frontiers | Frontiers in Education

ORIGINAL RESEARCH
published: 30 June 2022
doi: 10.3389/feduc.2022.917442

Children's Views of SARS-CoV-2 and COVID-19 Preventive Practices: Comparing Verbal and Visual Empirical Evidence

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Despite the growing body of research on the consequences of the COVID-19 pandemic on children's wellbeing, few studies so far have explored children's points of view, while the majority were based on data collected during the first year of the pandemic. The present study attempted to capture children's views 1 year after the beginning of the pandemic, and to this end, data were collected during Spring 2021 in Greece. Specifically, by combining verbal and visual data, the study attempted to explore children's views of SARS-CoV-2 and COVID-19 preventive practices. Participants involved 320 children, ranging in age from 4 to 12 years, who were asked to verbally describe and draw (a) Coronavirus and (b) the preventive measures adopted to mitigate the pandemic. Data analysis indicated that overall, children's views involve elements of scientifically appropriate information since from an early age they are able to describe and depict SARS-CoV-2 in ways that reflect the abundance of available verbal and visual information in the public sphere. Moreover, children recommended suitable COVID-19 preventive practices since their verbal and drawing responses included references to both the Hygienic and Social preventive practices that prevailed during the time of data collection. Age-related differences in children's views, as well as differences between the two data collection techniques, were also found. Results also showed that children who described SARS-CoV-2 as a virus or a germ tended to report more hygienic practices than those who failed to describe the term appropriately. The findings shed light on the way children form their views of the novel coronavirus and COVID-19 and raise research educational implications.

Keywords: children, COVID-19, drawings, SARS-CoV-2, preventive practices

OPEN ACCESS

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Specialty section:
This article was submitted to STEM Education, a section of the journal Frontiers in Education

Received: *11 April 2022*
Accepted: *10 June 2022*
Published: *30 June 2022*

Citation:
Christidou V, Bonoti F, Papadopoulou P, Hatzinikita V and Doumpala P (2022) Children's Views of SARS-CoV-2 and COVID-19 Preventive Practices: Comparing Verbal and Visual Empirical Evidence. Front. Educ. 7:917442. doi: 10.3389/feduc.2022.917442

INTRODUCTION

Since the emergence of COVID-19, an abundance of information about infection and transmission risks and related measures to contain the pandemic has been addressed to the public, including children (Provenzi et al., 2020; Thompson et al., 2021; Zou and Tang, 2021). Most countries have imposed restrictive measures and broadcasted campaigns involving visual and verbal slogans to promote citizen observance of safe behavior (Berasategi et al., 2020; Bray et al., 2021a). It has been

argued (Assante and Candel, 2020; Idoiaga et al., 2020) that this storm of information might have embedded children in social representations (Moscovici, 1984) of COVID-19. The available social representations might have facilitated their effort to transform scientific knowledge into everyday thinking, to become familiar with this unknown and dangerous phenomenon, to regulate the negative emotions it aroused, and finally to understand it (Moscovici, 1988).

Research has shown that the pandemic abruptly disturbed children's daily lives that have impacted their physical and mental health, wellbeing, and education (Assante and Candel, 2020; Garcia de Avila et al., 2020; Valadez et al., 2020; Berasategi Santxo et al., 2021; Bray et al., 2021a; Spiteri, 2021). These findings indicate the need to support children, who will probably face similar emergencies later in life, in understanding SARS-CoV-2 and its resulting disease (Manches and Ainsworth, 2022). Consequently, it is essential to scaffold children's understanding of COVID-19 and assist them in coping with this unpredictable condition, to empower their responsible participation in mitigating the pandemic (Garcia de Avila et al., 2020; Provenzi et al., 2020; Maftei et al., 2022; Manches and Ainsworth, 2022; Rydström et al., 2022), and to prevent traumatic effects (Assante and Candel, 2020; Idoiaga et al., 2020).

However, how the public discussion and the available information on SARS-CoV-2 and COVID-19 are conceptualized by children has not been fully explored thus far. For any teaching intervention or information campaign to be meaningful to them, it is crucial that it starts from their point of view. It is therefore of great importance to gain insight into children's understanding of the novel coronavirus and ways of responding to the crisis (Thompson et al., 2021). Such insight would allow the selection and formulation of age-appropriate and accurate explanations and representations that they could meaningfully handle. This, in turn, would make learning about viruses relevant to children and support them in preserving their overall wellbeing (Assante and Candel, 2020; Berasategi et al., 2020; Garcia de Avila et al., 2020; Idoiaga et al., 2020; Majid et al., 2020; Bray et al., 2021b; Manches and Ainsworth, 2022).

Few studies so far have investigated children's views of the pandemic (Idoiaga et al., 2020; Thompson et al., 2021; Rydström et al., 2022), although a rapidly growing body of research related to COVID-19 and its consequences on children's wellbeing has evolved during the last 2 years (e.g., Garcia de Avila et al., 2020; Valadez et al., 2020). Interestingly, despite the previously documented lack of appropriate understanding of infectious diseases and prevention practices in non-experts (Jee et al., 2015), recent studies report high levels of awareness of COVID-19 even in young children (Rydström et al., 2022), and their sensitivity in perceiving and adopting adults' reactions to the pandemic (Valadez et al., 2020; Thompson et al., 2021). This awareness has been revealed in children's ability to distinguish SARS-CoV-2 (cause) from COVID-19 (result); to name common symptoms of the disease (for instance cough, fever, or sneeze); to understand the possibility of asymptomatic infection; to recognize the necessity of preventive and mitigation practices such as social distancing or handwashing; to describe airborne transmission and high contagiousness of the virus (Idoiaga et al., 2020; Bray et al., 2021b; Christidou et al., 2021; Martinerie et al., 2021; Thompson et al., 2021; Bonoti et al., 2022; Maftei et al., 2022; Rydström et al., 2022).

In their attempt to understand this unprecedented phenomenon, children might have been facilitated by depictions of SARS-CoV-2, its transmission, and pertinent mitigation measures which have dominated public discourse during the COVID-19 pandemic. Nowadays, visual images are increasingly used to convey information and support meaning-making (Avgerinou and Ericson, 1997), especially in the realm of science, where communication and meaning-making are inherently multimodal (Lemke, 1998; Givry and Pantidos, 2012). Furthermore, images are particularly valuable when invisible entities are at play (Lemke, 1998; Jewitt, 2008; Coleman et al., 2011; Jarman et al., 2012; Manches and Ainsworth, 2022), all the more so in crisis circumstances (Höijer, 2010; Alcibar, 2018; Stark and Stones, 2019).

