The Effect of Prolonged Exposure to Online Education on a Classroom Search Companion

Mohammad Aliannejadi[1], Theo Huibers[2], Monica Landoni[3], Emiliana Murgia[4], and Maria Soledad Pera[5](✉)

[1] University of Amsterdam, Amsterdam, The Netherlands
m.aliannejadi@uva.nl
[2] University of Twente, Enschede, The Netherlands
t.w.c.huibers@utwente.nl
[3] Università della Svizzera Italiana, Lugano, Switzerland
monica.landoni@usi.ch
[4] Università degli Studi di Milano-Bicocca, Milan, Italy
emiliana.murgia@unimib.it
[5] Boise State University, Boise, USA
solepera@boisestate.edu

Abstract. Exposure to technology impacts children's perception and conceptualisation of the way devices they regularly use work. This prompts us to study if almost two years of online teaching, enabled by a broad range of technologies, have influenced the way children imagine a search companion would look and behave when helping them perform school-related search tasks. We conducted a 2-stage study during which children ages 9 to 11 drew and described their imaginary search companion; they also chose a few desirable and non-necessary traits. By following the protocol of a study conducted pre-pandemic, we contextualise salient altered expectations that we attribute to exposure to technology prompted by the COVID-19 pandemic. We highlight and discuss emerging trends observed from the analysis of data gathered before and after the extensive online experience and how these will guide the design of functionality of a search companion for the classroom.

Keywords: children · classroom · search companion · COVID-19

1 Introduction

The design of technology to support children's education in and out of the classroom interests researchers and industry practitioners [4,8,19,36,37], as its intentional use can leave a lasting impact on students and teachers alike [16]. It is then imperative to carefully consider the complexities involved in designing and deploying technology for the classroom context, regardless of the instruction modality (i.e., in-person or remote) [9,26,40,41].

A. Barrón-Cedeño et al. (Eds.): CLEF 2022, LNCS 13390, pp. 62–78, 2022.
https://doi.org/10.1007/978-3-031-13643-6_5

A learning-related aspect sustained by technology is information gathering [16]. Children use mainstream search engines for locating resources that can formally (within structured assignments) or informally support knowledge acquisition [2,52]. Given the ubiquitous presence of voice assistants (VA), like Siri or Alexa, and the fact that even before they can read or write children can already interact with VA [29], it is not surprising for them to also turn to VA for inquiries concerning formal and informal learning settings [43,49]. VA, however, have not been designed with children in mind, instigating research to understand how children interact with VA, their perceptions and expectations, and the limitations faced [13,31,64]. Literature in this area aims to advance knowledge on child-VA interactions in the broad sense [64]. We instead seek to expand on foundational works focused on understanding how VA can aid the search process [24,64] to explicitly consider the classroom context.

We argue for the benefits of designing a *Search Companion for Children in the Classroom* (SCCC) to support learning [15,34], anchored on the search as a learning paradigm [11] and principles related to spoken conversational systems that help users navigate the information space, keep track of context, and seek a natural flow of conversation [50]. This SCCC could facilitate children's quests for curriculum-related information and offer necessary scaffolding while affording them the benefits of voice-based interactions they have grown accustomed to and minimising the barriers faced when using search engines (e.g., SERP navigation) or VA (e.g., query formulation via speech interfaces) [3,14,38,48,65]. Taking such a SCCC from theory to practice requires that we first understand what children expect from technology, how and why technology is used in a classroom setting, and which factors influence acceptance and success [32].

The COVID-19 pandemic has caused a shift from in-person to blended or virtual learning environments. This has translated into the integration of technologies into online lessons (e.g., search engines) as well as the adoption of technologies to support instruction delivery (e.g., Zoom) [17,18,47]. Screen time and interaction with VA among children have naturally increased over the past two years [57]. We wonder if the long-term exposure to and the broader adoption of technologies that directly or indirectly enable online teaching and learning has impacted what children expect from technology for the classroom–in particular from a SCCC that facilitates completion of online inquiries for learning purposes. This prompted us to replicate the study we ran [25] before the pandemic to compare trends and assess the potential impact extensive online learning has had on children and their perspective on technology in the classroom. In doing so, we explore changes in children's attitude towards technology in the classroom and their effects on the design of tools to scaffold their learning, specifically search as learning, both in terms of process and outcome. To control scope, we use a framework that establishes four pillars for the design and evaluation of information retrieval systems for children: (i) *strategy*, (ii) *user group*, (iii) *task*, and (iv) *context* [24]. Here, (i) personifying and empowering a SCCC, (ii) children[1] in

[1] From here on, whenever we say children we mean children aged 9 to 11.

primary five (ages 9 to 11), (iii) online inquiries about topics common among primary five curricula, and (iv) classroom setting.

Two questions drive our 2-stage exploration: **RQ1**: *What do children expect from a SCCC?* and **RQ2**: *Does prolonged exposure to online instruction impact children's expectations for a SCCC?* In Stage 1, we elicit children's needs and expectations for voice-driven technology that can ease information discovery in the classroom. In Stage 2, we examine data we collected pre-pandemic [25]. We then compare findings as data collection using the same protocol, where the only difference is in (ii). Neither user group of children in primary five was tech-savvy, i.e., children did not receive formal technology-related or search literacy instruction. Yet, children in Stage 1 have frequently used technology over the past two years given pandemic mandates.

The pandemic marks a turning point in attitude towards technology and its adoption. Reported outcomes are not meant as a rigid picture of the status quo but as insights into trends to help researchers and industry practitioners–in areas like Information Retrieval, Natural Language Understanding, Human-Computer Interaction, Spoken Dialogue, and Artificial Intelligence–better interpret the evolution of children's requirements for SCCCs. Findings also call for shifting a classic paradigm: Start by outlining requirements to design explicitly for a particular user group and context, as opposed to designing for average populations and then adapting to serve users with differing needs. In this way, we could better explore and define the dimensions impacting algorithmic and interface design.

