The IDC Research and Design Challenge throughout the years: achievements, reflections and next steps

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ABSTRACT

In this paper we describe and reflect upon the setup and outcomes of the Research and Design Competition at the Interaction Design and Children (IDC) conference over the years. We frame it against similar initiatives and discuss its achievements so far while suggesting the steps that could increase its visibility and popularity both inside and outside of our academic community. In fact, we believe such an initiative is a great opportunity to state and declare the community's core principles and values. This is done by having children as protagonists, and listening to and acknowledging their contributions. Reaching out to, inspiring, and rewarding the other adults in the loop, such as parents and teachers, is essential to ensure children's participation and empowerment. Equally important is actively promoting diversity and inclusion to maintain a healthy and balanced community's growth. Here, we review progress to date, outline plans for moving forward and establishing this initiative as a fun place for children to interact with new technology, as researchers and practitioners better understand their needs and expectations. Therefore, our primary contribution is a set of guidelines and best practices for it to develop, which is based on a thorough examination of the challenge so far.

CCS CONCEPTS

• **Human-centered computing → HCI theory, concepts and models**; **Empirical studies in HCI**.

KEYWORDS

children, research and design challenge, drawings, competition, idc

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1 INTRODUCTION

The Research and Design Challenge (R&D challenge in short) is a competition open to children from all over the world, which has been held every year since 2016 during the Interaction Design and Children (IDC) conference. In this paper we reflect on the achievements so far, but also on the issues and limitations that have emerged throughout the years, in terms of participation by children and by adult researchers, and we propose guidelines and best practices for the challenge going forward.

After a comprehensive description of the current state of the challenge, we will introduce some other competitions and challenges held by different organisations and companies in the world. We will then present a review of the literature on the topics of children's participation in design and innovation, and in the involvement of schools and teachers in design, as these are both aspects that are highly relevant to the R&D challenge.

Then, we will take a look at how we collected a data set composed of all the submissions to the challenge, from 2016 to 2022, and what we are able to tell from this data set about:

- **RQ1**. How did the children's participation in the R&D challenge initiative change over time in terms of diversity and inclusion?
- **RQ2**. How did the IDC community contribute to the R&D challenge initiative over time, and in what forms?

Finally, based on the answers, we will propose guidelines and best practices to enhance the benefits for children, teachers and the research community.

2 THE RESEARCH AND DESIGN COMPETITION

Since IDC websites are taken down after each conference, we resorted to the Internet Archive: Wayback Machine [5] to find archived copies of previous years' websites, and we were able to find all the R&D competition calls except for 2017.

The Research and Design competition was first introduced in the 2016 edition of IDC with the theme "Let's invent the future!". Children all over the world were invited to submit ideas about the "smart things" of 2030, thinking of how children would learn, play and keep in touch with others in the future. During the first edition, submissions were collected by email, with the possibility of also physically mailing them to the track chair. However, the call did not explicitly mention who would judge the submissions, and how the IDC community would use them.

While we were unable to locate the call for the 2017 challenge, we learn from reading the conference proceedings how in that year children submitted written challenges instead of drawings, and it was also the first time that adult researchers' extended abstracts in response to these challenges were included.

In 2018 the two phases of the competition were explicitly mentioned in the call, with a first phase in which children were invited to submit their ideas for future technology that would "celebrate diversity and foster social inclusion". The second phase was open to researchers and designers, who were invited to submit design concepts built on children's ideas. Adult submissions were then judged both by the track chairs and by children who participated in the first phase of the challenge; the finalists' submissions were then included in the conference proceedings.

The competition was ran in the same way in 2019 and 2020, with the theme for 2019 being "ideas for technology that would help kids feel better physically and mentally", and for 2020 "technologies that address some of the problems our planet faces today: e.g. climate change, the loss of animal and plant species, inequality between people".

However, 2020 also saw the first edition of the junior competition, in which children in primary and secondary school were invited to submit a description of a design concept that would address one or more of the ideas submitted during the first phase, not necessarily their own. Children submitted videos and short explanations written in English, that were then judged by a jury made of children, with the help of the adult jury organised by the track chairs.

In 2021 the challenge underwent a drastic change: while there were still two phases, the challenge only involved children and there was no adult track. In the first phase, children were invited to submit ideas - in the form of a description supplemented by a drawing or other materials - in response to the topic "(Re)imagining a world after COVID-19". In the second phase, children that had already submitted an initial idea were invited to elaborate on a design concept regarding the same topic of their Phase 1 submission, and submit a video of their concept. The videos were then judged by all the children who had participated in phase 1, and by a panel of adult judges, with the three top submissions presented in video form at the conference.

In 2022 the theme of the challenge was "Connectedness", with the competition running in the same way as 2020, with an adult track and a junior challenge, however the junior challenge was divided into two categories: up to 12 years old, and 12 to 17 years old, with the three finalists in each category being invited to present during the IDC conference.

In 2023, the theme of the challenge is "Smart Communities: Rebuilding a compassionate world!", with the challenge running in the same way as 2018, 2019 and 2020: a first phase with children submitting ideas in the form of drawing, and a second phase for adult researchers.

It is interesting to note that, throughout the years, the words "challenge" and "competition" have been used interchangeably in the calls.

In order to better frame the R&D challenge, we now describe similar initiatives run by different organisations similarly aiming at discovering how children relate to technologies. For each we report on the participants, the roles played by children and adults, and the setup of the competition.

3 OTHER CHALLENGES AND COMPETITIONS

The research and design competition is not the only challenge that aims to involve children in the design of new technology; some other similar initiatives are the micro:bit do your :bit Challenge, the Samsung Solve for Tomorrow: Next Gen, the COBIS Design & Technology Competition and the Raspberry Pi Pioneers initiative.

3.1 micro:bit do your :bit Challenge

The micro:bit is essentially a small computer with LED displays, buttons, sensor and many features, that can be programmed in the same way as other microcontrollers such as Arduino. It was originally created in 2014 as part of the BBC's Make it Digital initiative [11], and in 2019 the first do your :bit challenge[37] was introduced.

The challenge has the aim to allow students to design and show ideas to solve real world issues; children choose one of the Global Goals For Sustainable Development agreed by the UN by 2015 [54] and then design and prototype an idea to tackle issues related to those goals.

The challenge is divided into three categories according to age, with a specific category for younger children who only submit a drawing and description of their idea, with no code. Children can compete on their own or in teams; then, a panel of judges chooses winners for each of the six global regions - Africa, Asia and Pacific, Europe, Latin America, North America and Middle East - and for each category, with second and third place in each category also getting a prize. Prizes are micro:bit packages, accessories and merchandise.

