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DOI
10.1145/3613905.3637143

Publication date
2024

Document Version
Final published version

Published in
CHI '24

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Link to publication

Citation for published version (APA):
Read, J., Sim, G., Fails, J., Boden, M., Korte, J., Bhatnagar, S., Borchardt, L. H., Constantin, A., Gavrilescu, D., Wilson, C., Good, J., Andries, V., & Eriksson, E. (2024). Exploring Similarities and Differences in a set of Linked Multiple-site Design Sessions with Children. In *CHI '24: Extended Abstracts of the 2024 CHI Conference on Human Factors in Computing Systems* Article 519 The Association for Computing Machinery. https://doi.org/10.1145/3613905.3637143

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Download date:13 Nov 2026

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Figure 1: When the sea-level rises due to climate change - An underwater hotel and examples of moving sea creatures in an underwater world. Made by 12 year old children in Denmark together with Ole Caprani.

ABSTRACT

In this paper, we present a multiple-site case study to illustrate the similarities and differences in design with children in situated research contexts. The aim is to provide the reader with an insight into the planning, execution and evaluation of a set of linked, yet individual, studies from several different contexts and countries. The cases provide a platform to think about how design studies might be collectively reported and evaluated even when they are carried out in different ways. We illustrate the inherent complexity of this process by considering six case studies from five countries on three continents. The contribution is an illustration of differentiated replication in multiple distributed participatory design case studies with children in different countries. We share our thoughts on replication and differentiation, on the value of the design activities, and on how to carry out a larger project.

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CHI EA '24, May 11–16, 2024, Honolulu, HI, USA

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ACM ISBN 979-8-4007-0331-7/24/05
https://doi.org/10.1145/3613905.3637143

CCS CONCEPTS

• **Human-centered computing → Interaction design theory, concepts and paradigms**.

KEYWORDS

Child-computer interaction, Co-design, Distributed participatory design, Case study

ACM Reference Format:

Janet Read, Gavin Sim, Jerry Fails, Marie Boden, Jessica Korte, Sanjana Bhatnagar, Lilly Hope Borchardt, Aurora Constantin, Dina Gavrilescu, Cara Wilson, Judith Good, Valentina Andries, and Eva Eriksson. 2024. Exploring Similarities and Differences in a set of Linked Multiple-site Design Sessions with Children . In *Extended Abstracts of the CHI Conference on Human Factors in Computing Systems (CHI EA '24), May 11–16, 2024, Honolulu, HI, USA.* ACM, New York, NY, USA, 9 pages. https://doi.org/10.1145/3613905.3637143

1 INTRODUCTION

It is widely reported that participatory design approaches with children are valuable (e.g. [8, 10, 13, 16, 31–33]), with authors citing benefits to children that include skills development in design thinking, education in the topics being designed around, opportunities for collaborative working and engagement with research/design teams. Given all these benefits, it is pertinent to ponder ways to bring design activities to a wider population of children.

Distributed participatory design (DPD) describes an approach to design in which "*all or most [of the] design team members are physically and perhaps temporally dispersed.*" [4]. This approach requires coordination of activities across locations and/or time zones, to ensure equitable participation in, and contribution to, design activities. Recent studies reporting DPD consider some of the practicalities, challenges and opportunities of working in this way [4, 12, 23, 27].

Considering DPD, as a bigger and broader way of working with multiple children in different places, we previously described an imaginary mega-project, termed the World's Largest DPD Project [6, 18], in which researchers around the world would work with local or distributed children to explore children's responses to a global issue. The rationale for such a project would be that locally, children might benefit as described above and potentially learn things, and change things, relevant to their own situations, and globally, the 'managing' team could draw together disparate results from around the world whilst also gaining valuable research insights into how design can be distributed in this way..

As a team we began to imagine this project happening; and this highlighted how difficult it might be to facilitate and plan. We had unanswered questions about local and global value, about what we would learn as researchers and about how successful the local activities would collectively be in meeting the general goals of PD, including empowerment, participation, and democratization of design. We began the journey towards realizing this mega-project by formalising some of our initial thoughts in a research protocol [5] that was intended to set some boundaries and expectations. We continue our journey in this case study paper by exploring the practicalities of presenting, packaging, carrying out, and making sense of a set of locally arranged design sessions with children as a pilot study for our greater adventure.

