverse school environment placed in a low socioeconomic neighborhood in Spain.

Methodology

Objectives of the Study

This study aims to analyze the impact of DSGs on developing the scientific literacy of a group of children from a school placed in a low socioeconomic neighborhood in Tarragona (Spain). As mentioned above, DSGs have been implemented for years with adult participants but not with children. Therefore, this study aims to take one more step in analyzing this educational action's transferability in a school context. Specifically, it intends (1) to investigate the promotion of scientific literacy of the children participating in the DSG (instrumental learning, analytic and critical thinking, and social abilities) and (2) to identify evidence of the impact of the rise of scientific literacy (decision-making and participation in society).

Context of the Research

The school. This study has been carried out in a culturally diverse school located in a low socioeconomic neighborhood in Tarragona (Spain), which was transformed into a Learning Community in 2012. *Learning Communities* are social and educational transformation projects aiming to improve all students' academic achievement by implementing educational actions that have been validated by the scientific community (Flecha, 2015; Flecha & Soler, 2013). One educational action that has successfully improved education for all children are *Dialogic Gatherings*. The school implements DSGs from Pre-K (3-year-old students) toward "middle school" (16-year-old students). A total amount of 207 students attend this school. Regarding their ethnic distribution, around 70% of the students are Roma, whereas 20% are migrants from Morocco and 10% are Latinos (migrants from Latin-American countries).

Intervention. Six sessions of DSGs were carried out between January and March 2020, each one of 1 hour and a half. These sessions included the pre-session (preparation of the DSG) and the session (implementation of the DSG). In the pre-session, children read the article independently and search for information regarding the scientific concepts embedded in the reading that they want to share with their peers because they didn't understand them or because that concept claimed their attention or curiosity. Then, they select the reading fragment containing the idea they want to share with their peers. In some cases, they choose the piece because it explains a scientific concept that is new for them. In other cases, they chose it because they connected the scientific idea in the article with their daily lives.

The session follows the structure of all the Dialogic Gatherings, as detailed in Díez-Palomar (2020). This way, in the session, all children could share their fragments and thoughts with their classmates. When children intervene, they read the selected piece. Then, they share why they chose the fragment and explain their thoughts and thoughts about the text. Afterward, everyone is invited to participate and share their thoughts about the scientific idea contained in the piece. During the gathering, children share an egalitarian dialogue in which they discuss scientific ideas, meanings, particular examples, etc., sharing their arguments and respecting everyone's voices. Another aspect that is important to remark about the DSGs is the role of the facilitator. In the DSGs, the facilitator must ensure dialogic interactions among the participants. All the voices are valued and respected and are based on arguments instead of power relations. Thus, the function of the facilitator consists of giving the turns to speak and promoting the debate, raising questions and facilitating egalitarian interactions among participants. The facilitator should never intervene to explain the scientific concepts that the participants have not understood or express their interpretation of the text but to promote the co-creation of knowledge among the participants.

Data Collection and Analysis

This case study has been conducted using the *Communicative Methodological* approach (Gómez et al., 2019). The communicative methodology has been broadly used in previous studies involving dialogic gatherings, and it is related to the social impact of research (Díez-Palomar, 2020; Garcia Yeste et al., 2018; López de Aguileta et al., 2020). The communicative orientation of this research included an egalitarian dialog between researchers and participants throughout all the research. Thus, knowledge was created through an intersubjective dialog between researchers and participants, based on the exchange of arguments found on validity claims.

Instruments. We used qualitative data collection instruments, including communicative observations and semi-structured interviews with communicative orientation. One

Table 1. Analysis Grid for the Communicative Observation.

	Promotion of scientific literacy			Impact of scientific literacy	
	Instrumental knowledge	Analytic and critical thinking	Social abilities	Evidence-based decision making	Participation in society
Exclusionary dimension					
Transformative dimension					

of the researchers conducted six communicative observations of the DSGs, where children read and discussed adaptations of scientific readings about the human genome, climate change, and bees' learning abilities. The DSGs were audio-recorded and transcript. The communicative observations aimed to collect evidence regarding the promotion of scientific literacy with the DSGs and the impact of improving children's scientific literacy. The communicative observations included five categories and two dimensions of analysis (see Table 1).