While this is not a requirement, many children who join the challenge are involved in micro:bit projects and classes at school or as an extracurricular activity conducted elsewhere, such as code clubs and libraries.

3.2 Samsung Solve for Tomorrow: Next Gen

The Solve for Tomorrow: Next Gen Tech Design Competition [48] was launched in 2021 by Samsung UK, addressing children aged 11 to 15 and their teachers. Teachers who participate in the competition receive a video that takes students through the Design Thinking process, a Sprintbook (differentiated by age) and a delivery guide; prizes include smart boards for the schools, and other Samsung Galaxy products for winners and runners-up.

3.3 COBIS Design & Technology Competition

This competition [15] is open to all COBIS (Council of British International Schools) pupils aged 11 to 18 (KS3-5); here, students have to identify broken or discarded electro-mechanic products and make them usable again by using innovation and skills to solve a problem. This competition is also teacher-led, and prizes include trophies and mentorship by professionals.

3.4 Raspberry Pi Pioneers

In 2016, Raspberry Pi launched the Pioneers program [41], with a series of challenges to inspire young people to develop and share new ideas. The challenges were open to teams of children aged 12 to 15, with each team making a video about their ideas, and the winners getting different kinds of prizes. The first challenge took place in 2017 with the theme “Make us laugh with tech”. However, the challenge has since been discontinued.

We can see across initiatives how there is an emphasis on consistently rewarding children’s participation with prizes, while at the same providing support to the involved adults, teachers and educators. The competitions also involved libraries, coding clubs and other non-school entities, where extra curricular activities take place. Children of similar age groups compete against one another in the respect of various abilities and skills linked to the different stages of development. Organisers rely on a robust network of partners that makes it easier to reach out to young participants.

Even in this brief overview of existing initiatives we can see how children have a central role, and their effort is clearly acknowledged and rewarded. The outcomes of these competitions are often in the shape of drawings and/or early prototypes. Their analysis provides a valid and rich insight into children’s expectations when it comes to future technology. On this line in the next section, we present relevant literature regarding the role children have in design, also describing how drawings have been used over time as a method of choice to gather children’s feedback. Finally, we discuss ethical considerations in relation to the involvement of school teachers and children in such initiatives.

4 RELATED WORK

4.1 Children’s participation in design and innovation

There is a long tradition in Child Computer Interaction (CCI) research of involving children in the design and evaluation of new technology, which can be traced back to the 1970’s, where children were involved as users in the development of new technology [40]. In the mid 90’s, children became involved as informants in the design of new technological products. Druin and Salomon [21] extended children’s participation involving them as design partners. Based on the relation that children and the research team have, as well as the stage at which children integrate the design process, children became users, testers, informants, or design partners [19, 20]. Recent developments critically reflect on children’s involvement arguing for a more preeminent role of children, seeking to empower children to drive and critically reflect on the development of technology [31, 32]. Kinula et al. [33] call for a reflection on how children can be genuinely involved, proposing a framework that posits that children’s true participation must be Meaningful, Effective, Contextual, Political and Educational. That is, children must feel motivated to participate and sense that their participation is relevant, and generates value. They must be empowered to make their own informed decisions, with their participation having an impact and making changes. Researchers need to be aware of the context, since every participation takes place within a specific historical time, with its own cultural values, involving power relations. Culture shapes both behaviour and cognitive processes transcending “the boundaries of individuals” [30]. Participation must also aim for mutual learning. Together, these dimensions aspire to support a critical and structured reflection on children’s participation, and “in empowering children and aiming for their genuine impact on the digital technology design process and its outcome” [33]. Yet collecting children’s opinions is challenging [3, 12, 27]. User-centred design methods adapted to suit and include children (e.g., [19, 27, 44, 66]), or methods specifically designed for children [3, 8, 44, 45, 53, 66] have shown that they face a series of shortcomings: depending on age and cognitive development, children may find it difficult to understand interview or survey questions and to clearly communicate their thoughts verbally [3]. Also, children’s responses may be influenced by the desire to please adults [3, 12, 26, 27]. When using scales, children tend towards using responses on the extreme sides of a scale [3, 12, 14], not often using scores in the middle of the scale [26]; also, children find it difficult to differentiate between similar ratings (e.g. “especially happy” and “slightly happy”) [3].

An interesting evaluation method is Drawing Intervention [39, 50, 51, 61–63]. Drawings have an historical tradition as a method to evaluate cognitive development and have been used in Child-Computer-Interaction to involve young children in different design activities.

4.2 Analysing children’s drawings

Drawings have long been used in education, at all levels, e.g., to gather information about students’ knowledge in specific areas, such as biology, ecological concepts, the water cycle or the tropical rainforests [13, 16, 18, 34, 42]. Drawings have also been used in non-educational settings to gather children’s perspectives and ideas on various themes, for example sustainability in the home [17], “what the future will be like” [60], their favourite toys, animals or objects [57] and also, more generally, technology [46].

While drawings by themselves are not enough to really probe children’s understanding of these themes [46], the drawing-telling method described by Wright [60], in which the researcher asks open-ended questions to better understand children’s drawings, proved more useful in capturing children’s ideas and reflections.

In Child-Computer interaction, drawings have also been used both in the evaluation and in the collaborative design of new technologies. For example, drawings have been successfully used to catch a description of children’s experiences with specific interfaces, being particularly effective at capturing the “fun” element [64]. Drawings have also been used to evaluate programming apps, mixed-reality museums exhibitions and interactive museum prototypes, both as stand-alone techniques to elicit feedback [49, 58] and as starting point for interviewing children about their experiences [39]. When compared with other methods such as Think-Aloud and Peer tutoring, the Drawing intervention method has been found to be the most successful when evaluating tangible interfaces with children aged 8 to 9 years old [61]

While most studies focusing on children’s drawings involve children aged 6 and older, children in kindergarten (aged 4 to 5) were also involved in some cases, with mixed results: while drawings were not deemed sufficient to assess the usability of a computer game for children in this age range [50], having children interact with tangible interfaces helped them feel more involved, leading to more detailed and explicative drawings [52]. Some techniques designed for older children have however been adapted also for younger ones: the already mentioned Drawing Intervention Method has in fact been explored with children aged 4 to 7 years old; while all children were able to create drawings that were on topic and showed their understanding, it was difficult for younger children (4 and 5 years old) to work together. The study also revealed some interesting observations, such as the idea that children take inspiration from one another [9].

Since the majority of the aforementioned studies were conducted in classrooms, we will now discuss the required ethical issues associated with this type of environment.