We report on six cases in which different researchers and facilitators conducted in-person sessions with children (ages 7-15) in five different countries. The cases were inspired by our previously described protocol [5] and focused on design for climate change. The cases follow the multi-case notion of differentiated replication [19] in which some aspects stayed the same while other aspects were allowed to deliberately vary in order to better predict what could happen with thousands of children, across the world, all engaging locally, in our future World's Largest DPD Project.

Considering the six cases together, we reflect on the conditions that varied and remained constant across the cases, and consider related impacts on any larger study.

2 POSITIONING OUR WORK

Some years ago, Torgersson et al. called for the Child Computer Interaction (CCI) field to build more on each other's work to mature the field. They argued that without this, there is a risk that the field would fall into a constant exploration of possibilities, where only a small part of the knowledge gained from one study can be carried over to the next [28]. What we see, especially in PD with children, is that studies are typically reported on as single studies, (e.g., [9, 11, 22, 23, 35]) with multiple, comparative or replication types of studies being under-represented. Replication, in its purest form, would not find a home in the PD community. However, looking to the roots of PD, we find Pape and Thoresen's *"cumulation"*, which refers to working on one case, then shifting to the next, somewhat similar case, whilst bringing along technological prototypes, research findings, and methods [21]. In support of [28], a set of design studies that are connected and can share methods, would provide a way for the CCI community to mature. Such an approach provides researchers with the possibility to study and learn from situated practices and varied appropriations of technology [3].

2.1 Multiple-site case study and replication

Design studies in HCI are not typically written up as case studies; however, when an activity is the focus of an inquiry, the case study protocol can be applied to design activities. A case study is defined as an empirical inquiry that investigates a contemporary phenomenon [34]. In a multiple-case study, researchers study multiple cases to understand similarities and differences [34]. The logic underlying the use of multiple-case studies is that each case beyond the original must be carefully selected in order to either (a) predict similar results (a literal replication) or (b) predict contrasting results but for reasons that can be anticipated (a theoretical replication) [34]. In contrast, *differentiated replication* involves deliberate, or at least known, variations in fairly major aspects of the conditions of the study, and is a search for exceptions, a route towards establishing the conditions under which the generalization does not hold [19].

2.2 Many children - Many designs

In studies where there have been many children doing design, sometimes at different times, the 'one facilitator one project' method is the norm. The example from [23] highlights a 'many child, many design' study where the authors worked hard to give every child the same experience. A PowerPoint describing the design context, along with a script, was shown to over 140 children in four different sessions. The children were all given printed booklets to design into; midway through their design activities, the children were all given additional ideas that were consistent across all groups. The outcome was a set of very similar design outputs and a consistent

experience for the children. Contrast this with the imaginations of the World's Largest DPD Project, where multiple facilitators in multiple languages would be delivering to children of all ages; there we might ask, what should be kept the same? what should differ? Successful replication is the bedrock of scientific knowledge and, in publishing scientific results, we should therefore insist on some degree of replication. If highly differentiated replications are carried out, they need to be described in some detail, at least in terms of describing the conditions and context that have varied greatly. Close replications, in contrast, where little has changed, can be reported very briefly, especially if the outcome was successful [19].

3 STUDY DESIGN

We sought to explore the feasibility and possibilities of a large, single topic, multi-site DPD project by examining a small set of PD cases constrained by a grounding in a published DPD research protocol [5], and having a common theme (climate change). The study design championed differentiated replication by allowing for deliberate and known variations, including ages of children, location of study, tools used, and approaches taken. This design met the aims of multi-site qualitative research which produces findings that are reflective of context, but hold broader applicability across settings [15]. Six case studies from five countries on three continents were included in this study. For an overview, see Table 1 and the Appendix. No personal data was gathered during the cases. Local ethics protocols were applied by the individuals running the different events, and adult consent and child assent was gained. Note that we refer here to all the young participants as children; this is for ease of reading – we acknowledge that some might consider children to be an unusual word when applied to 14 year olds. The different cases were designed and planned by the paper authors and spanned a six month period. While the studies were being run, we held online meetings, during which we reflected on our experiences and observations from each session. We discussed a number of aspects, including the role and influence of the facilitator within the study, the children's experience, and the outcomes of the sessions. As we learned lessons, some of these fed into later studies as described later in the paper. The aim of these meetings was to use lessons learned to adapt forthcoming case studies; and to promote a critical discourse to evaluate the individual sessions before synthesising key attributes.