On the one hand, three of the categories (instrumental knowledge, analytic and critical thinking, and social abilities) were related to the promotion of scientific literacy as a result of the DSGs, whereas the other two (evidence-based decision making and participation in society) correspond to the social impact of the promotion of scientific literacy. On the other hand, following the communicative methodology, the communicative observation included collecting and analyzing evidence reflecting how children's scientific literacy improves because they participated in DSG (*transformative dimension*) and those barriers that hinder this improvement (*exclusionary dimension*).

Besides, three semi-structured interviews with schoolteachers were carried out. The interview included four sections: (1) previous experience in Dialogic Gatherings, (2) promotion of scientific literacy in the participants, (3) The impact of the scientific literacy in children, and (4) sustainability and future challenges of the DSGs. Because the school lockdown motivated by the pandemic, the interviews with the teachers were carried out online. We also audio-recorded and transcribed all of them.

Participants

Participants were 10-year-old children in the fifth grade ($n = 9$). Researchers had already met school staff and families from previous studies. In addition, one of the researchers had participated as a volunteer in dialogic gatherings with this group of students for 3 years. Thus, researchers informed school staff, participants and their families about the study's purpose and the implications of their participation, including anonymity of data and the voluntary character of their involvement. Parental consent forms were signed to participate in the study. Besides, three school staff members who participated as observers or facilitators also took part in the study (see Table 2).

Table 2. Participants of the Research.

Pseudonym	Gender	Description
Ana	Female	Spanish Roma
Ilias	Male	Moroccan
Julio	Male	Spanish non-Roma
José	Male	Spanish Roma
Yumara	Female	Spanish Roma
Ezequiel	Male	Spanish Roma
Mercedes	Female	Spanish Roma
Hannan	Female	Moroccan
Isaías	Male	Spanish Roma
María	Female	School Principal
Tomás	Male	School Teacher
Susana	Female	School Teacher

Note. All names are pseudonyms.

Results and Discussion

Promotion of Scientific Literacy Through DSGs

During the gatherings, researchers observed how the debates children shared around the text promoted scientific literacy more than the reading of the text itself. Specifically, three outcomes were detected: improvement of instrumental knowledge (related to a better understanding of scientific concepts and gain of vocabulary), promotion of analytic and critical thinking (related to reasoning skills) and the promotion of social abilities (related to the ability to provide arguments to the debate and solidarity relations among children).

Improvement of instrumental knowledge. Children participating in the DSGs read adaptations of articles published in scientific journals such as *Nature* or *Science*. These scientific readings included concepts children had not learnt yet; thus, the texts were above their ability level (according to their age and grade). Reading these types of books represented both a challenge and an opportunity, and children were able to turn the difficulty of reading them into opportunities for further learning science. Children engaged in discussions about science topics that were new to them because they didn't learn about them in their regular science class, such as DNA, human genome, microplastics, climate change, or neuroscience. DSGs helped these children access scientific knowledge that is not even included in their curricula. Children

could understand and learn these scientific concepts when discussing the articles with other children and not when reading the text independently. This way, egalitarian interactions between children are the cornerstone of DGSs, which implies that the facilitator must know their function and avoid giving explanations to children (Díez-Palomar, 2020; Hargreaves & García-Carrión, 2016). This constitutes one of the main challenges of the intervention, as facilitators must ensure that the principles of dialogic learning are followed throughout the gathering (Flecha, 2000; García-Carrión et al., 2020). DSGs have already been demonstrated to be an effective action in helping individuals access the highest quality scientific works, regardless of the participants' academic background (Buslón et al., 2020). Data collected in this study endorses this claim. One of the teachers highlighted how children were able to access and discuss scientific readings in this setting (within the DSGs):