4.3 Involving schools and teachers: ethical considerations

School-based research, which involves teachers and children, is not always easy, as there are several issues that need to be overcome. To conduct a study, it is necessary to obtain several layers of consent: first by the participants, whose right to full disclosure of research intentions, to confidentiality, and to withdraw from the study at any moment have to be guaranteed, especially to children. Secondly, it is necessary to obtain additional permission from parents or caregivers, who will need to be informed about the scope and aim of the research as well as of the specific data collection and management. Lastly, it is necessary to obtain gatekeeper's permission - meaning that the school principal and the teachers have to consent to the research and allow the researchers access to the school [43].

Promoting the research project among the school staff, disseminating information through direct methods such as face-to-face or telephone calls rather than by emails and pamphlets, and providing incentives to those who participate are all effective methods in improving participation [59], however it is also important to be mindful of under-representation of specific populations, tailoring recruitment strategies especially for those groups of students who are less likely to participate [28].

When cooperating with teachers, it is also important for researchers to be mindful of the role they offer to the teachers, and how teachers are going to be recognised for their work. Researchers should be aware and consider the perceived power differential between them and the teachers, especially in those cases in which teaching is not respected enough as a career - which is, unfortunately, the case in many countries. The focus should be on giving something back to all the involved parties - teachers, parents, children, and to value teachers' opinions on their experiences as research participants [7].

More broadly, when doing research with teachers it is important to address the issue of ownership; while the researcher is usually considered "by default" to have ownership over the research projects, the idea of ownership should not be taken for granted, with the aim to move the researcher-teacher relationship towards a true partnership, in which both sides share the ownership of the research project, and the responsibility for the children involved in research [6].

After this literature review describing the core research elements behind existing initiatives, we are ready to explore in greater detail the IDC R&D challenge.

4.4 The IDC Research and Design Competition

A search in the ACM digital library for papers published in the IDC proceedings, in the Research and Design competition track, resulted in 12 extended abstracts published between 2017 and 2022. In general, the papers addressed the theme of the respective call. In 2017, the two extended abstracts presented technology that aimed at promoting children's adequate use of language. Feelbot, a cloud based self-learning system helped children reduce the use of bad words in person and online communication using wearable hardware [23]. CARE helped young people better understand the consequences of their use of language in a community of peers, mapping the content of their messages to positive or negative emotions [35].

In 2018, under the theme: "celebrate diversity and foster social inclusion", two extended abstracts addressed multiculturality. CULTURE BOX, a tablet-based learning game, featured cultures from all countries, and aimed at promoting open- mindedness, respect and other traits that are important for children in multicultural societies [25]. Dream Stones, a set of physical programmable robotic balls aimed at facilitating new intercultural meanings for children, bringing together 40 ideas from children around the world [10]. The third paper presented Create, a platform that allowed children to collaboratively illustrate short stories [24].

In 2019, in response to the topic: "ideas for technology that would help kids feel better physically and mentally", two extended abstracts presented technology that aimed at promoting emotional wellbeing. Digipack Pro, a backpack that facilitated social interactions and promoted playful activities during social encounters [38]. EmotoTent, aimed at helping children learn and practise emotion regulation and empathy with peers to reduce school violence [4]. A third paper, KidLED, used a LED activity display that represented the user's activity and aimed at encouraging physical activity to fight children's sedentary behaviour and prevent or reduce obesity [47].

In 2020, dealing with the topic: "technologies that address some of the problems our planet faces today", two extended abstracts presented technology that aimed at encouraging conscious attitudes towards the environment. SuperSolar, a wearable energy generator for children's outdoor play, aimed at promoting children's outdoor play while making them aware of energy consumption [36]. Two in a Pod, a smart toy that helped children learn about gardening, to increase vegetable consumption and raise awareness about sustainable eating [55]. Wonder with Elinor, a socially contingent video viewing experience was designed to prime children to engage in science inquiries with the main character as the story unfolds [65]. In 2022, in line with the theme "Connectedness", both contributions aimed at encouraging communication. Draw, Explore, Learn, and Unite the World, presented an interactive web page concept that aimed to support communication through drawings [22]. KidConnect VR, allowed kids to connect with others via a virtual environment, where they could play, chat, and even study with friends [29].

From this quick excursus we can see how the R&D challenge has taken different forms and tried to engage children and adults in various ways over the years. In doing so it has enabled the CCI community to gather an interesting data set of children's drawings describing their perception of current and future technology. Furthermore, it has also made possible for researchers to draw inspiration from children's ideas for their own research, which - as mentioned above - resulted in a collection of interesting contributions to the field, which is by itself a significant accomplishment.

Here, we look at the achievements, but also at the open issues and limitations of the challenge so far. To achieve that, we turn to the data submitted to the challenges so far. We code drawings and artefacts produced by children, analyse associated metadata, and examine papers written by adults who were inspired by the ideas presented by children.

5 SUBMISSIONS

5.1 Data Collection

Our first task was to collect the data from past R&D challenges. We reached out to the chairs from 2016, 2018, 2019, 2020 and 2022, since those are the years in which the challenge was organised, and we were sent copies of the drawings for each year.

The drawings from 2016 were not yet formally organised; upon contacting that year's chairs, we received three PDF files, each containing a collection of drawings. For each drawing, there was also a form filled by the child with their name, class, the name of their "smart thing", what it did, how did you use it, and where did you take it. These drawings were the most challenging to analyse, as children's handwriting was often difficult to interpret, and in some cases not all the fields had been completed.

The drawings from 2018 were organised in a website that is still online [2]; for each drawing, there was a short description in English, the names of the children involved, their ages and the school they attended. Some ideas did not include a drawing, or they included digital drawings - which were not present in 2016.

The drawings from 2019 onwards were organised in PDF booklets, with each drawing including a description in English, the names of the children involved, their age and the school they attended. Some ideas included 3D representations, as artefacts made of cardboard, fabric or other materials instead of a drawing.

5.2 Coding

Following the data collection we started the coding process. For each drawing, we annotated the year it was submitted, the age of the child (or children), and the name as submitted by the child. We furtherly grouped the drawings into age ranges: "younger children", 8 and younger; "older children", 9 to 12; "teenagers", 13 and older; "mixed age groups", when children in a group belonged to two or more age ranges, and "unknown" (see Figure 1).

We inferred the country from the name of the school, combined with the information given by the chairs about the schools that had participated in a given year. We inferred the gender from the name of the child, putting "Unknown" when the name was gender-neutral or a drawing was anonymous. As shown in Figure 2, the participation by gender is generally balanced, with the exception of 2018 in which the number of female participants was significantly higher than male participants. Mixed groups also had a significant presence in 2018 and 2019, and to a lesser extent in 2020 and 2022.