Therefore, in the context of COVID-19, visual images have become powerful communication means with the potential to convey meanings more effectively than verbal communication by rendering complex information accessible to non-experts (Joubert and Wasserman, 2020). Besides, images, as socio-cultural mediating tools, apart from representing scientific information touch upon social, emotional, or cultural facets of the pandemic (Delicado and Rowland, 2021; Zou and Tang, 2021). Publicly available images of SARS-CoV-2 typically involve (a) the morphology of the virus, emphasizing its sphere-like shape and the spikes on its surface (Delicado and Rowland, 2021) and (b) anthropomorphic elements, echoing a tendency to assign human features, like eyes, mouth, facial expression, or human-like limbs to the virus (Joubert and Wasserman, 2020; McGellin et al., 2021). This is no surprise since anthropomorphic representations are commonly used when representing entities inducing uncertainty and fear, as in the case of SARS-CoV-2 (de Rosa and Mannarini, 2020). On the other hand, visual representations of mitigation measures and illness have been more realistic and straightforward, since they typically depict real-life, observable situations. These mainly involve (a) visualized instructions on protective measures (e.g., mask-wearing, hand washing, covering the mouth, and nose when coughing), (b) COVID-19 symptoms; (c) iconic symbols of different levels of medical intervention, namely, testing, treatment (e.g., hospitals, medicines), or vaccination; and (d) depictions of the social aspects of the pandemic [e.g., lockdown, deserted streets, business, and school closures (Bray et al., 2021b; Delicado and Rowland, 2021)].

Visual communication is particularly popular among children, who typically resort to drawing to express their ideas, emotions, and experiences (Brechet et al., 2009; Cox, 2005; Misalidi and Bonoti, 2014). In this sense, children's drawings are seen as documentations of how they understand and interpret scientific concepts. Thus, they become valuable tools for exploring students' science ideas and their evolution as their learning progresses (Jewitt, 2008; Brooks, 2009; Ainsworth et al., 2011). More particularly, when engaged in the act of drawing children

are also engaged in meaning-making by creating multimodal artifacts that can be regarded as inscriptions of their mental images. In this way, children express and communicate their knowledge with others (Matloob Haghanikar and Leigh, 2022). In addition, inviting students to express their views of a scientific issue visually engages them in relating sociocultural to scientific knowledge (Smith and Joffe, 2013; Zou and Tang, 2021; Bonoti et al., 2022). This allows them to communicate scientific meanings without relying on specialized vocabulary, while it offers a more wide-ranging picture of their understanding and experiences compared to verbal communication alone (Kress and van Leeuwen, 1996; Jewitt, 2008; Jolley, 2010; Mutonyi and Kendrick, 2011).

Acknowledging the multimodal character of perceiving SARS-CoV-2 and COVID-19 and that much of the public information about these issues has been visually communicated, previous studies (Bray et al., 2021a; Christidou et al., 2021; Martinerie et al., 2021; Thompson et al., 2021; Rydström et al., 2022; Bonoti et al., 2022) have exploited the potential of children's drawings to capture their views when combined with verbal tasks (Driessnack and Gallo, 2013). Children's drawings of SARS-CoV-2 vastly replicated the visual representations widely available in the media, i.e., its sphere-like shape with spikes (Martinerie et al., 2021; Thompson et al., 2021; Bonoti et al., 2022), while instances of anthropomorphic depictions were also common (Martinerie et al., 2021; Bonoti et al., 2022). These findings are also in line with previous research on children's representations of micro-organisms, depicting them in regular geometric shapes (e.g., circles), or with anthropomorphic characteristics including physical (e.g., hands, and legs), or mental features, such as intentionality (Nagy, 1953; Byrne et al., 2009; Byrne and Grace, 2010; Byrne, 2011; Jee et al., 2015; Prokop et al., 2016). Furthermore, in some cases, SARS-CoV-2 was depicted as animal-like or as an aggressive monster (Thompson et al., 2021; Bonoti et al., 2022). Some children have also expressed visually their understanding of the process of transmission (Bray et al., 2021a; Martinerie et al., 2021; Thompson et al., 2021; Bonoti et al., 2022). Moreover, their depictions of COVID-19 preventive measures have been found to emphasize advisable hygienic practices, such as handwashing, social distancing, or wearing a mask (Bray et al., 2021a; Christidou et al., 2021; Martinerie et al., 2021; Thompson et al., 2021; Rydström et al., 2022).

As the pandemic and related research on children's views is still in progress, questions that merit more systematic investigation arise. Data in most studies to date (Assante and Candel, 2020; Berasategi et al., 2020; Idoiaga et al., 2020; Valadez et al., 2020; Bray et al., 2021a,b; Christidou et al., 2021; Martinerie et al., 2021; Thompson et al., 2021; Bonoti et al., 2022; Matloob Haghanikar and Leigh, 2022; Rydström et al., 2022) were collected during the first year of the pandemic, in 2020, when restrictions and preventive measures were novel. By examining children's views during the second year of the COVID-19 pandemic, namely 1 year after its outbreak, this study could provide insight from a different angle. More specifically, such an exploration would capture the accumulated experience of a long-term, ongoing, and continuously evolving crisis (Thompson et al., 2021), which probably implies rapid changes in children's understanding of viruses and infectious diseases (Manches and Ainsworth, 2022).

Furthermore, existing studies, have only shed light on some aspects of children's understanding of SARS-CoV-2 and COVID-19, while the development of this understanding has not been fully explored (Christidou et al., 2021; Martinerie et al., 2021; Bonoti et al., 2022). However, it has been suggested that it is important to investigate children's understanding of health information from a developmental point of view (Velardo and Drummond, 2017; Rydström et al., 2022). Thus, it would be valuable to determine whether the development of children's views follows the major changes observed in their overall biological knowledge around the age of 7 (Duschl et al., 2007), or if their progression toward more scientifically appropriate views is less straightforward.