> I think the DSGs are showing very satisfactory results, right? [. . .] There are two parts, right? First the preparation, and then it comes the part of the DSGs itself; here's the good thing, right? [. . .] because it's not the same as giving the article to the kids, and they'll make it. I mean, the gathering plays a significant role here, isn't it? And then there's the fact that all the articles they read, even though they're of a very high standard, are appropriate if they are worked on in the right way. - María (School Principal)

For all children participating in the DSGs was their first contact with concepts such as DNA, genes, microbiome, or paleoecology research, among others. Therefore, when they read the readings and prepared the gathering, they searched for additional information about the concepts they did not understand. Afterward, they exchanged their understanding of the reading and shared doubts and inquiries with other children participating in the gathering. In these debates and interactions based on children's arguments in the DSGs, they learned new concepts related to the text and increased their instrumental knowledge. In line with previous research about the promotion of scientific literacy through argumentative practices (Chen, 2019; Cigdemoglu et al., 2017; Sengul et al., 2020), DSGs enhanced the acquisition and knowledge of new vocabulary and scientific concepts, as pointed out by one of the teachers:

> Vocabulary improvement, yes, because as understanding is more complicated, they need to know all the vocabulary that they have not understood; therefore, I think that afterwards, they have retained that vocabulary- Susana (School teacher)

An example of how children retained the vocabulary and could transfer and use these new concepts and words happened in a Spanish language exam: children were asked to read a text containing one of the ideas discussed in one session of the DSGs. Those children who had participated in the DSGs already knew the concept and were asked to explain it to their classmates. They succeed in doing so. They were able to explain the idea to their peers. This example is aligned with previous studies showing the interdependence between science learning and developing language skills (Capitelli et al., 2016; Hall et al., 2016; Hong & Diamond, 2012; Thier, 2002). In addition, the challenge of reading scientific texts enhanced children's interest in learning more about some topics, such as the development of the brain, genetics or microplastics, which also contributed to their scientific background.

Promotion of Analytic and Critical Thinking

In their discussions, children actively questioned how science and scientific research are built. For example, in the following excerpt, children wondered how scientists could have sequenced the entire human genome from a piece of chewed resin:

> Ana: "The entire genome has been extracted"; It has caught my attention because it seems incredible to me that they have known all the information of a person with only one chewing gum.
> Ilias: Well, I think that they can know it through the saliva because the DNA is in the saliva, and that's why they can realize it
> José: But it was 5700 years ago
> Ana: It was not because of saliva, because it had already dried
> Ilias: No, but it remains; I think it would stay . . . not that if you touch it, it is wet, no, but I think there would be something left. The DNA, I think, would remain, the saliva itself would go away, but the DNA would continue to stay. DNA remains because it is unique [. . .] let's see. . . DNA comes from the saliva but, [. . .], the saliva [going away] does not mean that the DNA goes with it
> Ana: The DNA remains in the resin because it was trapped, DNA has been sucked

This fragment illustrates how the DSGs fostered analytic and critical thinking and how children engaged in a debate to ask questions about how a researcher could have sequenced the genome. In this line, children also reflected on the implications of scientific advances for further research. They wondered if future scientists would know the lifestyles and habits of the children who participated in the DSG if they sequence the genome of one saliva sample obtained from chewing gum. The dialog enabled them to understand complex scientific concepts and increased their analytic thinking and reasoning. Previous studies have identified similar outcomes that place argumentation and dialog at the core of interventions (Díez-Palomar, 2020; Hand et al., 2018). This is consistent with previous evidence about the importance of interactions to foster scientific learning (Murphy et al., 2018; Soysal, 2020).