4 THE SIX CASE STUDIES

In this section we present the six cases in chronological order, considering the planning, execution and evaluation of each in turn (for overview, see Table 1). We focus on the variations in conditions and context from three perspectives: the researchers, the facilitator and the children.

4.1 Planning

USA: Our first case was with an ongoing intergenerational design team made up of *children* (ages 7-11) and *adults*. The team meets after school, twice a week, throughout the school year, in a kid-friendly space in a university-owned location in the downtown metropolitan area. In order to prepare for the session, the *adult team* reviewed the protocol before meeting with the full team.

The *facilitator* has 20 years of experience conducting design sessions with children and had worked with the other adults on the team to learn and use techniques to better elicit open collaborations with children. Adults were not the only facilitators, researchers, and co-designers; children understood their roles as researchers and co-designers as well.

Denmark: Two sessions were held in a classroom in a school and were part of a scheduled course on making. The *facilitator* for this case worked at the university, but visited the school every week doing teacher training in the subject entitled FabLab[1]. The researchers met with the facilitator to share the protocol; then the *facilitator* designed the sessions, and provided materials including a Tinker Qube[2] to design around, Lego Spike robots, diodes, and various tinkering materials. The *children* knew beforehand that they would have the subject FabLab according to the schedule.

UK1: The session was planned for forty *children* (age 10), to participate in one of two versions of a 1 hour design activity one afternoon at their own school. Prior to the study, the *teacher* and a *researcher* from the university received the protocol and designed a session. The *children* were all in the same school year and were in one of two class groups. The *researcher* facilitating these sessions had over 20 years experience of doing design sessions with children.

Romania: The *researcher* met with the *facilitator*, an undergraduate student, before the study to present the protocol and discuss the study design. The plan was to include 6-8 *children* (ages 12-15) and four adults (*researcher*, *facilitator* and two *teachers* with the roles of observers and assistants). The child participants were selected by the teachers.

Australia: The *facilitator* was a researcher with over 15 years of experience facilitating hands-on design workshops with school children, but was not an author of the DPD protocol. The facilitator had previously collaborated with one of the school's *teachers* on Design Thinking [20]. The *teacher* asked to include the design thinking process [14] in the workshop so the *children* and *teachers* would be introduced to the process; and that the workshop's topic fit into the class's curriculum on sustainability. The facilitator familiarised herself with the DPD protocol and used it as inspiration.

UK2: The *facilitator* was the same *researcher* from UK1 and had prior experience of the protocol. Five groups of *children* (ages 12-13) came to design sessions held at the University in groups of five or six as part of a STEM day out at the University. The groups were mainly friendship groups and the *children* all knew each other, coming from a Year 8 class of a school in a semi rural area of Northern England. The *children* had around 30-35 minutes for this session that used the Tinker Qube that was also used in the Aarhus study in Denmark.

4.2 Execution

USA: The team that day consisted of seven *children* and four *adults*. The team spent one 90-minute design session working together to design around the general question: *"What can we do to benefit our environment?"*. Food waste, energy, transport, or anything else

[1]A class for technology comprehension and programming.
[2]See https://www.upfind.dk/

Country	Context	Participants	Time	Theme
USA	Cooperative Inquiry Team	7 children (ages 7-11) Facilitator, Researchers	1x90 min	Provided options – transportation selected
Denmark	Classroom - Grade 6	22 children (age 12) Facilitator, Teacher, Researchers	2x90 min	Water rise
UK1	Classroom - Grade 5	40+ children (age 10) Facilitator, Teacher, Researchers	2x60 min	Re-use rather than recycling
Romania	Classroom - Grade 5 to 8	8 children (age 12 to 15) Facilitator, Teacher, Researchers	1x90 min	Reducing waste
Australia	Classroom - Grade 5	30 children (age 9-10) Facilitator, Teachers, Observers	120 min	Recycling and waste
UK2	Classroom - Grade 5	25 children (age 12-13)	5x30 min	Off-grid school

Table 1: Overview of the cases, sorted in chronological order.

were provided as options, and the collective group decided to focus on transportation. The larger group then divided into four small groups with at least one child and one adult per group. Smaller groups shared their designs and concluded the session by writing in their individual research journals on *"What will traveling look like in 10 or 20 years?"*