2 Background and Related Work

Preference Elicitation. Drawing is a widely-used technique for eliciting feedback as it provides even young children with a convenient way to express themselves freely. The downside is in interpreting the artefacts produced by defining codes and procedures for assigning them. Besides the groundwork described in [28], we refer to [56] which describes how to involve primary school children in designing specific functions for a pedagogical agent. Combining an initial phase of free drawing with a follow-up "scaffolded ideation phase", made guideline extraction easier as children focused and elaborated on visual representations of good collaboration. In our study, we explore the influence that long-term usage of (educational) technologies to support learning can have on children's expectations of the look and feel of a SCCC. Obaid et al. [42] examined free drawings made by children and interaction designers. They contrasted the designs of educational robots while assessing the influence of knowledge of robotics on children's designs. We concentrate on children's designs but do not compare them with adults'. We engage children in structured activities to get a better understanding of their preferences and the reasons behind these preferences.

User Experience. Literature describing factors that foster successful interactions between assistants/agents and children are inconclusive. There is a consensus, however, on children preferring personification [64] much more than adults [28,45]. Hence, we explore children's preferences for personification for their SCCC. Because of reports comparing children and adult drawings, we use technical knowledge as another dimension that can influence users' perceptions [28]. We were inspired by findings of the FMBT design model [10], which stresses how the conversational Functions linked to content and the interaction process should be kept separated, the importance of different Modalities to support communication, the emphasis on Behaviour beyond functions and how Timing is an essential element of conversation. Luger and Sellen [32] linked users' perception of intelligence to the look and feel of the VA, how the system represented information and the quality of the interaction with users. Most unsatisfactory interactions were associated with a gap between expectation and reality; wider among users with lower expertise in technology. Examining (non-)human properties of VA to understand the expectations of children aged 3 to 6 and the impact on future development Xu and Warschauer [61] note that children are reticent to describe VA as living beings or artefacts; often attributing animate properties. Yang et al. [63] highlight the relevance of pragmatic (e.g., response content and interaction) and hedonic (e.g., comfort, pride, and fun) qualities. We adopt this categorisation for our analysis set on young users, not adults.

The context in which VA are used also influences users' perceptions. Matsui and Yamada [35] investigate user perception of humanoid VA and how "one's emotion infects the partner" in emotional contagion. They suggest that experience and familiarity are key to users; culture also plays a crucial role. Thus, for the school context, we turn to pedagogical agents, which are "interactive systems that teach by talking to students" [51]. As teachers, pedagogical agents help students learn a new topic or skill, as companions they provide emotional support, and as students they serve as a peers others can learn from. Similar findings are in [22,23] where primary school children created a teachable 3D Tutor, following activities like drawing sessions, devised in agreement with teachers. This resulted in a 3D tutor with the appearance and personality of a friendly Alien.

Learning. VA are seldom explored in a classroom setting. Lee et al. [28] study adults and children's perceptions of VA personas; Druga et al. [13] investigate instead question-asking behaviour when children (ages 5 and 6) turn to VA at home. Lovato et al. [31] aim to understand how children conceptualise the way VA work. Bhatti et al. [5] argue for the design of a VA that could act as a childcare assistant for parents of young children. Oranç and Ruggeri [43] looked at spontaneous interactions of children aged 3 to 10 with Alexa and concluded that the effects of familiarity with VA and technology, in general, had to be further studied in terms of possible influence on learning habits and success. Literature addressing the usefulness of VA supporting learning is often focused on fostering the development of a particular skill, such as science [55,60], literacy [59], reading [62], computer science [51] and history [33]. This evidences the need to allocate efforts to the design, development, assessment, and deployment of a `SCCC` which could instead support a broad range of inquiry tasks related to the primary school curriculum–something already known to be of interest among children aged 7 to 12 when it comes to VA supporting in-home learning [15]. Perhaps the closest related works are two that seek to understand what children expect for a VA [15] and a search companion [25] supporting learning. Still, both report findings are based on children's expectations before COVID-19.

3 Experimental Set-Up

Our study description, including rational procedure and protocol, was approved by the school ethics committee so that it could be administered by teachers as part of normal in-class teaching. Following the **protocol** and questions used to elicit children's responses in [24,25], study participants completed three tasks.

– *Task 1.* Guided by their teacher, children engaged in a *drawing* activity during which they were asked to sketch their ideal SCCC, i.e., how it would look like. This allowed us to infer children's preferences in appearance.
– *Task 2.* Children wrote a brief *description* of how they expect a SCCC to look and behave. Task 2 enabled us to elicit attributes not captured in drawings, given children's disparate ability to draw and attention to detail.
– *Task 3.* From a pre-defined *trait* list inspired by [35,63] and introduced in [25] (Table 1), children *identified* those desirable and non-necessary for the SCCC to be supportive of their classroom needs. Inspired by Yang et al. [63], we link traits to pragmatic (i.e., helpful and easy interactions with SCCCs) or hedonics (i.e., related to the fun, pride and comfort experienced when engaging with SCCCs) qualities. Task 3 enabled us to interpret Task 1 drawings and elucidate essential attributes to be considered when translating children's vision from theory to practice.

We rely on two sets of **data** collected using the same protocol at schools in Italy with the same program for instruction, which does not include formal training on (the use of) technology or search tools. We were permitted to use anonymised data (stored in a secure location) for research purposes.

– *PreCOVID-19Data* includes drawings, descriptions, and choices generated by 20 children in primary five; ages 9 to 11, gender uniformly distributed. This data–collected in late 2019–was made available by the authors in [25].
– *COVID-19Data* includes drawings, descriptions, and choices from 19 children (10 boys, 9 girls) in primary five; ages 9 to 11 (disjoint from PreCOVID-19Data) who engaged in a data-gathering session in January of 2022.