Promotion of social abilities. Another impact observed from DSGs is the promotion of children's social abilities. Through DSGs, children shared a debate based on the exchange of arguments, allowing them to express different reading opinions. As all ideas were based on scientific evidence and not power claims, children felt confident and safe sharing their thoughts and inquiries. All claims were equally respected. An example of this impact was observed during one session, when children discussed human and animal intelligence, as shown in the following dialog:

José: We think that the memory of a fish is tiny, don't we? But it is not; it has more intelligence than we do.
Isaiah: I did know that because animals are more intelligent than humans
Anna: Yes? Are animals more intelligent than humans?
Ilias: I think animals are not more intelligent than humans because humans have evolved, and animals are still as they were. They have become in the way they look. So maybe they were different than they are now, right? And yes, they have evolved, but not like humans, who have taken a big step.
Isaiah: It is true what you say

This fragment shows how children had two opposing perspectives about animals and humans' intelligence at the beginning of the dialog, but it did not lead to any conflict. On the contrary, they were able to exchange arguments for creating a common framework of knowledge. Previous studies have provided evidence that participants showing disagreement exchange polite arguments fostering dialog within dialogic gatherings, instead of creating conflict trying to impose their claims or discrediting others' opinions (Llopis et al., 2016).

DSGs enhanced children's interactions around the text. These interactions enabled the emergence of relations of solidarity between the participants, who helped each other face the challenge of understanding the scientific concepts. Thus, when children had a question or did not understand something about the text, they did not ask the teacher but shared their inquiry with the group. Then, drawing on all the participants' contributions in the DSG, they got everyone to understand the concepts. For example, in this fragment, a girl wondered if children are their parents' flesh and blood, which means that they also share their parents' DNA:

Ana: But, if they say that we are from the same blood as our father and mother [. . .], do you know who our parents are?
José: Yes, they do know
Ilias: Yes, but no, it is not the same blood, but . . . similar . . . because, for example, my mother is 0 and I am A. This is no longer the same blood [. . .]
Ana: But then, my mother and I do not share the same genes?
Ilias: No, because otherwise, she would be like you
Hannan: And the twins, are they also from the same genes?
Ana: It's true, the twins! In the case of twins, yes, because they are the same!
Hannan: I think they have some differences. Something must be different [. . .]
Isaías: Yes, it is the same as *Girl1* and *Girl2* [two twins in the school], right? Because one wears glasses and the other does not.
Hannan: It's true! Yes, I have cousins who are also twins, right? But they are slightly different.

In this case, children understood the unicity of human DNA and the possible differences between parents and children's type of blood with the questions and answers they exchanged with their classmates. As a result, they provide meaningful examples and connect scientific knowledge with their daily lives and contexts. This interaction between daily lives and the text of the gathering is also found in other experiences of dialogic gatherings (Garcia Yeste et al., 2018; Salceda et al., 2020). The emergence of relations of solidarity among participants was also evident to one of the schoolteachers, who highlighted how the challenge of reading complex texts could be overcome if children can build relations of mutual support:

> It is dialogic learning. It is the excellent relationship between them, a helping relationship, especially an academic [helping relationship] [. . .] Especially with educational actions like these, right? which involve a very high academic level and the effort is more elevated. As the effort is higher, this also implies that children have to help each other more, okay?- María (School Principal)

This fact has also been validated in previous research (Elboj & Niemelä, 2010).

Impact of the Promotion of Scientific Literacy

As a result of the improvement of scientific literacy, researchers found an increase in children's awareness of the importance of grounding their decisions on scientific evidence and promoting the relationship between scientific literacy and participation in society.

Awareness of the importance of drawing the decision on scientific evidence. Previous studies have highlighted the importance of scientific literacy for democratic decision-making (Yacoubian, 2018). One of the impacts of promoting scientific literacy is that DSGs raised children's awareness of the importance of making decisions based on scientific knowledge and evidence. With the gatherings, children could make sense of scientific knowledge, transfer it to their contexts, and express how it would be used to make decisions affecting their day-to-day lives. Furthermore, in the DSGs,

children discussed possible applications of the scientific knowledge acquired through the reading. For example, they discussed the possibilities of using natural medicines instead of pharmaceutical compounds after reading about the antiseptic and medicinal properties of birch resin raised, as can be seen, below:

> Ilias: I think it is perfect because if it removes dental pain, they could use it to create a medicine that eliminates it. For example, instead of using paracetamol, we could use this. [. . .] Because [the girl] had dental pain and avoided the pain she found this, she chewed it, and the pain ended. It cured her.