We also annotated whether each drawing was drawn manually with pen and paper, digitally or a 3D representation, and whether it was in colour or black and white (for this purpose, drawings that were drawn using only a specific colour - for example with a blue or green pen - were annotated as black and white).

Then, we started our coding from the categories identified by Valguarnera et al. [56] within a subset of this same database, which were: magic, grounded in reality, communication, translation, time travel, teleportation, mind reading, transportation, digital devices, holograms, wearable, robots, school, video games, human, animals, food, money and space.

To these, we added the following categories, some of which described the previous years' challenges, and some described different themes in the envisaged tools: apps, novel technology, no technology, VR, sensors, emotions, friendship, multiculturality, disability, health, environment and flying.

Having defined the categories, each drawing was then coded by three researchers separately; when two or more researchers agreed on a specific code, it was entered for the final analysis. We also added the category "not understandable", for drawings whose meaning we could not ascertain. This was used mainly for 2016's drawings, as the textual descriptions were handwritten by young children and they often did not help understand unclear drawings.

Most of the categories were self-explanatory, but some of them were more subject to interpretation; for example, the category "digital device" was used when the idea depicted a piece of hardware already existing in the real world (a tablet, a computer, a smartphone), while the category "novel technology" was used when the idea depicted some kind of hardware that does not exist in the real world (for example, a helmet that translates languages).

Overall, the categories that we used can be clustered in three groups: categories related to the characteristics of the drawings, such as whether it was digital or pen and paper, categories related to "how" the idea was represented, such as holograms, wearables, robots and so on, and categories related to "what" the idea was abot, such as communication, transportation, animals, health etc.

While the theme of the challenge in 2016 was very generic ("My smart thing of 2030"), some categories can be directly mapped to the themes of the R&D Challenge from 2018 onwards:

- **IDC 2018 - "Diversity"** - multiculturalism, disability, translation, communication.
- **IDC 2019 - "Health"** - health, food.
- **IDC 2020 - "Climate change, inequality"** - environment, disability.
- **IDC 2022 - "Connectedness"** - communication, translation, transportation, teleportation.

5.3 Analysis

An analysis of the metadata associated with children's submissions provided the number of participants and countries for each year, as represented in Figure 3 and 4 and show that both the participation in terms of absolute number of participants, and in terms of number of participants by country has been very unbalanced throughout the years. The highest number of participants was in 2022, with 160 entries, which makes up almost half of the dataset, while 2018, 2019 and 2020 are all below 50 entries. We can also see that the number of participating countries for each year is small, with one country often making up the majority of the entries: UK for 2016, and Switzerland for 2020 and 2022. Switzerland alone makes up more than half the dataset, with 182 entries (see Figure 5).

The amount of entries by country, considering the whole dataset, is also very unbalanced, with Switzerland and the UK making up the vast majority of the dataset. Regarding age and gender the data is

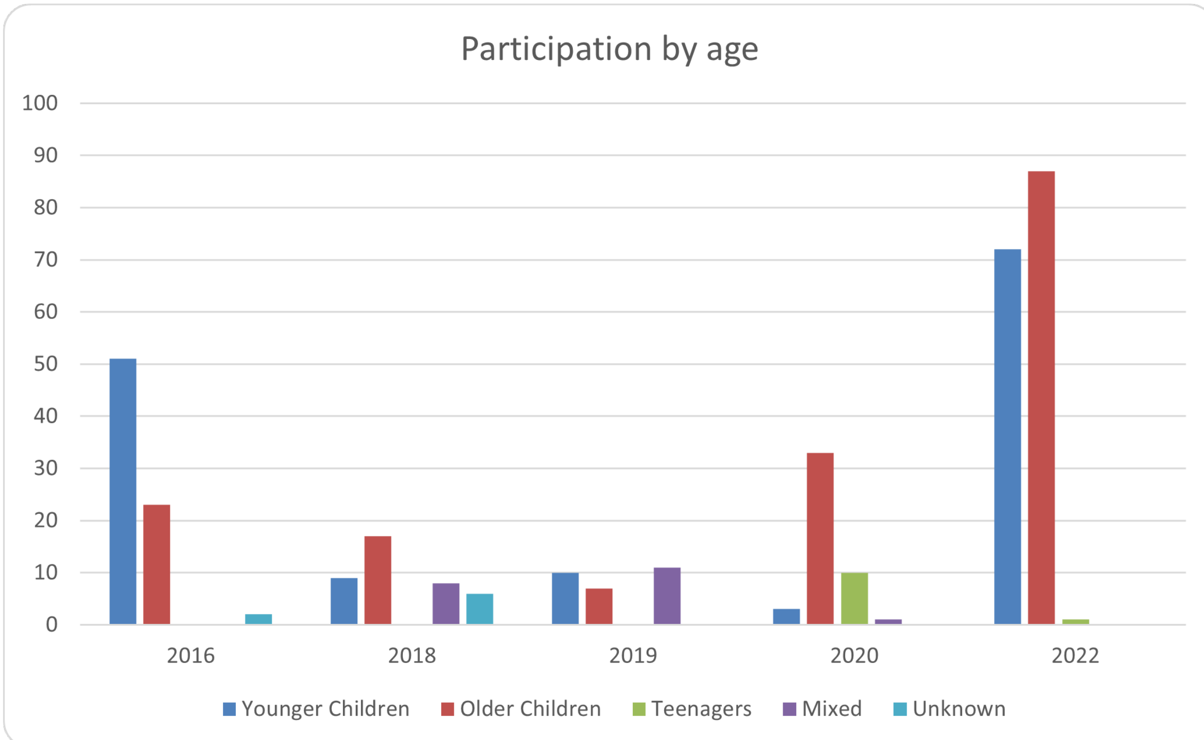

Figure 1: Age distributions of the participating children throughout the years

more balanced, although teenagers are scarcely represented, except for 2020 (see Figure 1).

Given the inconsistency of the data set, it was not possible to proceed with a statistical analysis. Instead, we focused on the most common categories represented each year, and how they relate to each year's theme.