In the present study, 4-to-12-year-old children in Greece were invited to express both verbally and visually their views of SARS-CoV-2 and COVID-19 preventive practices during the second year of the pandemic in an attempt to investigate the extent to which these views involve elements of scientifically appropriate information. To attain this aim, the following research questions were investigated:

1. What are children's views of SARS-CoV-2?
2. Do children's views of SARS-CoV-2 differ between age groups and data collection techniques?
3. What types of measures do children recommend to protect themselves from the disease and mitigate the pandemic?
4. Do the proposed types of measures vary with age and between the two data collection techniques?
5. Do the types of recommended preventive measures relate to children's views of SARS-CoV-2?

MATERIALS AND METHOD

Participants

A total of 320 children (140 boys and 180 girls) ranging in age from 4 to 12 years participated in the study. The sample was distributed in three age groups: (a) 4-to-6-year-olds (n = 107, 48 boys and 59 girls, M = 66.78 months, SD = 9.96), (b) 7-to-9-year-olds (n = 114, 51 boys and 63 girls, M = 101.43 months, SD = 10.85), and (c) 10-to-12-year-olds (n = 99, 41 boys and 58 girls, M = 133.67 months, SD = 10.18).

A snowball sampling procedure (Parker et al., 2019) was adopted to approach children from different cities in Greece. Specifically, researchers used their social networks to invite families to participate in the study, who in turn suggested other potential participants. Parents were informed about the purpose of the study, and they provided their written consent. The children's willingness to participate in the study was also obtained and they were informed that they could quit the process at any time.

The study has achieved the approval of the Ethics Committee of the Department of Early Childhood Education/University of Thessaly (18/26.02.2021), affiliation of the second author during the design and implementation of data collection.

Procedure

Data were collected during the second year of the COVID-19 pandemic (March–April 2021) through electronic platforms due to the restrictions imposed by the Hellenic Ministry of Health. Precisely, during that period the following governmental measures were adopted to mitigate the spread of the pandemic: (a) stay-at-home suggestions (b) social and physical distancing guidelines (c) closure of schools and non-essential businesses (d) movement and traveling restrictions, (e) night curfew (f) mandatory use of mask, (g) gradual vaccination of the population (optional), and (h) implementation of teleworking. To ensure measure observance by the citizens an automated service through SMS messages on mobile phones was initiated, instantly granting permission to phone holders to go out for specific reasons apart from professional ones (e.g., visiting a doctor, shopping for essential goods, or physical exercise).

To eliminate physical contact between researchers and participants, each child was tested individually while being in his/her home through a video call. His/her parents were asked to recommend the electronic platform in which they had access and to propose a suitable time for them to arrange an appointment. Researchers made the video call at the present time, while parents were prompted to not intervene in the process but to offer their help in case the child could not cope with the technical requirements of the procedure. Each video call lasted 10–20 min.

Overall, children were asked to answer a couple of simple questions and to produce two drawings. They were also advised to use two sheets of white paper, and colored pencils or crayons. Initially, children were asked to describe verbally SARS-CoV-2 (*"Do you know what coronavirus*[1] *is?"*) and then produce a picture of it (*"Would you like to draw coronavirus?"*). Subsequently, they were prompted to mention the preventive measures they followed (*"Please tell me, what do you do to protect yourself from the coronavirus disease?"*) and then to create a picture *"showing what you do to protect yourself from coronavirus."* After the completion of each drawing, children were asked to describe what they had included in them.

Children's verbal descriptions were transcribed verbatim, while photos of their drawings were emailed to the researchers by themselves or their parents.

Coding of Verbal and Visual Data

Coronavirus

Children's verbal descriptions and depictions of SARS-CoV-2 were coded as Adequate, Partially Adequate, and Inadequate, depending on the degree to which they involved elements of scientifically appropriate terminology and imagery (Bonoti et al., 2022). Specifically, verbal descriptions were classified as Adequate when they referred to a virus or a germ, as Partially Adequate when there was an explicit connection of SARS-CoV-2 with a health issue or the pandemic, but no reference was made to micro-organisms, and as Inadequate when they incorporated mythical or irrelevant elements. Respectively, children's drawings were characterized as Adequate when they portrayed the virus in a circular shape with or with no spikes, as Partially Adequate when they involved both appropriate and inappropriate elements (e.g., a circular virus enriched with symbolic or anthropomorphic elements like a crown, or frown eyes) and as Inadequate when the drawing included mythical (e.g., depictions of coronavirus as a monster) or irrelevant elements (e.g., the coronavirus as an animal). In a next step, two female coders, trained students of an Educational Department in Greece, who were unaware of the aims of the study, were asked to rate data by assigning a score of 3 to the adequate, a score of 2 to the partially adequate, and a score of 1 to the inadequate verbal and drawing responses. Interrater reliability in assessing the verbal descriptions and the visual representations of coronavirus was satisfactory since intraclass correlation coefficient (ICC) values were 0.89 and 0.92, respectively.

Preventive Measures

Quantitative content analysis has been applied in children's quotes and drawings of preventive measures since this method is considered appropriate for analyzing both verbal and visual data (Stemler, 2000; Krippendorff, 2018). This analysis revealed two main themes, namely the Hygienic and the Social. Analytically, the Hygienic theme included verbal or drawing indices of (a) wearing a mask, (b) washing hands, (c) sanitizer use, and (d) medical care (hospital, medical staff, vaccines, and rapid, or self-testing). The Social theme included indices of (a) social/physical distancing (avoiding crowded or indoor places and intimacy such as hugging or kissing), (b) staying at home, (c) governmental restrictions (remote schooling/teleconferences, curfew, requirement for permission for any outdoor activity through SMS messages, restrictions on travel/movement between regions) and (d) lack of interaction with significant others (such as peers or grandparents). In the next step, the two independent coders mentioned above were asked to review the transcripts and the drawings by giving a score of 1 for the presence of each of the aforementioned indices and a score of 0 for its absence. Inter-coder agreement in identifying the indices included in participants' verbal responses and drawings ranged from 89 to 98% and divergences between coders were resolved after discussion. **Figure 1** illustrates the categories of the Hygienic and Social themes.

Data Analysis

Initially, descriptive statistics have been used to summarize collected data. In order to examine whether children's views of SARS-CoV2 and preventive measures relate to their age and the data collection technique we performed mixed Analyses of Variance with repeated measures, while a series of chi-square tests was applied to detect possible age differences in the incidence of each preventive measure. Finally, to examine whether children's views of SARS-CoV-2 as expressed in their verbal descriptions and their drawings differentiate children's recommendation of Hygienic vs. Social practices to mitigate the spread of COVID-19, a series of Analyses of Variance was applied

[1] During data collection, the term "coronavirus" was used to denote SARS-CoV-2, as has been typically the case in public discourse since the beginning of the COVID-19 pandemic.