To examine data, we expand on the methodology proposed in [25]:

– *Code Analysis.* Inspired by [28], researchers and an education expert coded Task 1 drawings as *Animal*, *Device*, *Human*, *Robot*, and *Other*. Rare disagreements were solved using Task 2 descriptions.

Table 1. Task 3 traits. **H** indicate hedonic traits and **P** pragmatic ones.

Traits	
T1 (H). Behave a research fellow / peer	**T8 (P).** Remember your previous requests
T2 (P). Be a research expert / librarian	**T9 (P).** Keep the conversation fluidly without interruptions
T3 (H). Be like a human being	**T10 (P).** Use external services when needed (e.g. open a video)
T4 (H). Take care of your privacy	**T11 (P).** Respond promptly
T5 (H). Worry about not distracting you	**T12 (H).** Make you feel safe
T6 (H). Learn your tastes and needs	**T13 (H).** Make you feel proud because you use new technologies
T7 (P). Anticipate your requests for information	**T14 (H).** Make you have fun

– *Description Analysis.* We examined term occurrence (stopword removal, lemmatization, and tokenization using Python's NLTK [7]) in Task 2 descriptions seeking common terminology used to describe a SCCC. We also considered description length as a proxy to assess engagement.
– *Trait Analysis.* We examined the frequency with which Task 3 traits were selected as desirable or non-necessary. We investigated how hedonic and pragmatic traits can inform different layers of design–the emotional, interactive, and internal architecture. Given children's preferences for personifications [64], we investigated connections between appearance and trait selection.

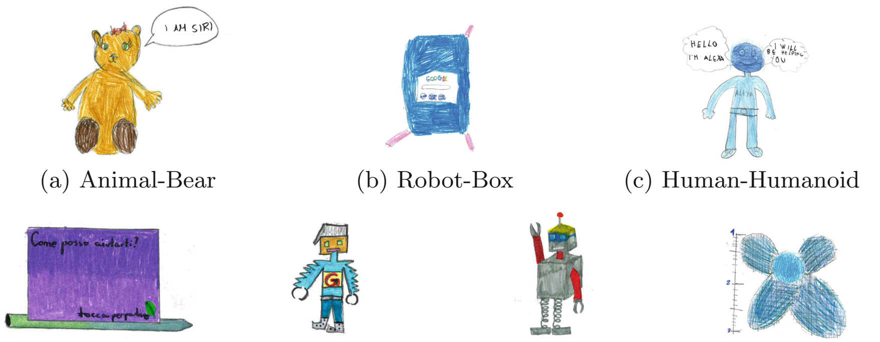
4 Results and Discussion

4.1 Stage 1: Children's Expectations

Appearance (Task 1) The 19 drawings in COVID-19Data were distributed as 4 Animals, 2 Humans, 3 Devices, 8 Robots, and 2 Others (Fig. 1). Among children's depictions, we saw a prevalence of robots and devices, much more so than human-like or animal-like personifications. Moving beyond the general appearance, an in-depth perusal of the intricacies captured in children's characterisations of a SCCC revealed that regardless of the code assigned, most drawings (∼75%) exhibited 'technology-like' components. Animal-/human-like portrayals evinced a technology-like demeanour. This is evident, for example, in Figs. 1a and 1g, which depict a bear and a flower. Both with details that signal how the sketches depart from classic representations: 'I am Siri' linking to the well-known VA and an embedded audio device turning the flower into a gadget, respectively. Similarly, the human-like body in Fig. 1c mentions Alexa, another popular VA.

Descriptions (Task 2) Using brief descriptions in COVID-19Data, we built a word cloud emphasising prominent terms used to describe SCCCs (Fig. 2b). Analysing the word cloud and the descriptions, we infer that children envision a SCCC as always available (e.g., 'wifi' in Fig. 2b) and supportive of not just classroom-related concerns, but 'everything'. Clues in the descriptions (like 'voice', 'ask', and 'search') suggest that children see a SCCC as an extension of well-known VA or tools (see 'Alexa,' Siri,' and 'Google' on Fig. 2b). These are tools children already turn to for educational inquiries and beyond [6,30].

Traits (Task 3) One of the most thought-after traits was for the SCCC to 'learn your tastes and needs' (Fig. 5). This points to children expecting a SCCC to offer a personalised experience. Other salient traits included the ability for a SCCC to be mindful of children's privacy and one that behaves as a research fellow/peer. Regarding traits that could be overlooked, we saw less of a consensus. Except for a SCCC not needing to neither behave like a research expert nor look like a human being, the rest of the traits were often selected by at most a single child (Fig. 6d). The top desired and top non-necessary traits are a mix of hedonic and pragmatic choices. The desired ones, however, align with the behaviour of the SCCC, whereas non-necessary ones refer to appearance. We noted from Fig. 6b that except for pragmatic trait T9 (fluent conversation) which was often selected along with hedonic traits, the strongest co-occurrences were among T1, T4, and T6. From



(a) Animal-Bear (b) Robot-Box (c) Human-Humanoid

(d) Device-Tablet (e) Robot-With logo (f) Robot-Classic (g) Other-Flower

Fig. 1. Sample SCCCs included in COVID-19Data.

(a) PreCOVID-19Data (b) COVID-19Data

Fig. 2. Word-cloud based on sentences collected in response to Task 2.

Fig. 7b we see children who designed personified SCCCs tended to choose a wider range of hedonic and pragmatic traits to attach to them than counterparts who went for non-personified depictions; similarly when considering non-necessary hedonic traits (Fig. 7d).

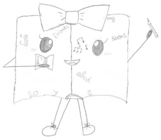
4.2 Stage 2: Unintended Consequences of the Pandemic

We gauge unintended pandemic consequences, as children worldwide were regularly exposed to and use technologies supporting remote teaching.

