ABSTRACT
Maker movement has recently gained worldwide recognition. Educating children in making activities has also become advocated. Studies have reported experiences on engaging children in making activities and the importance of nurturing a maker identity in children has been advocated. This study reveals findings from a case where, in the spirit of genuine participation of children, 10-12-year-old children gained initial experiences in design and making activities within an elective mathematics class as part of their primary school education. The study shows that children adopted multiple subject positions and relied on various discourses when describing their experiences. We argue that none of them developed a designer or a maker identity as such during the project, whereas many of the children reported of having developed some sort of meaningful relationship to design and making. We argue that this is a valuable outcome per se. Implications for HCI research and design are discussed.

Author Keywords
Children, making, digital fabrication, identity, school.

ACM Classification Keywords
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.

INTRODUCTION
Making is seen as the hottest hot in education of the young generation today. Making itself, i.e., crafting and tinkering, is not a new phenomenon, but the contemporary maker movement, i.e. “the growing number of people who are engaged in the creative production of artefacts in their daily lives and who find physical and digital forums to share their processes and products with others” [20: 496] has brought visibility and significance to this phenomenon. This is amplified by the recent developments, e.g., in technologies for digital fabrication including “physical computing technologies as well as digital production machines for printing three-dimensional objects and for cutting, shaping or milling material” [31: 3]. In the background are famous movements such as open source software and hardware movements as well as the Do-It-Yourself and hacker movements (see e.g. [1, 2, 5, 8, 12, 17, 31]).

It has also been acknowledged that children of today should be offered opportunities for familiarizing and engaging with such technologies and movements as well as for developing an associated maker mindset or identity [3, 43]. The maker movement argues for offering in-depth technology knowledge for children: the goal is to educate children to innovate, design, make, and build new technology (e.g. [5, 23]). However, it has been pointed out that too strong emphasis has been placed on building and technology so far, while digital fabrication and making should be intimately intertwined with design [3, 5, 8, 15, 31, 46]. Another challenge concerns teachers and schools: they should be able to offer children learning experiences in design and making. However, it has been recognized that school can be a challenging context to do such work with children [24]; schools and teachers are struggling in keeping up with the recent developments in technology (e.g. [34, 40, 47]) and teachers are in need for help in integrating design and making into education [3, 5, 28, 31, 47, 55]. It might also be challenging to advocate within formal schooling culture the tenets of maker movement that emphasize empowerment of people to make personally meaningful tools based on their own initiative and interest [9, 10, 24].

Children’s education in making is a topic addressed by many disciplines, while also the Child Computer Interaction (CCI) community has recognized and responded to the challenge. Numerous studies have reported on various kinds of making technologies and experiments (e.g. [3, 7, 8, 9, 10, 16, 31, 32, 35, 42, 46, 48, 51, 53, 54]), some of the studies addressing particularly the context of school [3, 7, 9, 10, 16, 46, 48, 49, 53]. The current study responds to a gap in the previous studies asking, “what kind of experiences emerge when children initially encounter design and making.” Such research is needed, as most kids in the world do not yet have these initial experiences and it would be highly beneficial to provide better support for the situation when novice makers and designers encounter design and making for the first time. To devise such support, understanding of the initial experiences and challenges is invaluable. In addition, the study acknowledges that making should be combined with a thorough design process that many times is lacking in

Citation:
making endeavours with children. We emphasize that equally important with developing a Maker identity in children is developing their Designer identity. We also see support for genuine participation of children [24] as highly significant in any making endeavour and thus tried in this study to ensure that our work aligns with the spirit of genuine participation of children (see [24]), at least to an extent. The study has been carried out in primary school context in Finland with the purpose to study the variety of ways by which children initially approach design and making and develop a meaningful relationship to those.

The paper is structured as follows. The next section introduces related research on children, design, and making as well as our theoretical lens for making sense of our empirical data. Thereafter, the research design and the methods for data collection and analysis are presented. The fourth section discusses our empirical findings, and the fifth section reflects on their implications for CCI research as well as concludes the paper.

LITERATURE REVIEW

Related research

The existing CCI research has already acknowledged that educating children in design and making is a concern of ours. As for design, already in 2002 Druin [14] identified a variety of roles children can take in technology development, including informant, tester, and design partner roles. Numerous methods have also been proposed to be used with children in technology development (e.g. [13, 19]), many of them advocating particularly the design partner model, some of them also highlighting the need to give children skills, competencies and authority in the design process (e.g. [6, 24, 25, 29, 33, 47]). Such work has also been conducted in schools, with the aim of educating children in design and technology [6, 24, 47], some even emphasizing their integration into the curriculum [7, 44]. In addition to these studies, however, CCI research is very limited in addressing the development of children’s design education and designer identity as part of their basic education.

Recently also the significance of integrating making into education of children has become acknowledged, i.e. offering of in-depth technology knowledge to innovate, design, make, and build new technology (e.g. [5]) as part of basic education. Researchers have identified suitable educational approaches to be used in this work: making has been particularly interlinked with critical and constructivist educational approaches (see e.g. [5, 27, 31, 49]) as well as with practice based, experimental, unstructured, self-directed, collaborative, and design-based learning, and learning by doing and making [1, 2, 3, 5, 8, 27, 31, 41, 54].