In 2016, the most depicted categories related to the "how" were digital devices (61%) and wearables (49%), while the most depicted category related to the "what" was humans. In 2018, when the theme of the challenge was Diversity, digital devices were also widely represented (35%) in the categories related to the "how", while the categories related to the challenge were represented respectively in the 23% of drawings for multiculturalism, 3% for disability, 18% for translation, 73% for communication. Another two widely depicted themes were humans (78%) and friendship (50%). In 2019, the theme of the challenge was Health. The most commonly depicted technologies related to the "how" were apps (46%) and wearables (21%), while the categories related to the challenge were represented in 50% of the drawings for health, and 39% for food. Other widely represented categories include emotions (32%) and games (25%). In 2020, the theme was "Climate change, inequality"; regarding the categories related to the "how", 30% of the drawings depicted novel technology, and 26% depict robots; as for the categories related to the challenge, the environment category was present in 79% of the drawings, while disability only in 4% of the drawings. Other widely represented categories include humans, health, games and communication, all between 11% and 15% of the dataset. In 2022, the theme was "Connectedness". Regarding the "how", 30% of the drawings depicted novel technology, 28% depicted digital devices and 31% depicted wearables; the categories related to the challenge were depicted respectively in 36% of the drawings for communication, 18% for translation, 14% for transportation, and 18% for teleportation.

By looking at the most common themes depicted in the drawings we can see how giving children a specific theme - as it has been done from 2018 onwards - they produce more varied drawings, that span all the possible categories associated with the theme, while in 2016 children concentrated on the "how" - with a significant number of drawings featuring wearables and digital devices - without really addressing the "what", with many drawings describing devices that "did everything".

In the following years, the challenge tackled different themes that were related to real life problems, such as diversity, health and climate change. While specific depictions of technology varied - from wearables to novel technologies - children managed to produce rich and creative drawings while remaining on the specific topic of the challenge. However, the variety that we see might also be influenced by other factors, such as children being younger in 2016 - when the challenge only involved children in primary school - or the fact that the activity took place in a limited number of classes, with children influencing their classmates as they drew together.

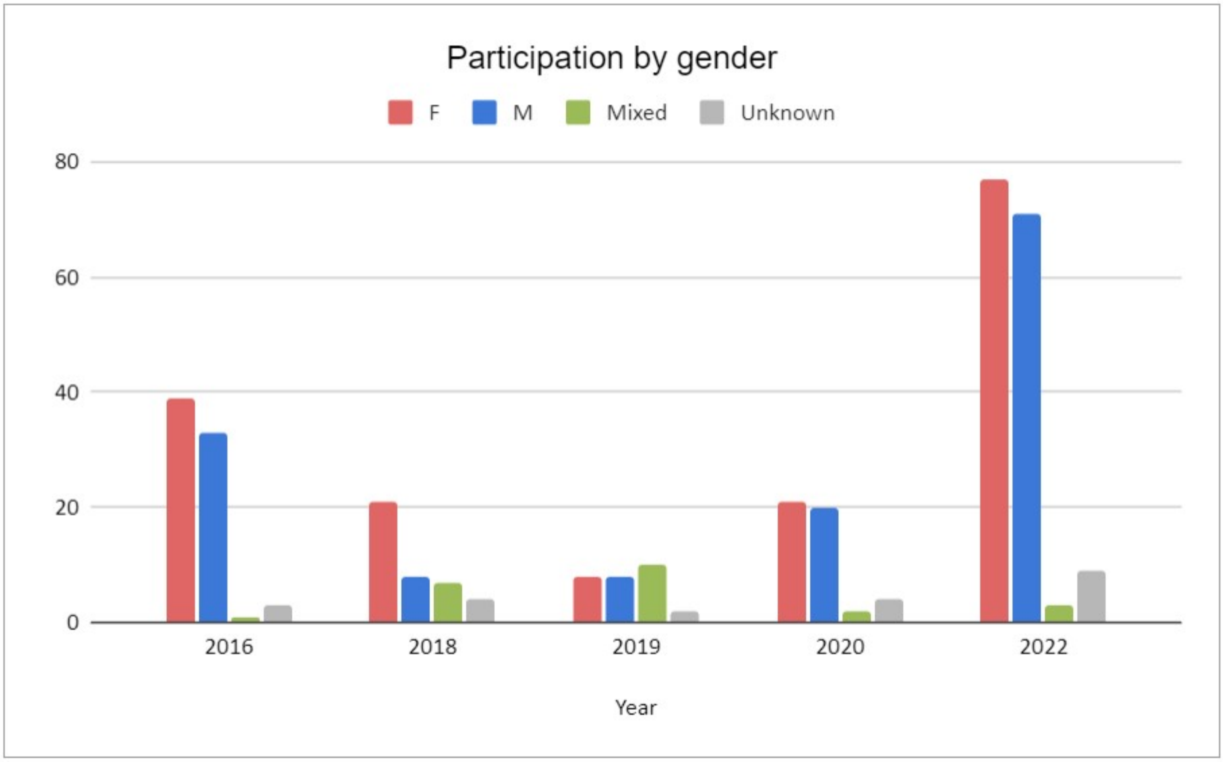

Figure 2: Gender distributions of the participating children throughout the years

6 ANSWERS, EMERGING ISSUES AND LIMITATIONS

Based on the analysis presented above we now answer the two research questions set to guide our exploration and highlight open issues to be addressed by proposed guidelines.

6.1 RQ1. How did the children's participation in the R&D challenge initiative change over time in terms of diversity and inclusion?

When coding the drawings, the first aspect that captured our attention was the fact that, despite the competition being open to children from all over the world, only a few countries are actually represented in the challenge, and the majority of the data set is composed of drawings from just two countries, UK and Switzerland, that were also the most represented countries respectively in 2016 for UK and in 2020 and 2022 for Switzerland (see Figures 4 and 5). Besides, the number of participants also varied significantly between editions.

The main issue that emerges from the data set is the strong imbalance concerning the number of participants among years and countries; this points us towards the need for a **wider participation**, both in terms of schools and countries involved. It is also worth noting that other challenges also actively involved libraries, coding clubs and other non-school entities, which we believe played an important role in expanding participation in all age groups. While the R&D challenge has mentioned "clubs" since 2021, all submissions so far have come from schools, and 2023 is the first edition in which after-school programs, clubs and maker spaces are explicitly mentioned.

One of the possible reasons for the sparse participation to the challenge could be the **issue of language**. Originally, the challenge has only been available in English; however, in 2021 children were invited to submit videos in their own native language, and since 2022 each challenge's prompt has been translated in several languages. However, the translations have not been consistent. For example, the call for 2022 was translated in Italian and Portuguese, while the call for 2023 has been also translated in Chinese, Persian and French - as well as being available in English. The translations that are available each year most likely stem from the contribution of passionate researchers who translated the call in their native language, who also personally contact schools to involve them in the challenge, and this is also reflected in the amount of drawings submitted by each country; for example, in 2022 the vast majority of drawings were submitted by Portuguese and Italian-speaking Swiss children, who speak the language in which the call was translated. However, the translation alone does not seem to attract submissions without the presence of researchers who personally work with schools; as an example of this, in 2022 there were no Brazilian or Italian children who submitted drawings.