Such type or arguments expands children's opportunities for democratic decision-making (based on scientific evidence, rather than someone's opinion).

In another session, children engaged in a similar discussion about the importance of a balanced and nutritional diet for having a healthy body and a healthy brain after reading about bees' learning abilities. These examples illustrate how children became aware of the importance of making daily life decisions (concerning, e.g., their health) based on scientific knowledge. A previous study about the impact of DSG also obtained similar results related to promoting awareness about the importance of making decisions based on scientific knowledge in the case of adult learners (Buslón et al., 2020). This finding confirms that scientific literacy has an impact on decision-making processes (Süerdem & Çağlıyor, 2016). Furthermore, it is aligned with the idea of how scientific literacy can be promoted in the school context and can empower children to make daily–life decisions based on scientific evidence (Flecha et al., 2011; Hazelkorn et al., 2015; Rudd, 2010).

Relationship between science and active participation in society. Finally, the DSGs promoted the awareness of the importance of pairing science with civic participation. Children who participated in the gatherings expressed how the gatherings raised their awareness about society's challenges and the role that scientific development and active citizenship play in facing these challenges. One of the examples in this regard can be found in a session about the effects of pollution on animals:

> Hannan: I was looking for information about [. . .] how many animals are becoming extinct, there are not many left, not many fish or anything. . . The world is getting destroyed. . .
> José: Yes, it's getting destroyed.
> Ilias: No, we are destroying it
> Hannan: well, yes, it's getting destroyed because of us.
> Ezekiel: well, it's not us.
> Hannan: Yes, because of the entire humanity
> José: In general.
> Ilias: For example, when you leave a shop, you leave the shop eating a bag of chips. There is no bin? I throw it away! Do you think this bag of chips is not going to go anywhere? Do you think it's going to stay there? Or the sweeper will come and get it. But this bag out there, we don't know where it will end up. You don't see it going away, but it's going to go away. [. . .] Usually, I don't think about what we just said when I throw it away. We just said it, and I think: How many bags of chips are out there because of me?

In this excerpt, Ilias says he became aware of human actions' critical role in preserving the environment. After realizing that their actions impact the environment, children discussed overcoming this situation by changing citizens' habits. However, different perspectives emerged regarding the impact of individual actions from citizens in preserving the environment. Children addressed these differences through the exchange of arguments, as seen in the following excerpt.

> Ana: Not because four people recycle. . . because we're at school now, aren't we? And we have worked on this issue, and we say, come on, let's recycle. Well, because four people recycle, they don't. . . because the others will continue to contaminate. So, for example, you throw a bag into the bin, and another person will throw the load on the ground. And it's the same as if you threw it away.
> Ilias: I'm afraid I must disagree with what Ana said because if four people recycle, they encourage others. . . For example, you recycle, and your friends, well, see you recycle, and they may be tempted to recycle too. So they, your friends, will have other friends who might also be tempted to do it again. [. . .]
> Ana: For four people who recycle, it's not. . . it's not that there's no more pollution or any of it. If, for example, as you say, Ilias, it was only done in this neighborhood, right? Because we raise the issue, for example. And a friend sees me and also wants to join in, right? So we'd stop polluting, wouldn't we? But this is not for all the world [. . .]
> Ilias: And what about Greta? You see Greta now, don't you? Look, it started as a girl who had the idea of wanting to recycle and going every Friday in front of the town hall with a banner, right? She ended up being a girl that almost half the world knows.