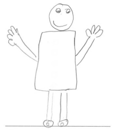
Appearance (Task 1). It emerges from Fig. 4a the increase in children envisioning SCCCs as robots. Drawings in PreCOVID-19Data were more evenly distributed across Animal, Human, Device, and Robot. Regardless of the category assigned to them, the illustrations in PreCOVID-19Data tended to be more friendly-looking and cute, with less of a 'technology' bias. This is visible in the sample illustrations in Fig. 3, all with friendly, happy faces, most with cute adornments (the bow in Fig. 3b); a sharp contrast with the sample sketches in Fig. 1, produced by children after prolonged exposure to technologies.

Descriptions (Task 2). Descriptions in COVID-19Data were much lengthier than those in PreCOVID-19Data–close to twice as much as shown in Fig. 4b. From the word clouds in Fig. 2, we see that descriptions in COVID-19Data included


(a) Animal


(b) Other


(c) Other


(d) Robot

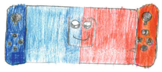
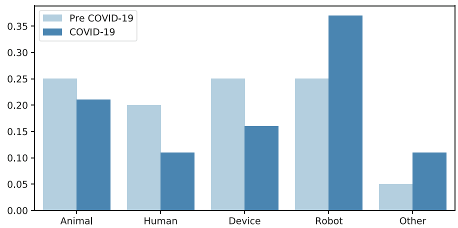

(e) Device

Fig. 3. Sample search companions in `PreCOVID-19Data`.

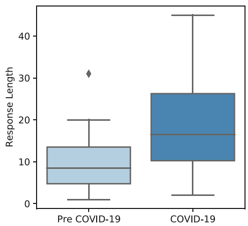
words commonly-attributed to tech-savvy individuals, e.g., 'voice', 'wifi', and 'understand'. Instead, descriptions in `PreCOVID-19Data` emphasised terms like 'help', 'friend', 'chatty', and 'funny'.

Traits (Task 3) There is evidence about expected traits a `SCCC` should exhibit. We begin by probing desired and non-necessary trait selections captured in Fig. 5. Based on `PreCOVID-19Data`, children gravitated towards traits that would result in a `SCCC` being fun (T14) but also able to prevent distractions when completing classroom assignments (T5) and be mindful of their privacy (T4). Instead, from `COVID-19Data` we noted that two years onwards, children voiced their longing for a `SCCC` capable of learning their tastes and needs (T6), behaving like a peer (T1), and enforcing privacy considerations (T4). Regardless of their (formal) exposure to technology, children are aware of privacy concerns that technologies they use must safeguard. Moreover, before COVID-19, children seemed to prioritise interaction characteristics (fun vs. distraction-trade-off), whereas children in `COVID-19Data` focused more on functional aspects of a `SCCC`. Overall, from the trait selection distribution showcased in Fig. 5, it is evident that there was a preference increase for T1, T4, T6, and T9 surfacing from `COVID-19Data` with respect to `PreCOVID-19Data`. There was less disagreement on requirements that could be overlooked. Except for T2 and T3, there is no majority agreement for non-necessary traits before or after COVID-19.

When examining the type of qualities expected in a `SCCC`, a mix of hedonic and pragmatic made it to the top based on `COVID-19Data`. From `PreCOVID-19Data`, it emerged that children desired traits were more prone to



(a) Distributions of coded drawings, normalised by total count per data source.



(b) Length of Task 2 descriptions.

Fig. 4. Drawings and description analysis using Pre- and `COVID-19Data`.

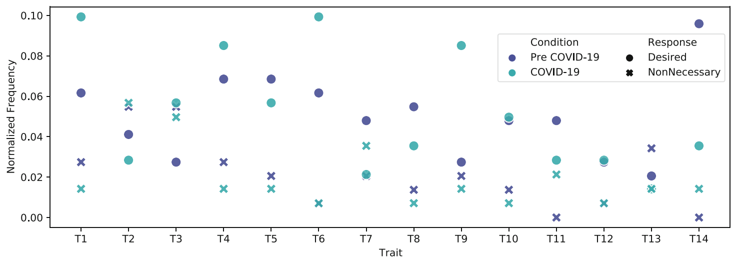
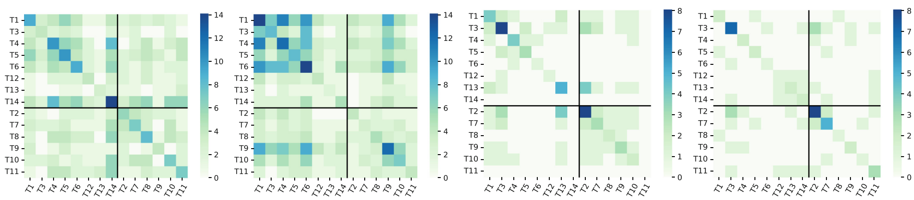


Fig. 5. Frequency distribution of traits (Table 1) that children find either desirable or non-necessary. Distribution normalised by total count per category.

be from a hedonic variety. The differing selection patterns are perhaps the most visible in Fig. 6, particularly for hedonic traits. Co-occurrences inferred from `PreCOVID-19Data` are visibly less strong than those inferred from `COVID-19Data`. This prompted us to investigate if chosen hedonic and pragmatic traits were conditioned by the appearance of an envisioned `SCCC`, both before and during the pandemic. We grouped children's drawings (excluding Others) into two groups: Personified (Human or Animal) and Non-personified (Robot or Device). As illustrated in Fig. 7, we saw variations in the required and non-necessary traits for a `SCCC` across trait type and appearance type. This is salient in hedonic traits, somewhat similar preferences during and before the pandemic on non-personified depictions, not so for personified depictions (Fig. 7a). The distribution of desired traits is consistent among children who did not personify their `SCCC`. In other words, choices inferred from `COVID-19Data` seem to converge on a smaller set of pragmatic requirements than those children who opted to personalise their `SCCC`. Children portraying a 'technology-like' `SCCC` were more likely to select a specific set of desired pragmatic traits, but like the children choosing to represent a personified `SCCC`, they too would go for a mixture of hedonic traits, possibly to suit their personality and make the search as a learning experience more engaging. Among non-necessary traits, pragmatic ones are similarly distributed regardless of children's level of exposure to technologies. We could then assume that, in general, drawings are good indicators of children's expectations and preferences.