Denmark: The study was designed as 2x90 min in a sixth grade class (age 12) of 22 *children* with a *facilitator*, *teacher* and *researcher* present. The *teacher* formed the groups. Since the study took place in class when they had the school subject "FabLab", the main learning goal was related to programming and tinkering with technologies, however this was framed around *"What is the impact of rising sea-levels?"*. In the first session, the *facilitator* started by introducing the setting and the problem. The task was for the *children* to construct underwater worlds, as the water is rising due to climate change, and their village will be under water in the future. One *researcher* acted as observer and assistant. In the second session, the *children* continued to construct their underwater worlds, but this time the *facilitator* introduced the need to add moving underwater animals (see examples in Figure 1). Three *researchers* acted as observers and assistants.

UK1: The study consisted of 40+ *children*, the *teacher*, and two *researchers* and was conducted in an afternoon in a school. The *teacher* divided the *children* into two groups. Both groups of *children*, roughly matched for boys and girls, were given the same overall design brief which was to *"Design for re-use"*. Of interest in this case was that one group was facilitated by an experienced *researcher* used to doing design work with *children*, and one of the co-authors of the protocol (acting almost as a control group) and the other was facilitated by the class *teacher*. Both sessions started with an introduction on the topic for approximately 10 minutes, then the children working on their designs individually.

Romania: The team consisted of 8 *children* (two girls), two *teachers*, a *facilitator* and a *researcher*. The 90 minute session was conducted in a rural school with the aim to design an educational game to teach children about *"reducing waste"*. First, the *facilitator* gave a presentation on climate change and its impact on the Earth, how food waste and plastic pollution are related to climate change, and how these affect animals and plants. Then a design brief was introduced, requiring *children* to use their imagination and draw or write ideas for how technology can help children similar to them learn about reducing waste. Children received pencils, blank sheets of paper, sticky notes, and relevant cut out images. After twenty minutes, the *children* were grouped into two teams. Each presented their work to their team members, discussing their ideas, and then each team was encouraged to create a poster with their group game by combining all the ideas. At the end, each child answered a brief questionnaire with three 5-point Likert scale questions and five open questions about their experience during the study.

Australia: A 120 minute workshop was hosted at a private, suburban co-educated primary school. The participants were 30 Year 5 school *children* (ages 9-10) and three classroom *teachers*. The children were introduced to the problem of *"A growing garbage mountain"* and asked to *"Design a garbage and/or recycling system"*. The children were given a choice of designing for either a home environment or a school ground environment. The teachers organised the children into six groups of five children in each group. The children received large sheets of paper, felt pens, glue and scissors to work with and then they were introduced to the design thinking process of empathising, defining, ideating, and prototyping. The workshop finished with the children presenting their ideas to the class, who gave feedback to the presenting group. During the workshop, two *researchers* acted as observers who made notes and took photos of the drawings, writings and prototypes produced. At the end of the workshop, children were asked to complete a short questionnaire similar to the one used in the Romanian study.

UK2: 25 children (ages 12-13) worked in groups of five with a researcher. Five sessions were run at the university, one for each group, and each lasted for around 35 minutes. The design activity was *"To think about an off-grid school"*. Each session was introduced by the same adult *facilitator* who deliberately stood back from the design work in order to allow the *children* to take control of the collaborative activity and to see if *leaders/facilitators* emerged. This facilitator had seen the materials used in this session when they were used in the Danish study some time earlier. The intro session included a very brief introduction to the design stage, with pieces of card and pipe cleaners being shown as objects to think and design with, a rapid introduction to the various prototyping materials that were available and then a brief conversation about what off-grid might mean with suggestions being teased out about how water, electricity and sewage could be managed and stored in an off-grid school. After about fifteen minutes of designing, the adult *facilitator*, having not intervened, warned the children they had about five

minutes left, after which time photographs would be taken and notes made.

4.3 Evaluation

After the first sessions were run we spent a lot of time as a team considering whether a set of evaluation variables could be used effectively to make comparisons across the different studies. We concluded that this was not a good way to think about the differences and similarities given that we were replicating some things and changing others and so evaluation was kept situational with a combination of field notes, observations, artefacts and surveys making up a rich data set from which we could draw insights.