In this session, children reflected on the importance of starting social mobilization, drawing on the example of the climate activist Greta Thunberg. After this session, children realized the importance of solidarity and collective actions to face these types of challenges and decided to act:

> They have thought about organising something at a social level [. . .] As a result of this [article], they talked about how we could do something at a school level, right? What action could they do

> to reduce waste? So, one day they talked and saw if we could organise something in this line. - Susana (School Teacher)

Children started to prepare a school campaign to share evidence about the effects of human pollution on the environment. Unfortunately, children could not implement their school campaign due to the lockdown motivated for the pandemic. However, their participation in the DSGs increased their awareness about the relationship between scientific knowledge and active participation in society. This claim is consistent with evidence from previous studies founding that in-depth science learning is related to a higher level of awareness toward the challenges of our society, as well as to higher levels of citizen participation (Buslón et al., 2020; Turrini et al., 2018). It is also consistent with other examples of "building awareness through science literacy," such as the one presented by Sjöström and Eilks (2018) with their concept *bildung*. According to them, bildung-oriented science education makes students capable of participating in their socio-cultural environment democratically, developing a sense of empathy and solidarity with others. Furthermore, participating in DSGs allows children to share their thoughts, creating the scope for a more informed and responsible civic participation in their everyday life context. In this sense, the impact of DSGs moves forward previous studies on the effects of science literacy and active participation in society since it creates the opportunity for participants to plan their agency drawing on the understanding of scientific evidence through the reading and discussion of the texts.

Conclusions

This study's findings suggest that DSGs, which had previously demonstrated their impact in adults, can be transferred to school-aged children (Buslón et al., 2020). Specifically, DSGs have promoted children's scientific literacy related to instrumental knowledge, analytic and critical thinking, and social abilities. This finding is aligned with international studies suggesting that argumentative practices are successful strategies to promote scientific literacy (Cavagnetto, 2010). Furthermore, this study constitutes an example of how through DSGs, children from a culturally diverse school read scientific texts, oral practice argumentation and share a discussion based on egalitarian dialog. One of the teachers also highlighted this fact in the interview:

> It is impressive; that is why I had said before that it is incredible to see families, that is, children of Roma and Moroccan families, okay? We always have prejudices "they will not know", "And how can you work [topics] so complex in this context" well, they are doing it, right? And well enough, well enough. Each one contributes, each one contributes with their knowledge, and everyone helps each other, that is why the group is there - María (School Principal)

Previous international studies found that DSGs are transferable to different countries and contexts (Buslón et al., 2020; ScienceLit Project, 2018). However, the impact of DSGs had not been studied in children before. Although the case study reported here represents one specific context, the DSGs have enriched children's instrumental learning, promoting new vocabulary acquisition and fostering reasoning and analytical thinking. Children participating in the DSGs engaged with science-related issues. They developed a critical approach to science and scientific thoughts. Besides, the effort needed to understand the readings was crucial in creating solidarity (chains of solidarity) among children. One of DSG's critical elements is creating an egalitarian environment where all contributions are appreciated and valued for their arguments. This way, children feel confident to discuss complex scientific concepts. They perceive that their daily life knowledge and cultural experiences are essential and significantly contribute to the debate. Therefore, this research points to the necessity of designing and implementing educational practices based on scientific evidence that creates spaces where children can share arguments. Finally, DSGs achieved social impact, as children became critical citizens, showing active agency (in terms of getting engaged with social movements). Children use scientific knowledge to make decisions and respond to society's challenges.

In conclusion, the main findings suggest that DSGs can be successfully transferred to school-aged children to promote scientific literacy due to the egalitarian interactions based on children's arguments around scientific texts. Moreover, this study has further demonstrated that access to scientific knowledge is not limited to specific groups. Still, all citizens can attain it, including school-aged children from ethnic minorities and migrant origin.

Limitations and Recommendations for Further Research

This case study was conducted during 2019 to 2020, and it was planned to last until June 2020. However, due to the COVID-19 lockdowns in March 2020, the school was closed, and the DSGs were discontinued after the first six sessions. In addition, the insufficient electronic devices and internet connection that affected children and their families hindered the possibility to continue with the DSGs online.

Recommendations for further research include the transference of DSGs to other and different contexts, both nationally and internationally, including children from diverse ages, cultural backgrounds, and socioeconomic statuses.

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