(a) D-Pre (b) D-COVID-19 (c) N-Pre COVID-19 (d) N-COVID-19

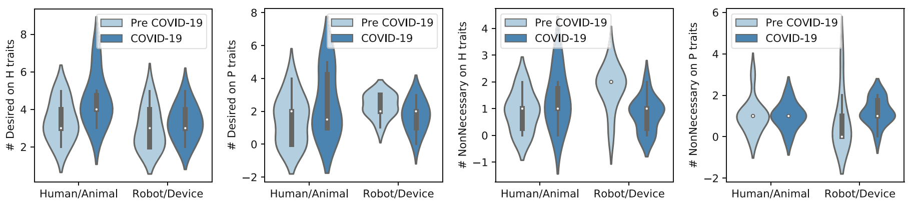
Fig. 6. Heatmap of Desired (D) vs. Non-Necessary (N) trait co-occurrences. We divide the heatmaps into 4 sections based on trait type: Left top shows the co-occurrence of H-H traits, right top H-P, bottom left P-H, and bottom right P-P.

4.3 Discussion

To answer **RQ1**, we refer to Sect. 4.1. From sketches, we surmise children's awareness of technology and, indirectly, how this impacts their expectations for the look and functionality of SCCCs. Children demonstrated an affinity for technology-like facades. They favoured robots and device-style depictions more than human-/animal-like personifications. Children's tie to technology was also visible in their descriptions. They made sure the demeanour they envisioned for a SCCC came across; prominently employing words like 'voice', 'search', and 'assistant'. They also articulated characteristics of a SCCC which could be missed by simply focusing on surface appearance. Human-like appearance/behaviour is not a primary concern for children when describing their SCCCs.

Reoccurring themes refer to expectations for SCCC to be voice-driven and to be everywhere. Given that the study prompt explicitly asked children to *"Imagine using a Vocal Assistant like Alexa or Google to run your school searches, what would it look like?"*, we focus on the repetition in children's descriptions of words like 'Alexa' or 'voice'. We posit this choice reveals the importance for children to go beyond classic search systems and instead rely on conversational search systems. For the latter, we attribute this to children's normalising that inquiries on the classroom context no longer take place only in the physical classroom.

From trait selection, it emerged that children's requirements prioritised functional aspects of a SCCC. Their mixture of hedonic and pragmatic traits pointed to both personalization (modelling and responding to individual's interests and preferences) and privacy being key components to consider when outlining the architecture of a SCCC. This brings up a conundrum when designing and deploying technology for children, as personalization and privacy are often at odds [20]. We notice a shift from children trusting more authoritative figures [24] to expecting a SCCC to behave like a peer, rather than an expert. This could be interpreted as children having more realistic expectations of the SCCC, given their increased exposure to technology; also an expression of their need to find ways to share their search experience as learning online proved for most lonely.



(a) H-Desired (b) P-Desired (c) H-NonNecessary (d) P-NonNecessary

Fig. 7. Distribution of Desired (a & b) and Non-Necessary (c & d) selections on H (a & c) and P (b & d) traits, given by children who designed personified (Human/Animal) vs. non-personified (Robot/Device) SCCCs.

To answer **RQ2**, we revisit Sect. 4.2. It became apparent that children's expectations for a SCCC have altered across all tasks. We attribute this to the mere exposure effect [66] to what is now familiar–technology to support the classroom context. Children now seem able to identify specific functional requirements and express them. They are more likely to overlook the appearance of a SCCC in lieu of its ability to remember past actions, converse fluidly, and guard users' privacy. These findings are grounded on the type of sketches produced prior to COVID-19 and after two years of children experiencing the pandemic. Drawings exhibit a technology-like demeanour that before was not there. Findings are also informed by the fact that anthropomorphization (i.e., depicting SCCC as cute, friendly, and often human-/animal-like), no longer surfaces as a common expectation among children. Also contributing to these findings is the fact that children participating in Stage 1 appeared to be more engaged with the task, offering longer and more detailed descriptions than their counterparts before COVID-19. In the end, we posit that long-term exposure to technology to support remote instruction resulted in children acquiring a more technology-related vocabulary which they now can and want to use to articulate their requirements for a SCCC. The impact of long-term technology use is the easiest to spot when probing traits expected to be exhibited by a SCCC (Figs. 5, 6, and 7). Indeed, personalization and privacy remain desired traits even after two years of the COVID-19 pandemic. And yet, from juxtaposing selections, it is evident that children now prioritise functional aspects of a SCCC more than before the pandemic, at which time children seemed more focused on behavioural characteristics. Interestingly, the pandemic caused less of an impact on non-necessary requirements.

Our findings related to the differences in how children envision a SCCC echo those reported for the home and classroom context in [25,28]. There, the authors emphasise that different personas are needed for different users. They attribute these users' background knowledge. Results on comparisons based on desired vs. non-necessary traits align with those we previously reported in [25]; in this study children known to be technically savvy tended to regard higher traits referring to the functionality of an ideal SCCC such as its ability to remember prior users' requests (T8). Our findings corroborate that background and informal exposure to technology often directly impact users' expectations.

5 Conclusions, Limitations, and Future Work

With our 2-stage study, we identified the initial requirements of a SCCC–a spoken conversational system meant to ease inquiry tasks related to the primary school curriculum. Outcomes disclose children's preference for a voice-driven companion, with 'technology-like' miens that can support classroom-related search needs regardless of the teaching modality. We glean from our preliminary exploration that informal guidance on the use of technology and persistent use of technology to support learning impact how children think about SCCCs. In view of these findings, which illustrate how rapidly children's preferences and attitudes towards technologies supporting inquiry tasks change, and indirectly influence their ever-evolving search behaviour, we discourage the research community from building on old assumptions and instead revisit explorations to capture current needs and open challenges. The roles children play in collaborative design must be revisited, as much as the power balance in inter-generational research teams. Lastly, the growth of familiarity with technology opens a window of opportunity for educational experts to use it in teaching more extensively and seamlessly.