USA: In each group, *children* and *adults* actively worked together to collaboratively design solutions by creating, building, expounding, combining, and elaborating on the shared ideas. At the conclusion of the design session, *children* presented their smaller group's ideas that consisted of adult and child collaborative ideas. All groups identified barriers and solutions to transportation issues and were able to think of design solutions. The need to motivate people to use less individual petrol-gas transportation options was addressed with an idea of taxing those people extra. Self-locomotion solutions (e.g., bicycles, electric scooters and even "smart sneakers" with electric expandable wheels) and public transportation (e.g., moving carpets or gondolas) that would replace individually driven vehicles and streets were other imagined solutions. One group focused on public transportation, reducing carbon-emission fuels, and accidents including safety protections from those driving under the influence of substances (a suggestion by one of the children). Another group focused on different energy sources like solar panels and innovating new locomotion inducing energy sources like compressed air/gases.

Children were highly engaged throughout this activity, although one had an "off" day with lower energy than usual.

Denmark: Photographs were taken of the designs, which each showed some understanding of what it might be like to live underwater, although some practicalities could be considered to have taken second place to the aesthetics; e.g. there were TVs co-existing with sea creatures in the designs. After the study, the *researchers* debriefed with the *facilitator*. The *facilitator* was not satisfied with the outcome as he did not feel that the main objective of the activity (learning programming), had been met; however he was satisfied with the fact that the *children* had had fun. The *researchers* concluded a relatively high level of engagement in the *children*, as well as a visible change in the *children* when they first experienced and then explored their village and homes under water (awareness of climate change).

UK1: A single *observer* took notes on both sessions. All *children* managed to complete the design task but it was evident that facilitation influenced the results. In the first session, when several children struggled to get started, the *teacher* suggested a robot, and this resulted in half the children producing robots. In the second session, the *children* were struggling to answer questions the researcher was asking, the activity seemed a little difficult for several children and the *teacher* intervened to prompt the children. There were some highly relevant designs, but some did not really fit the context – including litter grabbing robots and recycling solutions.

The differences between the two sessions were mostly seen in the way the activity was started. With the *researcher* the approach was conversational, with hands being put up in answer to questions asked. With the *teacher* the conversation was more educationally focused and she made a mind map on a whiteboard as she captured ideas from the children; she also teased out more ideas and semi-directed children towards ideas that she had perceived as being missing. In contrast, the *researcher* gave out some of the missing ideas, with the consequence that the *researcher* group had marginally more time to do the design activity than the *teacher* group.

It was observed that the *children* all seemed to engage in the activities and there were only a few signs of boredom, in the first session, when the introduction lasted around 15 minutes.

Romania: All *children* managed to contribute ideas. Two used text, drawings and cut out images, two used drawings and text, and the other four used only text. Five children included a clear goal for their game, e.g., collecting garbage and recycling it, learning about how to reduce pollution, becoming aware of animals' difficulties caused by pollution, and creating a clean new world. One of the children suggested something similar to Pokemon GO, a game that can be played outside in parks or green areas. Some children included rewards and characters for their games and mentioned worlds, plot twists and fun as possible game elements.

The group activity was more problematic. Neither team managed to create a poster, one of the groups presented a set of features for a game, while the other simply discussed the individual ideas.

The survey revealed that the eight children were happy to participate in the study and would like to do similar work again (N=6). Children appreciated the fact they learned new things about an important problem regarding our planet (N=4), the design activity (N=1), the free expression of their ideas (N=2) and the collaboration and discussion at the end (N=1). The aspects they liked least were the group work (N=2), and some parts of the presentation (N=2).

Without being asked, the two older *children* played a role of a *facilitator/mediator* in their teams, asking questions to clarify ideas and congratulating the other children for their ideas. The children liked to communicate with the *facilitator*, saying "D. is very cool, she knows how to talk to children, and her presentation was clear and easy to understand." The importance of the global problem on which the design was focused and the fact that *children* learned that other children like them around the world were included in the study appeared to be motivating factors. After the study, the *researcher* debriefed with the *teachers* and the *facilitator*. The *facilitator* and *researcher* were satisfied with the *children*'s outcomes and engagement. The *teachers* observed that all *children* were very engaged in the activities, though one of the boys lost energy at the end of the session (during the team work). The *facilitator* and the *teachers* were impressed by *children*'s willingness to express and discuss their ideas and offered to facilitate/host other studies.