However, there are great differences in the work accomplished. For example, researchers have relied on very different settings in their work: some of them have organized children’s making activities in informal, voluntary out-of-the-school settings such as in museums, libraries, computer clubs, Fab Labs, youth centers, conferences or universities [1, 2, 4, 8, 17, 31, 35, 42, 51, 54]. Making activities in such places have been voluntary for children to attend. In other studies, then again, making has been integrated into children’s schoolwork (e.g. [3, 4, 7, 9, 10, 16, 46]), in which case it has been either mandatory for children to attend or offered as voluntary part of schoolwork, e.g. as elective after school classes or extra-curricular activities.

The studies also provide various kinds of findings. They report that children enjoyed experimenting – taking control of their own game [1]. Nurturing of a Maker mindset and identity in children is argued for [7, 8, 9, 10, 35]. Maker spaces managed by kids for kids are appreciated [2] as well as peer support and collaboration in making activities [17, 35, 41, 42, 48]. The studies posit that making activities should be based on personal, meaningful ideas – ideas that people bring into the lab [31, 41, 42]. Facilitation of Bildung (deep sustainable learning) is argued to be significant [31]. Such Bildung can be facilitated in various kinds of maker spaces, while some researchers argue for integrating making with school activities, possibly even into the curriculum [3, 10]. In schools, design-based learning, design thinking, and collaborative learning are argued to be valuable, with teachers acting as coaches and learners own interests driving the making activities [3, 46].

So far, however, the studies have not focused much on challenges in introducing design and making activities into the education of children. As for making, some studies can be identified, while for design, CCI research remains very limited. Somanath and colleagues [48] address making in the context of high school in India. They list both monetary, resource, and situational challenges in making activities at school. They report that in a resource limited setting, there may be a fear for trial and error and for exploration. Reasons for the fear may be both monetary and psychological. The students may lack intellectual courage to explore also due to the cultural characteristics of the educational setting. The learning resources in use may also be severely limited in such a setting. The participants’ previous experiences, skills and capabilities needed in making activities might also be very limited, slowing down the learning and making processes. [48] Also in less resource-limited settings some studies have briefly touched upon the challenges involved, while they have mentioned that children may lack skills and competencies as regards making and technology [7, 52] or collaboration [46], the tools and materials in use may remain unfamiliar or difficult to understand and grasp for children [46, 52], collaboration among children may not always be functioning very well [7, 46], children may lack guidance and examples [2] and combining the tenets making with formal schooling culture may not be easy [10].

Another acknowledged challenge relates to the integration of designerly thinking with digital fabrication and making with children [5, 8, 15, 31, 46, 47]. Designerly thinking tries to capture what is involved in designers’ practice – in their
(often non-verbal) skills and competence (see e.g. [30]), where design is viewed as a reflexive practice, a problem-solving activity that involves reasoning and making sense of things as well as meaning making. Designerly thinking advocates creative view of design: design necessitates creativity, reflection, and improvisation of the designers with expertise and judgment [36, 37]. Digital fabrication and making with children should be combined with designerly thinking – with creativity, innovation, exploration, sense-making, wicked problem solving, iteration, and reflection [5, 8, 31, 46]. However, this combination has not been explicitly addressed in most studies on children and making. There particularly is a lack of studies examining children’s initial experiences, interpretations, and challenges when introducing this combination into their education. The current study will delve deeper into this topic.

**Analytic lens of this study**

Due to our long-term emphasis on understanding children’s genuine participation [24] we are particularly interested in children’s own experiences when they approach design and making in the school context. Thus, we examine how children talk about their design and making activities in the interviews we have organized with them. Inspired by the work of Iivari and colleagues [26], we view children as adopting and constructing various kinds of subject positions and discourses in the interview situation as regards design and making. The children attach particular meanings to design and making as well as construct particular relationships to them – influenced by various kinds of issues such as their previous experiences, assumptions and preferences and by their relationships with other participants present in situ or more distantly shaping the social action in the background [26]. Hence, we treat our data similarly to Iivari and colleagues [26] as a window to the interviewees’ reality and identity construction, instead of assuming the interviews are giving us ‘objective facts’ of the discussed topics. This discourse perspective allows us to look at the interviewees as posing and positioning themselves in relation to the audience and participants in situ but also more generally in relation to design and making.

We view the subject positions and discourses as part of children’s identity construction, exploration, and performance [26]. However, related to design and making, we are hesitant to link the positions and discourses directly to Designer or Maker identities. Even if the positions and discourses indicate development of some kind of relationship to design and making, we think adoption of a Designer or Maker identity requires more: it requires self-efficacy (I can design/make), motivation (I want to design/make), and interest (I like to design/make) (modified according to [8, 10]). Self-efficacy as well as self-identification with maker movement or community [10] or with designer community or designerly approach to problems [30, 36, 37] is required. Design and making both require particular skills and competencies. For a Designer or Maker identity to emerge, also person’s own belief in having such skills and competencies as well as their motivation and pleasure associated with making use of these skills and competencies are all required. The positions and discourses identified in this study indicate that it would be too far-fetched to argue the children having adopted Designer or Maker identities, but our results show that valuable seeds for such emerged.