The availability of the call in different languages allowed children to submit drawings in their native language, however this created a burden on young researchers and collaborators, who translate

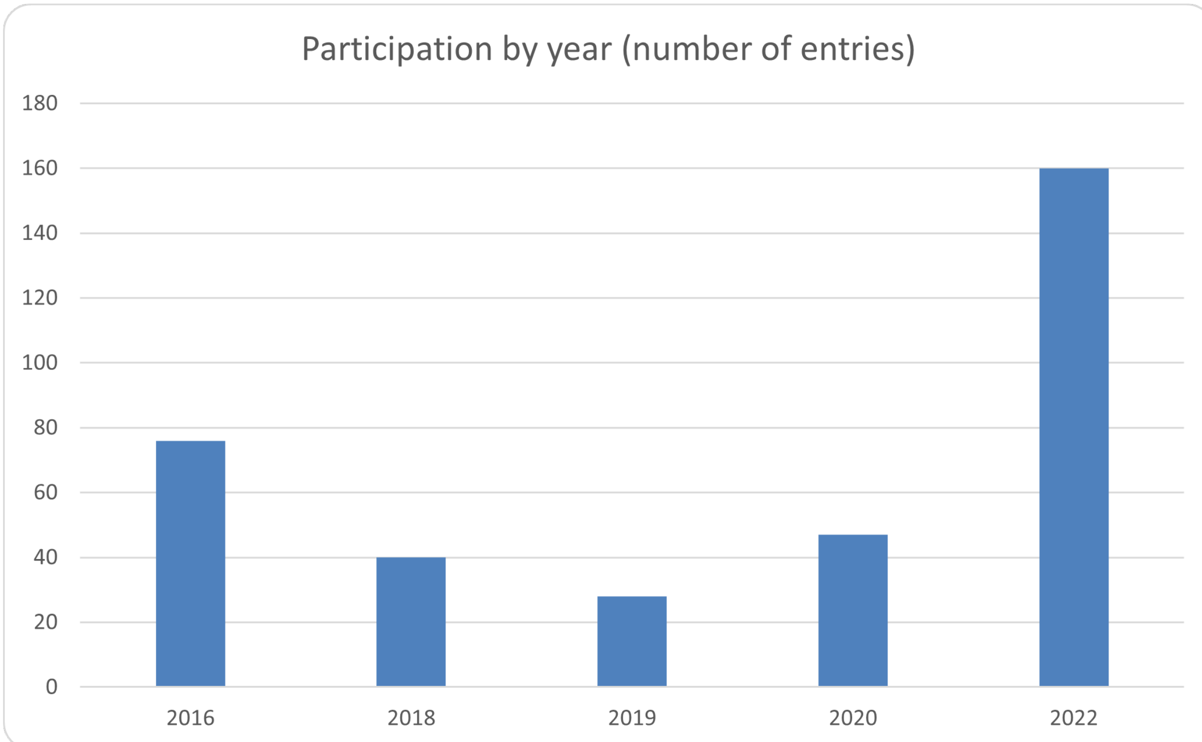

Figure 3: Number of participants to the challenge for each year

the submissions without having prior knowledge of the children, and without being privy to the context of the activity.

We also have n**o information about how the drawing activity was run** at each site, whether it was part of a class in technology or any other subject, e.g. art, how much children were already aware of and used to technology in the classroom and at home, what were the precise prompts given to them beyond the official description. We do not know how much time and effort was devoted to the drawing activity, what were the motivations behind children's participation and what role the adults played in the challenge. While each challenge's theme is presented every year on the IDC conference website, there are no established guidelines on how to run it, or what materials teachers should give to children.

Another issue pertains to the submission form: while the challenge call encourages children to participate in teams, teachers who wish to submit their pupils' work must submit a separate form for each group member, which takes a significant time as the form is composed of several fields. When teachers agree to run the activity, but have little time to submit the fall, the burden falls once again on researchers and collaborators who have to step in and prepare the drawings for submission.

Even though many schools and teachers are happy to participate just for the sake of participating, it is also worth noting that in its present form teachers and children do not gain any benefit from participating in the challenge: no recognition, no innovation, no involvement besides setting up the activity and providing data to researchers; this is also an aspect that merits a reflection. As referred to by Kinnula et al. [33] children must feel motivated to participate and sense that their participation is relevant and generates value.

6.2 RQ2: How did the IDC community contribute to the RDC initiative over time, and in what forms?

Unfortunately, there is no available data about how many submissions were made over time by adult researchers, members of the CCI community, thus we have no evidence of how popular the calls have been. A different indicator we can use to provide an answer here is the number of ideas sent by children as an indirect measure of the effort put by the IDC community in soliciting contributions. In this case, we can see the distribution and number of ideas submitted over time as in Figures 1 and 3 and observe how contributions mainly come from few countries. This could possibly suggest that only a few researchers actively contributed to the challenge by engaging with schools, soliciting, and gathering submissions.

We can speculate, based on the lessons learned from analyzing similar initiatives, that the reasons behind this lack of involvement could be the little familiarity with and popularity of the initiative, perhaps linked to low awareness of its previous editions and a difficulty in understanding how it could have a direct impact and relevance on own research path. Thus, it is important to be able to keep and **pass down the knowledge** from participants of past editions.

These issues all lead to involved parties not having clear benefits from participation, with an overall unbalance between cost and