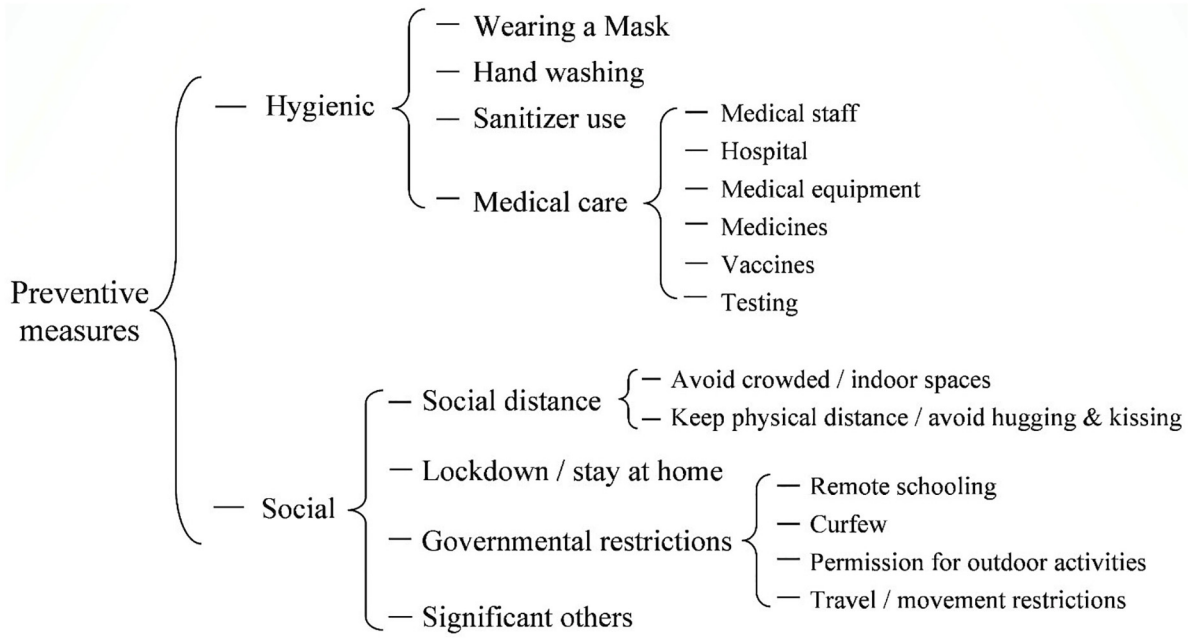

FIGURE 1 | Categories of hygienic and social preventive measures proposed by children.

using children's verbal and drawing scores about SARS-CoV-2 as the independent factor.

RESULTS

Results are presented in accordance with the research questions as follows: Firstly, children's views of SARS-CoV-2 and whether these vary according to age and mode of expression are presented. Secondly, analyses related to children's views of preventive measures and their variation with age and between data collection techniques are described. Finally, the relation between children's views of SARS-CoV-2 and prevention measures is reported.

Children's Verbal Descriptions and Drawings of SARS-CoV-2

First, the children's verbal descriptions and pictorial representations of SARS-CoV-2 were examined. Precisely, the analysis showed that the majority of children provided adequate responses and mentioned viruses or germs (n = 190, see Example 1), while fewer children gave partially adequate responses, for instance by connecting coronavirus to illness (n = 99, see Example 2). A small number of children responded inadequately and included mythical or other inappropriate elements in their answers (n = 31, see Example 3).

Example 1 (12-year-old boy):

> Coronavirus is a virus that is circular and it has little prickles. (. . .) it looks, if we see it from above, it will look like a crown,[2] and that's why they named it coronavirus. There are many coronaviruses. This particular (coronavirus) that's hitting us is called SARS-COVID-2. It's bad because a lot of people are dying from it.

Example 2 (10-year-old boy):

> It's an illness like all others but it's very contagious and this illness can easily kill you if you are old. And if you have not been vaccinated, then it is even easier for it to kill you.

Example 3 (5-year-old boy):

> Coronavirus is that people should not go out.

When asked to draw coronavirus most children produced either an adequate (n = 145) or a partially adequate representation (n = 158), as in **Figures 2** and **3**, respectively. Fewer children portrayed coronavirus including mythical or irrelevant elements in their drawings (n = 17, see **Figure 4**). The vast majority of children (n = 298) included spikes in their -either adequate or partially adequate- depictions.

In order to examine whether children's scores related to SARS-CoV-2 vary as a function of age and mode of expression we performed a 3 (*age group:* 4–6, 7–9, 10–12) X 2 (*mode of expression*: verbal, drawing) mixed ANOVA with repeated measures on the last factor. The analysis revealed a significant effect of age group, $F_{(2,317)} = 15.89$, $p < 0.001$, indicating that children's scores improved with age, with older children providing more adequate responses. *Post hoc* Tukey HSD comparisons revealed that statistically significant differences were observed between the 4–6-year-olds and the 7–9-year-olds ($p < 0.05$), between the 4–6-year-olds and the 10–12-year-olds ($p < 0.01$), as well as between the 7–9-year-olds and the 10–12-year-olds ($p < 0.05$). Furthermore, a significant main effect of mode of expression was found, $F_{(1,317)} = 5.03$, $p < 0.05$,

[2]In Greek, the word "corona" means "crown."

FIGURE 2 | A 9-year-old boy's adequate drawing of SARS-CoV-2.