One of the limitations of our work is the small *sample population*. Yet, this is a common sample size when conducting studies involving children [12,48]. Reported results reflect the preferences and expectations of *children aged 9 to 11* who are part of a specific school system. To best understand how online instruction may have inadvertently impacted children's view of technology, it will be necessary to repeat the exploration using the same protocol, but extending the age ranges of participants and including different school systems and countries. Given the focus on the impact of the COVID-19 pandemic, We did not analyse participants' gender, cultural background, socio-economic status, or stereotype biases. In the future, we aim to expand our study to consider how the aforementioned dimensions influence children's expectations [46,53]. Other immediate research direction includes extending our study to consider the role of emotions, given their impact on technology supporting learning [15]. Inspired by existing works discussing children's interactions with pedagogical agents [44,58], we also plan to account for traits that best align with the pedagogical aspects necessary to support the search as a learning paradigm as the foundation of a `SCCC`, such as their ability to provide the help needed to solve a task, as well as encouraging children to study and displaying emotional intelligence. Vtyurina et al. [54] studied how an intelligent VA could support complex search tasks for adults; they reported on the need for intelligent VA to recognise different types of tasks and user preferences and provide appropriate support accordingly. In line with our discoveries, it would be opportune to investigate whether children's requirements for a `SCCC` also differ when handling search tasks of varying levels of complexity.

Our work has implications for researchers and practitioners in broad areas. Children take for granted that a `SCCC` will be voice-driven; attributed to their early interactions with VA [29]. Yet, voice-driven technologies struggle to understand children [39]. Further, research on conversational user interfaces and their applicability to children and the classroom context is still preliminary [1]. We have focused on children, but it is important to note that the design and deployment of technologies to support the classroom must simultaneously account for the perspectives of multiple stakeholders (teachers, parents, industries, and the children themselves) if they are to be of practical use, and this is a nontrivial endeavour [27]. Educational and pedagogical implications related to the use of `SCCC` are not the only ones to consider; privacy and security are integral for safe deployment and use of technology among the sensitive population and context that are the focus of this work [21]. Given children's requirement for privacy

(Stage 1) it is pertinent to consider embedding within a SCCC opportunities for teaching about the safe use of digital technologies.

References

1. Allen, G.M., Gadiraju, U., Yang, J., Pera, M.S.: Using conversational artificial intelligence to support children's search in the classroom. In: CUI@ CSCW: Inclusive and Collaborative Child-Facing Voice Technologies: A Workshop at the Virtual ACM CSCW 2021 Conference (2021)
2. Anuyah, O., Milton, A., Green, M., Pera, M.S.: An empirical analysis of search engines' response to web search queries associated with the classroom setting. Aslib J. Inf. Manag. (2020)
3. Azpiazu, I.M., Dragovic, N., Pera, M.S., Fails, J.A.: Online searching and learning: YUM and other search tools for children and teachers. Inf. Retr. J. **20**(5), 524–545 (2017)
4. Barros, G., et al.: Learning interactions: robotics supporting the classroom. In: Stephanidis, C., Antona, M., Ntoa, S. (eds.) HCII 2021. CCIS, vol. 1421, pp. 3–10. Springer, Cham (2021). https://doi.org/10.1007/978-3-030-78645-8_1
5. Bhatti, N., Stelter, T.L., Scott McCrickard, D.: The interactive show: a conversational companion for young children and childcare assistant for parents. In: Proceedings of the 8th International Conference on Human-Agent Interaction, pp. 221–223 (2020)
6. Bilal, D., Gwizdka, J.: Children's query types and reformulations in google search. Inf. Process. Manag. **54**(6), 1022–1041 (2018)
7. Bird, S., Klein, E., Loper, E.: Natural Language Processing with Python: Analyzing Text with the Natural Language Toolkit. O'Reilly Media Inc., Sebastopol (2009)
8. Blikstad-Balas, M., Klette, K.: Still a long way to go: narrow and transmissive use of technology in the classroom. Nordic J. Digit. Lit. **15**(1), 55–68 (2020)
9. Burnett, C.: The Digital Age and Its Implications for Learning and Teaching in the Primary School. Cambridge Primary Review Trust York, Heslington (2016)
10. Cassell, J.: Embodied conversational agents: representation and intelligence in user interfaces. AI Mag. **22**(4), 67 (2001)
11. Collins-Thompson, K., Hansen, P., Hauff, C.: Search as learning (Dagstuhl seminar 17092). Dagstuhl Reports, vol. 7. Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik (2017)
12. Downs, B., French, T., Wright, K.L., Pera, M.S., Kennington, C., Fails, J.A.: Searching for spellcheckers: what kids want, what kids need. In: Proceedings of the 18th ACM International Conference on Interaction Design and Children, pp. 568–573 (2019)
13. Druga, S., Williams, R., Breazeal, C., Resnick, M.: Hey google is it ok if I eat you?: Initial explorations in child-agent interaction. In: Proceedings of the 2017 Conference on Interaction Design and Children, pp. 595–600. ACM (2017)
14. Festerling, J., Siraj, I.: Alexa, what are you? Exploring primary school children's ontological perceptions of digital voice assistants in open interactions. Hum. Dev. **64**(1), 26–43 (2020)
15. Garg, R., Sengupta, S.: Conversational technologies for in-home learning: using co-design to understand children's and parents' perspectives. In: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, pp. 1–13 (2020)