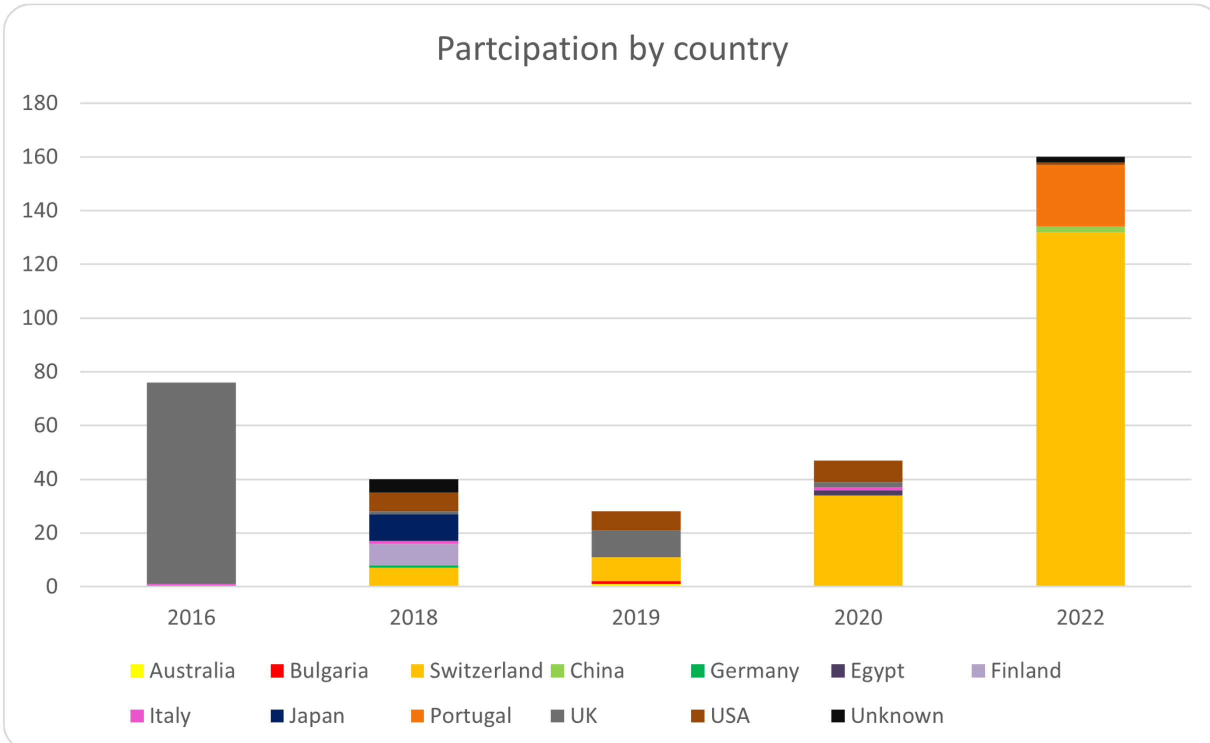

Figure 4: Number of participants to the challenge for each year, divided by country

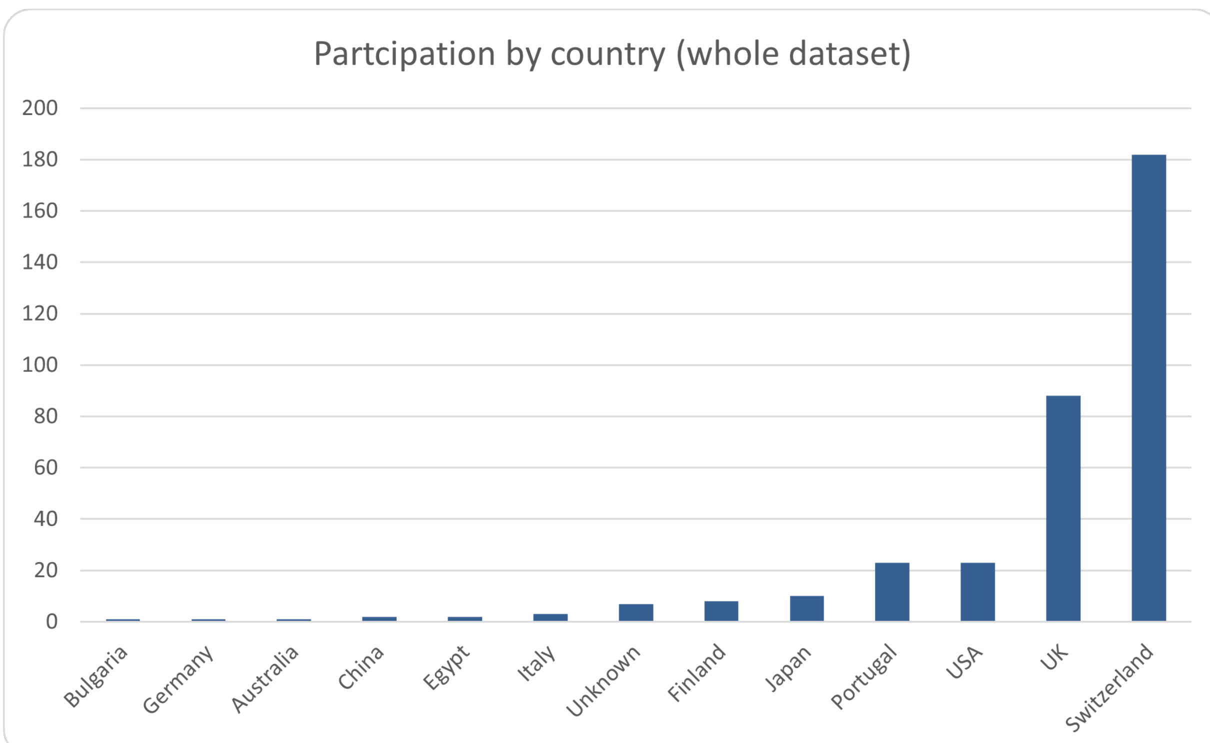

Figure 5: Number of participants to the challenge for each country, in the whole dataset

benefits when considering the difficulty in **engaging teachers** already busy with curriculum, These issues all lead to involved parties not having clear benefits from participation, with an overall unbalance between cost and benefits when considering the difficulty in **engaging teachers** already busy with curriculum, for instance in translating material describing the challenge and do the same for children's submissions too, and the distraction it could pose to children.

However, the same is true for researchers as well. While chairing the R&D competition is a significant undertaking in terms of time and responsibilities, the recognition is limited, and the number of submissions by adult researchers - that are based on children's ideas - is scarce, with some years only having 2 finalists whose papers are included in the proceedings: we look at a total of 12 papers produced by the R&D challenge finalist researchers from 2017 to 2022 – a total of 5 years excluding 2021 in which only the junior challenge was run. We can also find a WIP referring explicitly to the R&D challenge [56], that was presented as a poster in the 2022 edition of the IDC conference.

We could on turn interpret the fact that few countries, possibly research groups, keep appearing and contributing over different edition as a signal that **continuity and routine** are important for schools, children, and teachers. Once children and teachers had a rewarding experience with the challenge it is likely they would want to repeat it. The same could also be valid for researchers, that could see this opportunity as a way to reward the children and teachers they are collaborating with in other projects and give them a space to meet the rest of the IDC community while being recognised as an essential part of it.

The two research questions served as a guide for our investigation and gave us the opportunity to keep a critical eye on the challenge's past, present, and future. As a result, we can offer a list of guidelines and best practices.