Australia: The children demonstrated domain learning during the empathising and defining phases of the workshop. Each group created a design or paper prototype for their school environment. These designs were for something that would make disposing of waste correctly more fun or easier to get right, or for strategies for recycling, upcycling or otherwise using waste. Several groups considered financial aspects to their design, including ideas like

selling food scraps as compost. The *children* were very impressed that climate change challenges were being worked on by other children from all over the world, and this seemed to be a motivating factor for engagement. Based on comments from the children during the session, other motivating factors seemed to be the fun and novelty of the design session, and for some groups, the desire to teach other (younger) children. In the questionnaire, the children overwhelmingly reported that they enjoyed "working as a designer" (N=26) and that they would like to do more co-design projects (N=23). The most common favourite parts of the workshop were: working with others (N=10), coming up with creative ideas (N=8) and the presentation to the class (N=6); although two children reported that they did not like presenting and that it was their least favourite part. Sixteen children reported that there was nothing they disliked about the workshop. Twenty-two children agreed that they learned from the session (although 27 provided answers to the question "What did you learn from doing this workshop?"). Observers reported high levels of engagement with the activities for all but two children. Those two children had known adjustments within their classroom, and their team mates worked to engage with them at a level that was comfortable to them, including showing them prototype ideas to elicit feedback.

UK2: All of the children were able to complete a design, and the conversations around off-grid energy showed that their understanding of this topic was being developed as they designed. One group decided they would heat their school with energy from the earth's core and build a deep bore hole under their school which they then also realized could provide water. Learning about the context was also noted in so far as many children had not really understood the need to store, as well as generate, electricity. In terms of designs, very little was seen that was novel, but the children clearly had fun. The *facilitator*, who observed the children working, and the *teacher*, who was also a silent observer in each session, noted that effective design seemed to rely on collaboration, but also on a shared idea of what was being done as well as a willingness to be rough and ready with the design activity. Three of the five groups were able to self manage and create solutions that could be reasonably interpreted; the other two did not. The *children* were asked about their own management and the use of the Tinker Qube as a design prop - they all reported liking the cube but the two least functional groups did highlight that 'no-one knows what they are doing' and 'there was no leader'.

5 DISCUSSION

The first thing we can say about the six case studies is that in most cases there appeared to be high engagement and enjoyment. It is interesting to note comments from Romania and Australia, where children seemed enthused by the idea of being part of a larger project. The use of the survey in these two countries teased out what was and wasn't enjoyable: group-work was met with differing enthusiasm; across 'a many country, many cultures' study this would be something to take into account. In UK1, Denmark, and Australia, there was a learning goal alongside the design activity, and reports suggest that this was not necessarily a problem for the design work but again, account should be taken of parallel, and potentially competing goals within a design activity. Integration of such competing goals may be important in getting buy-in from gatekeepers including teachers and parents, as was seen in the Denmark case. There was some evidence that differences might be partially cultural and the use of English as a language to think in will have had an effect - both on how we as a team interpreted what was said and done and in how children's voices were later heard. For example, in the Danish study, children worked in Danish and some of the observers could only consider seen engagement as they did not understand what children were saying - contrast this with a situation where children and observers are culturally and lingually close - there will be an effect.

For us as researchers, seeking to learn about, and understand, variations and similarities in cases, it is necessary to consider whether, and how, any changes we made impacted the cases and also whether the planned replications gave any particular insights. Our plans were for two conditions to be replicated across all studies: use of the research protocol [5] and a focus on climate change. Two other conditions, having a live facilitator in the room, and having a relatively short time period for design (3 hours or less), were also replicated. It is interesting to consider how the protocol was used. The facilitator in the Denmark study was probably the one who used the protocol least. In UK1, the teacher facilitator looked at the protocol but didn't draw anything directly from it. Some of the experienced researchers used it only in a cursory way. From this, we might suggest that such protocols may be more suited to less experienced CCI researchers; they certainly have a place, having been used and appropriated in a wide range of subject domains [29, 30]; however, as a condition intended to be replicated, its varied use rather broke the intention.