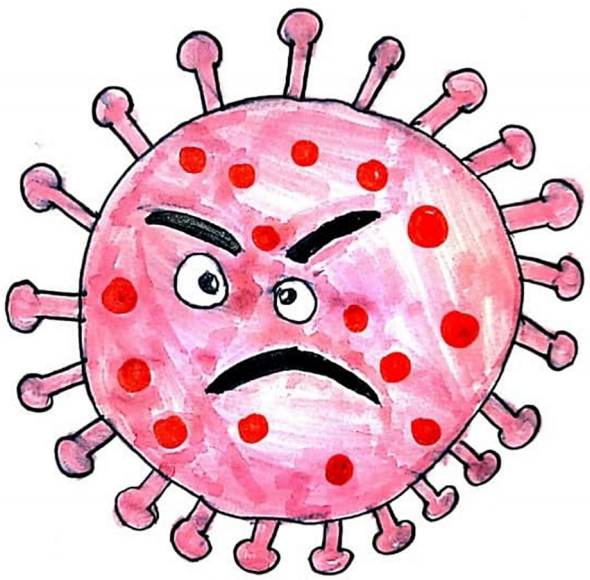

FIGURE 3 | An 11-year-old girl's partially adequate drawing of SARS-CoV-2 with anthropomorphic features.

since children's scores while verbally describing SARS-CoV-2 (M = 2.50) were higher than their scores while drawing it (M = 2.40). Finally, the interaction between age group and mode of expression was also found statistically significant, $F_{(2,317)}$ = 6.54, $p < 0.05$. This interaction was investigated further by a series of ANOVAs, which showed that age group differentiated significantly participants' verbal descriptions of SARS-CoV-2, $F_{(2,319)}$ = 19.81, $p < 0.001$, but not their drawing representations. As presented in **Table 1**, which summarizes the mean scores of children's responses by age group, even the younger age group seems to provide a partially adequate verbal description of coronavirus, while older children present higher

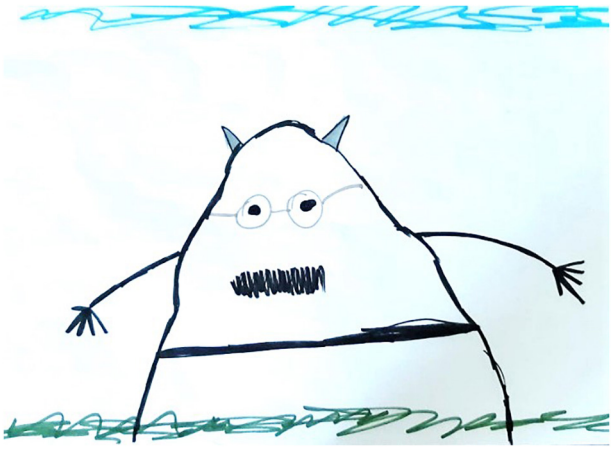

FIGURE 4 | A 6-year-old girl's inadequate drawing representing SARS-CoV-2 as a monster "with big hands because he reaches everything and eyeglasses because he sees everything."

TABLE 1 | Mean scores (and standard deviations) of children's verbal descriptions and drawings of coronavirus by age group.

	Verbal descriptions	Drawings
Age groups	***M (SD)***	***M (SD)***
4–6 years	2.22 (0.78)	2.35 (0.62)
7–9 years	2.51 (0.59)	2.35 (0.56)
10–12 years	2.78 (0.46)	2.52 (0.58)
Total	2.50 (0.67)	2.40 (0.59)

scores than the younger ones. On the contrary, mean scores of the drawing representations were at similar levels for all age groups.

Children's Verbal Descriptions and Drawings of COVID-19 Preventive Measures

In a next step, we attempted to identify the preventive measures proposed verbally and visually by participants to mitigate the spread of COVID-19. Overall, children mentioned equally Hygienic (n = 586) and Social (n = 585) measures. On the contrary, they included more Hygienic (n = 386) than Social (n = 218) measures in their drawings. **Table 2** presents the frequencies with which each preventive measure appeared in both modes of expression. Analytically, in their verbal descriptions children referred more often to Wearing a Mask (n = 276), Governmental Restrictions (n = 200), the need for Social/physical distancing (n = 191), Handwashing (n = 163), and use of Sanitizer (n = 112). Example 4 is indicative of participants' verbal responses. On the other hand, Wearing a Mask (n = 243, see **Figure 5**) and Staying at home (n = 105) were the most often depicted measures in children's drawings.

Example 4 (8-year-old girl):

> We can take the vaccine, wear a mask, use antiseptic and be cautious in general. We can't go out; they have limited us. We are

TABLE 2 | Frequencies (and %) of preventive measures in children's verbal descriptions and drawings by age group.

Preventive measures	Verbal descriptions				Drawings			
	Age groups							
	4–6 years	7–9 years	10–12 years	Total	4–6 years	7–9 years	10–12 years	Total
Hand washing	55 (51.4)	60 (52.6)	48 (48.5)	163 (50.9)	14 (13.1)	22 (19.3)	16 (16.2)	52 (16.3)
Sanitizer	33 (30.8)	48 (42.1)	31 (27.7)	112 (35.0)	18 (16.8)	31 (27.2)	29 (29.3)	78 (24.4)
Mask	84 (78.5)	103 (90.4)	89 (89.9)	276 (86.3)	74 (69.2)	83 (72.8)	86 (86.9)	243 (75.9)
Medical care	14 (13.1)	13 (11.4)	8 (8.1)	35 (10.9)	4 (3.7)	4 (3.5)	5 (5.1)	13 (4.1)
Social distance	46 (43)	72 (63.2)	73 (73.7)	191 (59.7)	5 (4.7)	19 (16.7)	27 (27.3)	51 (15.9)
Stay at home	27 (25.2)	37 (32.5)	29 (29.3)	93 (29.1)	34 (31.8)	40 (35.1)	31 (31.3)	105 (32.8)
Restrictions	55 (51.4)	74 (64.9)	71 (71.7)	200 (62.5)	9 (8.4)	30 (26.3)	15 (15.2)	54 (16.9)
Significant others	33 (30.8)	41 (36.0)	28 (28.3)	102 (31.9)	2 (1.9)	4 (3.5)	2 (2.0)	8 (2.5)

FIGURE 5 | A 6-year-old boy's drawing of his family members wearing masks.

not allowed to go out without sending an SMS. When we don't send an SMS, they check us and put a fine.

In order to analyze the data presented in **Table 2**, we created two composite scores for each mode of expression (verbal vs. drawing) by summing up the measures of Hygienic and Social categories (range 0–4). These data were analyzed by a 3 (*age group*: 4–6, 7–9, 10–12) X 2 (*type of measures*: hygienic, social) X 2 (*mode of expression*: verbal, drawing) mixed ANOVA with repeated measures on the two last factors. The analysis showed that the main effect of age group was statistically significant, $F_{(2,317)} = 13.94$, $p < 0.001$, showing that with age participants tended to introduce more preventive practices in their responses. The mean scores were 1.18, 1.49, and 1.49 for the younger, the middle, and the older group, respectively. *Post hoc* Tukey comparisons revealed significant differences between the 4–6-year-olds and the 7–9-year-olds ($p < 0.001$), as well as between the 4–6-year-olds and the 10–12-year-olds ($p < 0.001$). Examples 5 and 6 and **Figures 6** and **7** are indicative examples of older participants' attempts to include a variety of preventive measures in their verbal and drawing representations.