16. Hales, P.D., et al.: Alexa?: Possibilities of voice assistant technology and artificial intelligence in the classroom. Empower. Res. Educ. **3**(1), 4 (2019)
17. Hodges, C.B., Moore, S., Lockee, B.B., Trust, T., Aaron Bond, M.: The difference between emergency remote teaching and online learning (2020)
18. Hu, X., Chiu, M.M., Leung, W.M.V., Yelland, N.: Technology integration for young children during COVID-19: towards future online teaching. Br. J. Educ. Technol. **52**(4), 1513–1537 (2021)
19. Hyndman, B.: Ten reasons why teachers can struggle to use technology in the classroom. Sci. Educ. News **67**(4), 41–42 (2018)
20. Kucirkova, N., Toda, Y., Flewitt, R.: Young children's use of personalized technologies: insights from teachers and digital software designers in Japan. Technol. Knowl. Learn. **26**(3), 535–554 (2021)
21. Kumar, P.C., Chetty, M., Clegg, T.L., Vitak, J.: Privacy and security considerations for digital technology use in elementary schools. In: Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems, pp. 1–13 (2019)
22. Landoni, M., Murgia, E., Gramuglio, F., Manfredi, G.: Fiction design of a 3d tutor for and with school children. In: Proceedings of the Eleventh International Conference on Advances in Computer-Human Interactions, ACHI, pp. 94–97 (2018)
23. Landoni, M., Murgia, E., Gramuglio, F., Manfredi, G.: Teaching an alien: children recommending what and how to learn. In: 2nd KidRec Workshop Colocated with ACM IDC (2018)
24. Landoni, M., Matteri, D., Murgia, E., Huibers, T., Pera, M.S.: Sonny, Cerca! Evaluating the impact of using a vocal assistant to search at school. In: Crestani, F., et al. (eds.) CLEF 2019. LNCS, vol. 11696, pp. 101–113. Springer, Cham (2019). https://doi.org/10.1007/978-3-030-28577-7_6
25. Landoni, M., Murgia, E., Huibers, T., Pera, M.S.: You've got a friend in me: children and search agents. In: Adjunct Publication of the 28th ACM Conference on User Modeling, Adaptation and Personalization, pp. 89–94 (2020)
26. Landoni, M., Huibers, T., Murgia, E., Pera, M.S.: Ethical implications for children's use of search tools in an educational setting. Int. J. Child Comput. Interact. **32**, 100386 (2021)
27. Landoni, M., Huibers, T., Pera, M.S., Fails, J.A.: 5th KidRec workshop: search and recommendation technology through the lens of a teacher. In: Interaction Design and Children, pp. 658–661 (2021)
28. Lee, S., Kim, S., Lee, S.: "What does your agent look like?" A drawing study to understand users' perceived persona of conversational agent. In: Extended Abstracts of the 2019 CHI Conference on Human Factors in Computing Systems, pp. 1–6 (2019)
29. Lovato, S., Piper, A.M.: "Siri, is this you?" Understanding young children's interactions with voice input systems. In: Proceedings of the 14th International Conference on Interaction Design and Children, pp. 335–338 (2015)
30. Lovato, S.B., Piper, A.M.: Young children and voice search: what we know from human-computer interaction research. Front. Psychol. **10**, 8 (2019)
31. Lovato, S.B., Piper, A.M., Wartella, E.A.: Hey google, do unicorns exist? Conversational agents as a path to answers to children's questions. In: Proceedings of the 18th ACM International Conference on Interaction Design and Children, pp. 301–313 (2019)
32. Luger, E., Sellen, A.: "Like having a really bad pa" the gulf between user expectation and experience of conversational agents. In: Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems, pp. 5286–5297 (2016)

33. Mack, N.A., Moon Rembert, D.G., Cummings, R., Gilbert, J.E.: Co-designing an intelligent conversational history tutor with children. In: Proceedings of the 18th ACM International Conference on Interaction Design and Children, pp. 482–487 (2019)
34. Martha, A.S.D., Santoso, H.B.: The design and impact of the pedagogical agent: a systematic literature review. J. Educ. Online **16**(1), n1 (2019)
35. Matsui, T., Yamada, S.: Two-dimensional mind perception model of humanoid virtual agent. In: Proceedings of the 5th International Conference on Human Agent Interaction, pp. 311–316. ACM (2017)
36. Mercer, N., Hennessy, S., Warwick, P.: Dialogue, thinking together and digital technology in the classroom: some educational implications of a continuing line of inquiry. Int. J. Educ. Res. **97**, 187–199 (2019)
37. Meyer, M., et al.: How educational are "educational" apps for young children? App store content analysis using the four pillars of learning framework. J. Child. Media **15**(4), 526–548 (2021)
38. Milton, A., Anuya, O., Spear, L., Wright, K.L., Pera, M.S.: A ranking strategy to promote resources supporting the classroom environment. In: 2020 IEEE/WIC/ACM International Joint Conference on Web Intelligence and Intelligent Agent Technology (WI-IAT), pp. 121–128. IEEE (2020)
39. Monarca, I., Cibrian, F.L, Mendoza, A., Hayes, G., Tentori, M.: Why doesn't the conversational agent understand me? A language analysis of children speech. In: Adjunct Proceedings of the 2020 ACM International Joint Conference on Pervasive and Ubiquitous Computing and Proceedings of the 2020 ACM International Symposium on Wearable Computers, pp. 90–93 (2020)
40. Murgia, E., Landoni, M., Huibers, T.W.C., Fails, J.A., Pera, M.S.: The seven layers of complexity of recommender systems for children in educational contexts. In: Workshop on Recommendation in Complex Scenarios 2019, pp. 5–9 (2019)
41. Murgia, E., Landoni, M., Huibers, T., Pera, M.S.: All together now: teachers as research partners in the design of search technology for the classroom. In: KidRec 2021: 5th International and Interdisciplinary Perspectives on Children & Recommender and Information Retrieval Systems (KidRec) Search and Recommendation Technology through the Lens of a Teacher- Co-located with ACM IDC 2021, 26 June 2021, Online Event. arXiv preprint arXiv:2105.03708 (2021)
42. Obaid, M., Barendregt, W., Alves-Oliveira, P., Paiva, A., Fjeld, M.: Designing robotic teaching assistants: interaction design students' and children's views. In: ICSR 2015. LNCS (LNAI), vol. 9388, pp. 502–511. Springer, Cham (2015). https://doi.org/10.1007/978-3-319-25554-5_50
43. Oranç, C., Ruggeri, A.: "Alexa, let me ask you something different" children's adaptive information search with voice assistants. Hum. Behav. Emerging Technol. **3**(4), 595–605 (2021)
44. Pérez-Marín, D., Pascual-Nieto, I.: An exploratory study on how children interact with pedagogic conversational agents. Behav. Inf. Technol. **32**(9), 955–964 (2013)
45. Purington, A., Taft, J., Sannon, S., Bazarova, N., Taylor, S.H.: Alexa is my new BFF: social roles, user satisfaction, and personification of the amazon echo. In: Proceedings of the CHI Conference Extended Abstracts on Human Factors in Computing Systems, pp. 2853–2859. ACM (2017)
46. Rankin, Y.A., Henderson, K.K.: Resisting racism in tech design: centering the experiences of black youth. In: Proceedings of the ACM on Human-Computer Interaction, 5(CSCW1), pp. 1–32 (2021)