As we moved through the studies, we varied conditions, replicating some of the variations across studies. Some variations were necessarily unplanned, like the locations of the studies (e.g., classroom, university-owned kid-friendly space), the materials used (e.g., craft materials, paper and pen), and group vs. individual design. In our studies, the classroom-based sessions were more 'managed' and so one variation we actively tried was to run the two sessions in UK1 with different facilitators to see what a teacher would do if presented with this activity to manage. In Romania we then later devolved management of a session to a novice in design: in both cases a successful design session ensued.

Elements which were replicated across multiple cases were the questionnaire used in Romania which was further developed and used in Australia, and the Tinker Qube used in Denmark and then in the UK2 study. The repeated use of these tools could bring insights to the CCI and HCI community, and help with validation of tools (which has a long history in CCI [24] and helps to understand limitations through repeated use and reporting).

The Leuven Scale [7] was used to measure engagement in all the studies except UK2 and whilst we did not report numerics from it, we each used this to gauge general engagement in a very low effort, non-intrusive way. Adding the questionnaire in Romania and Australia allowed us to see if children would also report their engagement as high - which they did. Replicating the Leuven scale showed us how easy it was to use across contexts. Replicating the survey gave insights about different feelings for group work in different contexts. We chose to repeat the use of the Tinker Qube, having seen how well it seemed to facilitate group collaboration in

Figure 2: Variables considered in evaluation of the case studies.

design in Denmark. The Qube had a similar effect in UK2, with the observing teacher remarking on how it assisted the team to work together.

To query the success of the sessions, we can look at how children felt, and at design outcomes [26]. Whilst all the children were able to design, we did not formally evaluate designs. Observations and field notes captured aspects such as motivation, perceived learning and the effectiveness of teamwork, all attributes we would hope to associate with a successful PD session. Figure 2 provides a visualisation of domains of evaluation across the cases with the size of the word reflecting how often it was used.

What we have learned is that the use of a differentiated replication approach to case study design has shown interesting similarities and differences across the six cases that give further areas for study. Whilst we might methodologically argue for some degree of replication in DPD studies with children, we do not argue for close replication typically found in other fields. We rather call for others to consider variations and differences as they explore PD (and DPD) across contexts. This fosters not only transfer of knowledge from one case to the next, but also cumulation of knowledge [21], which ties together traditionally isolated studies, and which can both strengthen and mature the entire field [28].

5.1 Future direction and open questions

In returning to our mega-project in which we might want to engage with thousands of children from around the world, we have three main questions to consider: **1. Can we demand some degree of replication in DPD studies with children?** Our report on six case studies, which were guided by the same protocol, focused on the same theme, and were altered based on the lessons from previous cases, demonstrates that DPD with children is inherently messy. Even if exactly the same study was run by robots in multiple countries, the differences in context and individuality of children would result in differences in results. Practically speaking, it is likely not possible to run exactly the same study – that would ignore the needs, autonomy, and uniqueness of countries and cultures around the world, which is one of the benefits of worldwide DPD. **2. What other means than a shared research protocol can scaffold some degree of replication in DPD with children?** When we imagined the World's Largest DPD project, we chose a shared research protocol as the anchor point for replication. As a research protocol, [5] is somewhat vague in places, because as experienced PD researchers, we knew that some things should not be pre-specified across all contexts – researchers can and should work with children of different ages and abilities, in different settings, and they should make changes to suit the needs of the children (and adults) they design with. There may be other ways of scaffolding replicability that remain to be explored. **3. What are the next steps towards the World's Largest DPD Project?** Imperatively, our future directions include expanding this work beyond the Global North and mainstream classrooms. We wish to critically appraise whether or not this approach replicates beyond predominantly WEIRD[3] countries and beyond the researchers' immediate (convenient) research contexts, building on work by [27]; and to consider the needs of disabled and neurodiverse children, who may require more support and time to participate fully [1, 2, 17]. After all, our work is only replicable if it is replicable for all.

6 CONCLUSION

We have presented insights from a multiple-site case study, where six distributed participatory design studies with children in five countries have been guided by a single research protocol. Since reporting differentiated replication in DPD with children is rare, we contribute a unique illustration of variations in conditions and contexts and how these have influenced the planning, execution and evaluation of the related cases.