Example 5 (9-year-old girl):

> To protect ourselves from COVID-19 we should all wear masks, use antiseptics, and try to keep distance measures so that we don't catch it. These footprint stickers they have in supermarkets and department stores are good. (You) can't... contact people you don't know... You see, you are negative, OK? You don't know the other one doesn't have it. And the other one is also negative or has not had any symptoms, but we can both have (COVID-19) and not have any symptoms. That's why it is good to be cautious even without having the coronavirus and keep distances. This is the best. And (wearing) masks. As for hugs, I would suggest no.

Example 6 (10-year-old boy):

> We should take all necessary protection measures, that is mask, 2-m distance, frequent handwashing, antiseptic, and even the vaccine. We can't be in our homes forever, away from our friends and the people we love, e.g., grandpa, grandma.

Moreover, a significant main effect of mode of expression, $F_{(1,317)} = 401.33$, $p < 0.001$ was recorded, since children included more preventive measures in their verbal descriptions ($M = 1.83$) than in their pictorial representations ($M = 0.94$). The main effect of type of practices was also found significant indicating that children overall reported more Hygienic ($M = 1.52$) than Social ($M = 1.26$) practices. Additionally, a statistically significant interaction was found between mode of expression and type of practices, $F_{(1,317)} = 33.53$, $p < 0.001$, suggesting that drawings included more Hygienic ($M = 1.21$) than Social practices ($M = 0.068$), while verbal descriptions included equally Social ($M = 1.83$) and Hygienic ($M = 1.82$) practices.

Finally, the interaction between age group, mode of expression, and measures was also found significant, $F_{(2,317)} = 3.18$, $p < 0.05$. This interaction was investigated further by a series of ANOVAs, which showed that the effect of age-group was statistically significant in reporting Social measures [$F_{(2,319)} = 8.36$, $p < 0.001$] and in drawing Hygienic [$F_{(2,319)} = 4.22$, $p < 0.05$] and Social measures [$F_{(2,319)} = 7.2$, $p < 0.001$]. Subsequent *post hoc* analyses revealed that the younger group verbally reported fewer social measures than the

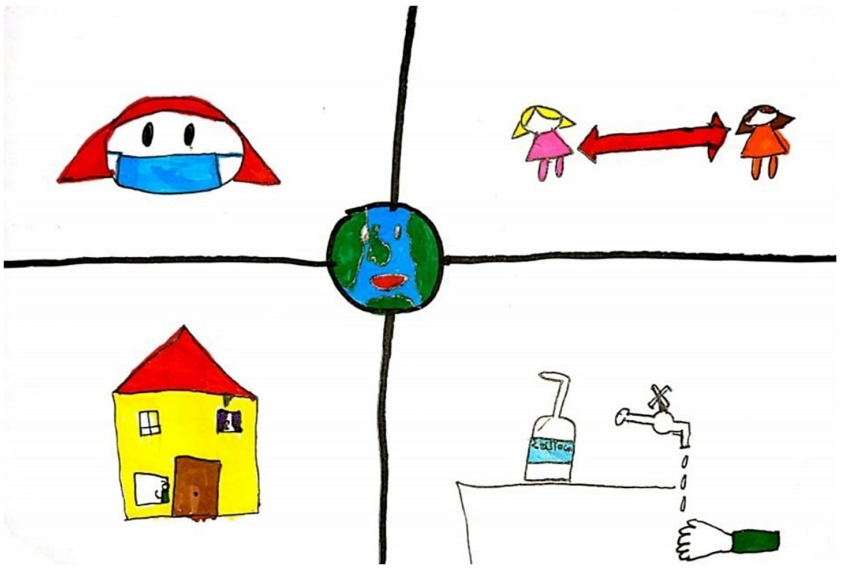

FIGURE 6 | An 11-year-old girl's drawing portraying a variety of COVID-19 preventive measures: Wearing a mask, keeping distance, staying at home, and washing hands.

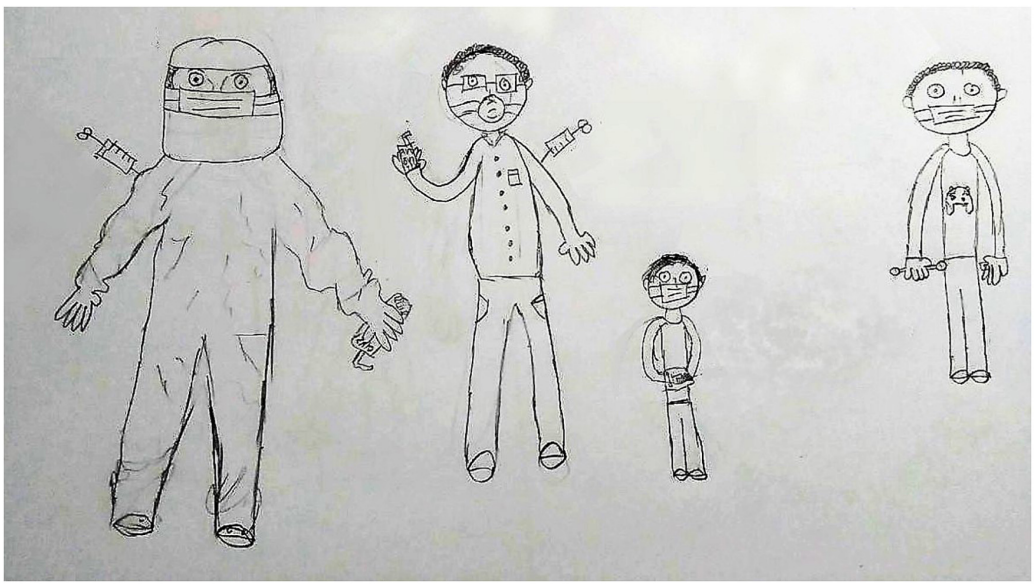

FIGURE 7 | A 10-year-old girl's drawing of her family taking preventive measures: masks, hospital uniform, vaccines, antiseptics, and self-tests.

middle and the older group, drew fewer hygienic measures than the older group, and fewer social measures than the middle and the older group (all *ps* < 0.05).