47. Sáiz-Manzanares, M.C., Marticorena-Sánchez, R., Ochoa-Orihuel, J.: Effectiveness of using voice assistants in learning: a study at the time of COVID-19. Int. J. Env. Res. Public Health **17**(15), 5618 (2020)
48. Szczuka, J.M., Strathmann, C., Szymczyk, N., Mavrina, L., Krämer, N.C.: How do children acquire knowledge about voice assistants? A longitudinal field study on children's knowledge about how voice assistants store and process data. Int. J. Child Comput. Interact. **33**, 100460 (2022)
49. Terzopoulos, G., Satratzemi, M.: Voice assistants and smart speakers in everyday life and in education. Inform. Educ. **19**(3), 473–490 (2020)
50. Trippa, J.R.: Spoken conversational search: audio-only interactive information retrieval. Ph.D. thesis, RMIT University (2019)
51. Urrutia, E.K.M., Ocaña, J.M., Pérez-Marín, D., Tamayo, S.: A first proposal of pedagogic conversational agents to develop computational thinking in children. In: Proceedings of the 5th International Conference on Technological Ecosystems for Enhancing Multiculturality, pp. 1–6 (2017)
52. Usta, A., Altingovde, I.S., Vidinli, I.B., Ozcan, R., Ulusoy, Ö.: How k-12 students search for learning? Analysis of an educational search engine log. In: Proceedings of the 37th International ACM SIGIR Conference on Research & Development in Information Retrieval, pp. 1151–1154 (2014)
53. Vanderlyn, L., Weber, G., Neumann, M., Väth, D., Meyer, S., Vu, N.T.: "it seemed like an annoying woman": on the perception and ethical considerations of affective language in text-based conversational agents. In: Proceedings of the 25th Conference on Computational Natural Language Learning, pp. 44–57 (2021)
54. Vtyurina, A., Savenkov, D., Agichtein, E., Clarke, C.L.A.: Exploring conversational search with humans, assistants, and wizards. In: Proceedings of the CHI Conference Extended Abstracts on Human Factors in Computing Systems, pp. 2187–2193. ACM (2017)
55. Ward, W., et al.: My science tutor: a conversational multimedia virtual tutor for elementary school science. ACM Trans. Speech Lang. Process. (TSLP) **7**(4), 1–29 (2011)
56. Wiggins, J.B., et al.: From doodles to designs: Participatory pedagogical agent design with elementary students. In: Proceedings of the 18th ACM International Conference on Interaction Design and Children, pp. 642–647. ACM (2019)
57. Wojcik, E.H., Prasad, A., Hutchinson, S.P., Shen, K.: Children prefer to learn from smart devices, but do not trust them more than humans. Int. J. Child Comput. Interact. **32**, 100406 (2021)
58. Woodward, J., McFadden, Z., Shiver, N., Ben-hayon, A., Yip, J.C., Anthony, L.: Using co-design to examine how children conceptualize intelligent interfaces. In: Proceedings of the CHI Conference on Human Factors in Computing Systems, pp. 575. ACM (2018)
59. Xu, Y., Warschauer, M.: A content analysis of voice-based apps on the market for early literacy development. In: Proceedings of the Interaction Design and Children Conference, pp. 361–371 (2020)
60. Xu, Y., Warschauer, M.: "Elinor is talking to me on the screen!" Integrating conversational agents into children's television programming. In: Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems, pp. 1–8 (2020)
61. Xu, Y., Warschauer, M.: What are you talking to?: Understanding children's perceptions of conversational agents. In: Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems, pp. 1–13 (2020)

62. Xu, Y., Aubele, J., Vigil, V., Bustamante, A.S., Kim, Y.-S., Warschauer, M.: Dialogue with a conversational agent promotes children's story comprehension via enhancing engagement. Child Dev. **93**, e149–e167 (2021)
63. Yang, X., Aurisicchio, M., Baxter, W.: Understanding affective experiences with conversational agents. In: Proceedings of the CHI Conference on Human Factors in Computing Systems, p. 542. ACM (2019)
64. Yarosh, S., et al.: Children asking questions: speech interface reformulations and personification preferences. In: Proceedings of the 17th ACM Conference on Interaction Design and Children, pp. 300–312 (2018)
65. Yuan, Y., et al.: Speech interface reformulations and voice assistant personification preferences of children and parents. Int. J. Child Comput. Interact. **21**, 77–88 (2019)
66. Zajonc, R.B.: Attitudinal effects of mere exposure. J. Pers. Soc. Psychol. **9**(2p2), 1 (1968)