One limitation of this work is the Global North focus. As the authors and inventors of the protocol and idea, it made practical sense to trial it in our own local contexts as a first step towards evaluating its usefulness but strongly propose that the next steps in ascertaining scalability should involve moving beyond our own localities and making concerted efforts to trial its use with CCI researchers in non-WEIRD and Global South communities. If this work is to be fully replicable, it is essential to co-create culturally and contextually relevant approaches to its use, fostering inclusivity and moving towards building ethical, equitable, and effective HCI solutions for children worldwide.

A second limitation is that we did not consider the 'quality' of design outputs and did not attempt to bring any of these together, locally or as a mass. We would not normally encourage researchers to design for the sake of designing and so we need to consider this going forward. Methods do exist that will be explored in future work [25].

Future work will consider what to try to keep the same, and what to vary, as well as an exploration of ways in which we can talk about these things. We acknowledge that some level of replication will mature the field [28]. This could increase the potential of qualitative research and support the development of interventions tailored to the populations they are intended to serve. This paper provides a basis for DPD replication from which future studies can build.

ACKNOWLEDGMENTS

We would like to gratefully acknowledge the contributions of the teachers and children who worked with us on each of these case studies. A special thanks to Ole Caprani at Aarhus University. UKRI HEIF participatory research funding from the University of Central Lancashire helped fund this work.

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7 APPENDIX

Conditions/Variables Table

		USA	Denmark	UK (1)	UK (2)	Romania	Australia
Workshop Focus		"What can we do to benefit our environment?"	"What is the impact of rising sea-levels?"	"Design for re-use"	"To think about an off-grid school"	a game to teach children about "Reducing waste"	"A growing garbage mountain, the task given was to design a garbage and/or recycling
Participants	**Children**	7 (ages 7-11)	22 (age 12)	40 (age 10)	25 (ages 12-13)	8 children (12-15)	30 (ages 9-10)
	Teachers and Facilitators	4 adults with teaching experience	• 3 researchers • 1 facilitator • 1 teacher	• 1 teacher • 2 researchers • facilitated by experienced researcher	• facilitated by experienced researcher	• 2 teachers • 1 facilitator • 1 researcher	• 3 teachers • facilitated by experienced researcher • 2 observers
Design Groups		Groups of 1 adult + at least 1 child	Groups formed	Divided into 2 groups. Students worked individually.	5 groups run separately	1 group	7 groups
Context	**Duration**	1x90min	2x90min	1x60min	5x30min	1x90min	120min
		After school	Classroom	Classroom	Children brought to university	Rural school	Classroom
Format & Materials		• Brainstorming • Research journals • Presentation • Feedback	• Lego Spike Robots • Diodes, and other material • Constructing prototypes	• Paper • Pencil	• Pieces of card and pipe cleaners • Prototyping methods	• Pencils • Paper • Sticky notes • Cut-out images	• Pencils • Paper • Prototyping • Presentations
Facilitators		Researcher with long experience working with children	• Phase 1 - One researcher acted as observer and assistant. • Phase 2 -3 researchers acted as observers and assistants • Facilitator introduced problem space. Teacher formed groups.	• Group 1 facilitated by researcher • Group 2 facilitated by class teacher.	1 researcher acting as facilitator	Undergraduate student	Researcher
Design of Study	**Method**	• Observations • Journals • Recordings	• Photographs • Debrief between researchers and facilitators • Analysis of outcomes and engagement.	• Notes (single observer in both sessions) • Outputs collected at the end of sessions	• Photographs and notes taken after students left	• Observers • Survey	• Observers • Survey
	Focus	Collaborative aspects	Learning	Learning	Collaborative aspects	• Enjoyment • Engagement • Learning	• Enjoyment • Engagement • Learning
Variables Analysed		• Collaboration within teams was successful • Design ideas developed that were on-theme and appropriate, if fantastical • Children were engaged	• Children gained understanding of topic • Felt that the learning outcome was not met, however children had fun. • Children focussed on aesthetics of design rather than practicalities.	• All children completed design task • Outcomes were influenced by facilitator's intervention	• Effective design seemed to rely on collaboration • Functional teams were able to create interpretable solutions	• All children contributed ideas. • Most developed goals for game • Very happy to share ideas. • Older children stepped into facilitator role in group work Motivating factors: • Global problem & knowing other children around the world were working on it • Novelty of session • Sharing ideas	• All groups developed ideas/prototypes • Almost all children engaged • Children gained understanding of the topic • They enjoyed working collaboratively and built on each other's ideas