Regarding the emergence of each preventive measure between age groups, the crosstabulation of data presented in **Table 2** showed significant differences in (a) Wearing a Mask [$\chi^2(2, N = 320 = 8.14, p < 0.05$ for verbal descriptions), $\chi^2(2, N = 320 = 9.78, p < 0.05$ for drawings)] (b) Social/physical distancing [$\chi^2(2, N = 320 = 21.09, p < 0.001$ for verbal descriptions), $\chi^2(2, N = 320 = 17.67, p < 0.001$ for drawings)] and (c) Governmental restrictions, [$\chi^2(2, N = 320 = 9.49, p < 0.05$ for verbal descriptions), $\chi^2(2, N = 320 = 12.92, p < 0.05$ for drawings)]. Specifically, the analysis showed that the youngest age group tended not to mention wearing a mask or governmental restrictions, while they referred to social/physical distancing less frequently than expected. Consistently, this group drew keeping social/physical distances and governmental restrictions less frequently than expected. Furthermore, the 7-to-9-year-old group drew governmental restrictions more frequently than expected, while 10-to-12-year-olds emphasized

social/physical distancing both verbally and visually more frequently than expected and tended not to draw masks. No statistically significant age differences were noticed regarding the emergence of Handwashing, Use of antiseptic, Staying at home, Medical care, and Lack of significant others either in verbal descriptions or drawings.

Relation Between Children's Views of SARS-CoV-2 and the Proposed Preventive Measures

The analysis performed to investigate the relation between children's views of SARS-CoV-2 and the proposed preventive measures showed that children's verbal references to Hygienic practices varied according to their verbal score concerning SARS-CoV-2 [$F_{(2,\ 319)} = 3.07$, $p < 0.05$]. Specifically, children who explicitly referred to a virus or a germ tended to verbally report more Hygienic practices ($M = 1.92$) than those who provided more generic descriptions of the novel coronavirus connecting it with illness ($M = 1.75$) or gave inappropriate answers ($M = 1.51$). *Post hoc* comparisons showed that statistically significant differences emerge between those children who offered an adequate and an inadequate description ($p < 0.05$). On the contrary, the adoption of social preventive practices did not seem to differ according to children's scores reflecting their verbal descriptions of Coronavirus. Finally, children's drawing scores of SARS-CoV-2 had no effect on either type of measures.

DISCUSSION

The present study aimed to explore children's views of SARS-CoV-2 and COVID-19 preventive practices during the second year of the pandemic in Greece. To attain this aim children aged 4–12 years were asked to verbally describe and draw the terms under investigation. In general, our results support previous findings suggesting that even from the beginning of the pandemic children have formed a significant level of understanding of COVID-19 related issues (Christidou et al., 2021; Bray et al., 2021a,b; Bonoti et al., 2022; Rydström et al., 2022). However, interesting differences emerged as a function of children's age or the data collection procedure.

Regarding children's views of the novel coronavirus, our data indicate that the majority of participants provided adequate responses by recognizing that SARS-CoV-2 is a virus or a germ. Fewer children seem to confuse SARS-CoV-2 with COVID-19 and other health issues or provide inappropriate answers. Similarly, their drawings mostly include either adequate or partially adequate representations, a finding which possibly reflects children's exposure to an abundance of publicly available images of SARS-CoV-2 which include its morphological characteristics, namely its circular shape and spikes (Delicado and Rowland, 2021; Martinerie et al., 2021), oftentimes with anthropomorphic elements (Martinerie et al., 2021; McGellin et al., 2021).

Remarkably, developmental differences in children's views of SARS-CoV-2 were evident only in their verbal descriptions, but not in their drawings. In other words, our results showed that children's verbal descriptions of coronavirus improve with age since as they get older, they express views more compatible with scientific knowledge. More precisely, analyses revealed significant differences between the younger and older participants, possibly indicative of the reported major changes in their overall biological knowledge taking place at around the age of 7 years (Duschl et al., 2007).

On the other hand, the lack of developmental differences in children's drawings of coronavirus verifies findings from the first year of the pandemic (Martinerie et al., 2021; Bonoti et al., 2022) and can be interpreted by the emphasis given on visual images of SARS-CoV-2 in information and health promotion campaigns since the beginning of the pandemic. Visual images of the SARS-CoV-2 morphology were abundant in these campaigns (Delicado and Rowland, 2021), quite often with anthropomorphic attributes (de Rosa and Mannarini, 2020; Joubert and Wasserman, 2020; McGellin et al., 2021). Therefore, representing a circular virus with spikes, and occasionally with malevolent intentions to indicate its menacing character was a well-established and easy-to-follow meaning-making device, even for the younger participants (Martinerie et al., 2021). Besides, anthropomorphic views of micro-organisms are readily adopted by students (Vasquez, 1985; Byrne and Grace, 2010; Byrne, 2011; Ruiz-Gallardo and Paños, 2018). Although anthropomorphic perceptions of microbes seem to decline with age, they can persist even among older students, who rather acknowledge it as an explanation tool than a literal description of reality, but continue to use it to explain abstract or invisible concepts (Byrne and Grace, 2010; Byrne, 2011). Yet, in the case of microbes, anthropomorphism often also entails anthropocentrism: viewing a virus as a hostile creature intending to harm people, can obscure biological knowledge and hamper children from neutrally considering the viruses' role as microorganisms within wider ecosystems (Gelman and Kremer, 1991; Byrne et al., 2009; Manches and Ainsworth, 2022).

The overwhelming majority of children who –irrespective of age– included spikes in their circular representations of SARS-CoV-2 (Martinerie et al., 2021; Bonoti et al., 2022) reveals that the visual mode constitutes a privileged field for conveying meanings about the novel coronavirus (Joubert and Wasserman, 2020) -even considering the limitations of its anthropomorphic and anthropocentric representations undermining and obscuring critical aspects of its biology (Manches and Ainsworth, 2022). This is particularly obvious, taking also into account that public verbal communication did not concentrate on descriptions of SARS-CoV-2 *per se*, but rather on its transmission, the resulting disease, and preventive measures.