7 PROPOSED GUIDELINES AND BEST PRACTICES

Starting from the issues and limitations that we uncovered in the previous section and grounded on the review of similar initiatives (see section on Other Challenges and Competitions), here we propose some guidelines and best practices to address them.

7.0.1 Promoting a wider participation and encouraging continuity. To achieve this goal, we propose reaching out directly to schools and other organisations, building a relationship and encouraging participation throughout the years. Researchers in the community who are interested in this topic should work together in a permanent committee to encourage participation from different countries and at all school levels - from elementary to high school. We recommend reaching out to schools who have participated in the past, and expanding the challenge to other countries as well. We also propose the development of a permanent website for the R&D challenge, where teachers and children can find previous years' challenges and submissions, making the challenge a year-round activity and making it easy to find all the relevant information in the same place, while also promoting the challenge through social media and newsletters, keeping teachers engaged and informed throughout the year.

7.0.2 Engaging teachers. As said before, when doing research at school with children and teachers the focus should be on giving something back to all the involved parties, and that is especially true in a case such as he R&D challenge, in which we expect teachers to perform significant work from which they do not benefit at this time. While we should try to make it as easy as possible for teachers to take part in the challenge, the level of involvement should be up to each teacher: while many of them are overworked and do not wish to add additional responsibilities to their plate, teachers who wish to be more involved in the challenge should be able to do so, and be recognized as true partners by the researchers. Teachers' involvement could include reaching out to other schools in their area, creating activity guides to help other teachers run the activity, as well as actually participate in the second part of the challenge together with adult researchers to build on children's ideas.

7.0.3 Running the activity and submitting drawings. To reduce the burden on teachers and ensure that the challenge is run in the same way all over the world, we propose writing a set of activity guides, tailored for different grades or age groups. This would have multiple benefits, as it would ensure consistency throughout the years and also make it easier for teachers to fit the activity during the school day.

Another current barrier to participation is the submission process, which is too time-intensive for many teachers: we recommend implementing a registration system in the already mentioned permanent website, to allow teachers to submit drawings in batches. Another advantage of such a system would also be the possibility to recall data from previous submissions, to make it easier for teachers who submit drawings by the same children over the years, or by children from the same schools, thus ensuring continuity.

7.0.4 Motivation for children. Children should also be more engaged in the challenge, and able to benefit from it as well. While, in the spirit of involving children in the design of initiatives meant for them, children can and should be directly involved in the betterment of the challenge, the first step in this direction would be making the challenge into a real competition, in which children of all ages can participate for the chance to win a prize, as that is an aspect that all competition and challenges have in common. While both in 2022 and in 2023 children's submissions were divided in two categories - up to 12 years old, and 12 to 17 years old - there is no clear difference in expectations and guidelines between the two categories, and the 2022 junior challenge required additional work to create a design concept based on one of the submitted drawings. While the split into two age categories is a good starting point, we propose a competition in which all submitted drawings will be judged by a jury of researchers and teachers, with winners being awarded recognition, prizes and trophies, so that children might be more motivated and engaged in the challenge.

While turning the challenge in a competition provide extrinsic motivation in children, other changes might also be useful in intrinsically motivate them: the analysis of the drawings revealed that children produced a richer variety of drawings when the theme of the challenge was more specific. Therefore, another avenue would also be to provide more specific challenge themes, in the form of real-life problems to tackle. Recognition is also another way to intrinsically motivate children, which could be achieved by the publication of previous years' submission in a permanent website, as mentioned before.

7.0.5 Passing down knowledge. As of now, previous years' challenges are not saved anywhere, and information about the number of submissions and finalists is also not available online; moreover, previous years' chairs are not always involved in subsequent editions of the challenge, and that makes it difficult to spot issues or problems, or just to pass down knowledge and best practices from one chair to another. While a permanent website would already be a step in the right direction, we also propose that each year the chair or chairs of the challenge should write a paper detailing their experience with the challenge, from how they chose a theme to the lessons learned during the challenge. By doing so, there would also be a tangible reward for chairs, who would get to publish a paper about their experience. We also propose to create a database of all previous submissions, available to all researchers.

7.0.6 Issue of language. While having a wide network of schools and institutions participating from many different countries would be an asset for the competition, this would also raise the issue of language. Although the competition is held in English and the results are presented in an English-speaking conference, in many countries it is not the primary language and many teachers - especially those who teach other subjects - do not speak English well.

We maintain that submitting entries to the challenge with a title and a description in English should still be a requirement, and we argue that this has successfully been done by many challenges and competitions throughout the world, even with the awareness that this would mean that many children's ideas would have to be translated. While not being the native language of many children, English is widely taught in schools, and we argue that involving ESL (English as a Second Language) teachers - both to translate younger children's ideas, and to assist older children and teenagers in translating their ideas themselves - would allow for a greater understandability in the drawings' descriptions, and also make the participation to the challenge a multidisciplinary activity for the class.

However, this would not solve the issue for libraries, coding clubs and other entities that do not necessarily have an English-speaking adult facilitator, therefore different accommodations should be made for those entities if and when needed, with the overall goal of reducing the burden on researchers and collaborators.

8 CONCLUSIONS

In this paper we are sharing our analysis of and reflections on the past R&D challenges with the view of how it could turn into a true asset for the IDC community.

We aim to have shown the enormous potential of such an initiative and argued that the R&D challenge is a chance that researchers, teachers, and children should not pass up. We believe it is our duty as researchers to make this opportunity as available and beneficial to all parties involved as we reasonably can. And because it embodies the values and principles of the IDC community, it should be treasured to develop into a reliable presence by possibly considering the guidelines and good practices highlighted above. We are aware of how much this will all cost in terms of time and effort, as we will need to strengthen and expand the current R&D challenge as well as plan for continued support to its future editions. Not to mention having to create, curate and keep a growing data set of drawings collected over time, complete with the metadata necessary to monitor changes in the perception children have of technology. A perhaps greatest challenge will be to ensure children's rights to privacy are protected and conditions for the ethical approval of the collection of such sensitive data across countries are respected. Nonetheless, we are confident this is a worthwhile investment and the right direction to go for the IDC community. In keeping with the statement made in the IDC2016 Chairs' Welcome: "Children's voices will be a feature of the conference with a new Research and Design competition" [1], we want children's voices to continue being a feature and grow stronger by promoting inclusion, louder with more to say as children play different roles, and speak a variety of languages to embrace diversity.

9 SELECTION AND PARTICIPATION OF CHILDREN

No children were directly involved in this study.

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