The results also suggest that children are well informed about the preventive practices implemented to mitigate the spread of COVID-19 (Bray et al., 2021a; Christidou et al., 2021; Thompson et al., 2021; Rydström et al., 2022). In other words, their verbal and drawing responses include references to both the Hygienic and Social preventive practices which prevailed during the second year of the COVID-19 pandemic. This finding seems to be in line with previous research (Jones and Rua, 2008) indicating non-experts' awareness of critical aspects of infectious diseases based on their relevant experiences. Overall, Hygienic practices seem

to emerge more often than Social ones, although this tendency is obvious only in children's drawings. In line with previous studies these findings reveal that children conceptualize COVID-19 as a multidimensional concept with hygienic and social facets, as has been the case with illness in general (Nagy, 1953; Schmidt and Frohling, 2000; Myant and Williams, 2005; Piko and Bak, 2006; Zaloudikova, 2010; Mouratidi et al., 2016; Prokop et al., 2016; Bonoti et al., 2019). Our results are also indicative of children's sense of emergency, responsibility, and readiness to take action toward protecting their families and the community (Bray et al., 2021a; Thompson et al., 2021).

When asked to describe verbally appropriate preventive measures, children report more practices, than those they include in their drawings. Although verbal responses seem to be richer than drawings, the two data collection techniques seem to provide similar information and act complementarily (Avgerinou and Ericson, 1997; Jewitt et al., 2001; Unsworth, 2004; Coleman et al., 2011; Matloob Haghanikar and Leigh, 2022).

Overall, although children tended to report more preventive measures with age, significant differences seem to emerge between the younger and the two older age groups, confirming that around the age of 7 years, children seem to be able to grasp a greater variety of measures that should be followed (Duschl et al., 2007). Moreover, from the age of 7 years onward, measures concerning governmental restrictions and instructions of social distancing tend to appear more frequently either in verbal or in drawing responses of older participants.

Interestingly, children who can describe SARS-CoV-2 as a virus or a germ, seem to report more hygienic practices than those who do not provide an appropriate description of the term. This finding supports Manches and Ainsworth's (2022) claim that a greater understanding of SARS-CoV2 assists children to differentiate the virus from the disease, to cope with the consequences of the pandemic, and finally to adopt positive health attitudes and behaviors. On the contrary, children's understanding of the term did not seem to differentiate their report of social preventive practices. Whether this finding indicates children's difficulty to relate the significance of the imposed social measures with the interception of the disease remains a question to be answered.

Limitations

Recruiting a wide age range of participants can be considered an advantage of the present study since this permitted exploration of possible age differences in children's views of SARS-CoV-2 and related mitigation measures. However, the adoption of a less-structured approach would permit to establish the level of their biological knowledge concerning SARS-CoV-2 and ultimately their degree of understanding of the term. Respectively, although our findings suggest that children present a remarkable awareness of the appropriate COVID-19 preventive measures, it should be noted that these data emerged from their self-reports, so one cannot conclude whether they actually adopted them to confront the threat of the pandemic. An in-depth interview, as well as the reports of their parents, could elucidate the degree of adoption of the aforementioned practices. Moreover, the imposed restrictions during the phase of data collection inevitably led to several limitations of the adopted procedure. For instance, the sampling method used as well as the implementation of data collection through video calls, which did not allow face-to-face communication with participants and did not exclude their parents' presence, might have had an impact on the reported results. Moreover, this remote communication and interaction did not facilitate to obtain data concerning parents' socio-economic and educational background which might have influenced children's expressed views; future studies should attempt to cover this challenging research question.

Implications for Science Education and Research

By combining verbal and visual data, this study has revealed aspects of children's views of SARS-CoV-2 and COVID-19 that could not have become apparent through language-based elicitation tools alone. The combination of two data collection techniques resulted in a more comprehensive understanding of the participants' perspectives that would not emerge otherwise (Pfister et al., 2014).

Future research could involve a more in-depth exploration of children's understanding of the biological aspects of SARS-CoV-2, such as its structure, its replication, and how it is related to infection, immune system response, and the emergence of symptoms. Furthermore, a more systematic investigation of how children associate the biological and the social aspects of COVID-19 could also provide valuable results, given that the current pandemic may be significantly influencing children's knowledge about viruses that has not been recorded by research in the previous years (Manches and Ainsworth, 2022).

Also, it would be valuable to compare research data on children's emerging views of SARS-CoV-2 and COVID-19 collected at different phases of the pandemic, to capture the changes they undergo amid the evolution of the crisis. Being part of a broader and ongoing project, this study has focused on data from the second year of COVID-19. Data collection and analysis are continuing during the current, 3rd year, which will enable useful comparisons between different time spots of the pandemic and provide insight on the implications of experiencing this long-term phenomenon on children's related views.

Considering children's verbal and visual responses regarding SARS-CoV-2 and COVID-19 preventive measures could serve as a starting point for designing appropriate teaching material and interventions to scaffold their rapidly developing understanding of the topic, and potentially of similar future pandemics. Visual representations would expectedly be a critical component in such endeavors, since they provide a powerful means for meaning-making in the case of viruses and infectious diseases (Mutonyi and Kendrick, 2011; Joubert and Wasserman, 2020; Manches and Ainsworth, 2022). Furthermore, having students read and create visual images of SARS-CoV-2, could scaffold their construction of more appropriate views as is the case with other concepts in science (Jewitt, 2008; Britsch, 2013) and engagement in relevant COVID-19 prevention and mitigation practices that could be applicable in future crises (Mutonyi and Kendrick, 2011).

Moreover, as Manches and Ainsworth (2022) suggest, learners' difficulties in understanding viruses do not originate so much from inherent cognitive limitations but are also highly dependent on how they are represented during teaching. Thus, the publicity of the novel coronavirus and the resulting COVID-19 pandemic might provide an appropriate context for children to become engaged in learning about the biology of viruses.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Ethics Committee of the Department of Early Childhood Education/University of Thessaly. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

VC, FB, and PP were collaboratively involved in designing the study and in data collection. PD was involved in data collection and coding. VC and FB performed data analysis and were involved in manuscript preparation. PP and VH contributed in the theoretical and methodological underpinnings of the study, interpretation and discussion of results, and manuscript editing. All authors contributed to the article and approved the submitted version.

FUNDING

This research was funded in part by the Aristotle University of Thessaloniki Research Committee (Grant No. 73453/2021).

ACKNOWLEDGMENTS

We would like to thank all participants in the study for providing their enlightening responses and for permitting the use of their drawings appearing in figures to exemplify data.

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