**RESEARCH METHODOLOGY**

**Research design**

The project was part of long-term collaboration between CCI researchers and local schools, advocating children’s genuine participation and aiming at offering children design and technology skills and competencies. The work of our research group has been particularly inspired by the Scandinavian participatory design (PD) tradition that we consider important to drive CCI research in general as well as practical work in schools with teachers and pupils. In this project, the particular aim was to offer children experiences in design, programming, and making, and to utilize the recently established Fab Lab of the University. A volunteering teacher was located in a Fab Lab presentation event in spring 2016. Local teachers and schools have a high interest in programming related projects as programming has been included as part of K-9 education in Finland at 2016. Hence, Finnish teachers are in the process of experimenting with suitable ways on how to integrate programming into education, into mathematics classes in particular.

The project participants and their roles in the project were the following: The participating teacher was a mathematics teacher responsible, among others, for an elective mathematics class for pupils of 5th grade (18 boys, 2 girls, aged 10-11) and 6th grade (16 boys, 2 girls, aged 11-12) in her school. In addition, four junior researchers (2 men and 2 women) participated in the project. They had BSc background in software engineering, information systems, and human-computer interaction and were in the final phase of Master’s studies. Three CCI researchers (the authors of this paper, all women) steered and guided the project.

The junior researchers worked independently as a group, each working ca. 260 hours for the project during autumn 2016, ca. 70 of those at school. They planned and executed the practical project work with children. One or more of the CCI researchers were also present in most of the workshops observing and guiding children’s and junior researchers’ work. The teacher had an important role as regards pedagogical aspects of the project: she decided with which classes and courses the project was conducted, knowing the children divided them in groups, reviewed and commented on the plans of the junior researchers, and ensured there was teaching staff present during the project (taking responsibility for, e.g., safety issues).

The CCI researchers, junior researchers, and the teacher collaboratively brainstormed and developed the shared goal for the project work for the pupils: to create for each class an
interactive ‘board game’ with multiple game spots. In line with genuine participation ideals, the exact content of each game spot was left open to be ideated, designed, and implemented within groups of 4-5 children, yet to include some game-like problem solving in order to pass through the game spot. The Fab Lab facility was also to be used when building the game spot. In addition, a Dash robot (by Wonder Workshop) was used to integrate individual game spots into playable and complete game. For this, the children needed to program as well. The CCI researchers gave also other playful tools to be potentially utilized in the project: Touch Board by Bare Conductive, Makey Makey, Lego education WeDo 2.0 + Workshop Kit Freewheeler (later referred as ‘tools’). The tools were selected based on a review of available tools and recommendations of other researchers working with children. Most of the project work was done at the school with two classrooms and lots of free space available, two groups of pupils working in one classroom (see Figure 1). Each pupil group had their own table and chairs around it.

The project work with children lasted 11 weeks and included ten sessions with the pupils of both classes (see Figure 2). The assignment and the expected outcome for each session were presented for the pupils in the beginning of each session. The pupils wrote their plans (textual descriptions of their possible game spot into their notebooks. The second session was for presenting Fab Lab tools in more detail (laser cutter, 3D printer, etc.). Ideating in groups continued by storyboarding.

Five making sessions: In the first session, material for game spots was introduced to the pupils (a brown cardboard box, colored cardboard sheets, glue, and different kind of arts and crafts material) and they started game implementation work. In the second one, pupils tried out and practiced the use of the tools in the school crafts facilities (Figure 3), considering which ones would be most suitable for their game spot plans. In the third session, game implementation was continued (Figure 1) and tools were combined with the game spots. In the fourth one, the pupils and the teacher visited the university Fab Lab for modeling and implementing objects needed for the game spots. Finally, the pupils assembled and finalized the game spots in the school crafts facilities.

A playing session: The junior researchers set up a ‘game board’ on the school library floor, i.e., a playable version of the whole game with all the game spots connected with ‘tracks’ leading to the next game spot (Figure 4). When playing the game, children moved between game spots by programming the Dash robot to follow the ‘track’ on the floor from one game spot to another. Later, they evaluated all the game spots and gave constructive feedback and improvement ideas for each game spot (Figure 5). Next week the pupils filled in a feedback questionnaire and participated in interviews either in pairs or in groups of three pupils.

Research data and analysis

Research material used in this paper includes field diaries of the researchers, videos of the interviews, and the questionnaires filled in by children, in which they reflected on their game project experience by selecting first a smiley (seven options) and then one or more adjectives (30 options) representing their feelings in the end of the project (see [50]). The interview data forms the primary data for this analysis, while the other data is used for triangulation purposes.
In the first phase of analysis, the interview videos were reviewed to get initial observations of children’s reflections on design and making related issues. Then, during the second round of analysis, the video data was reviewed again to more systematically collect and categorize information on design and making. The focus was on locating evidence on how children initially approached them. We identified in children’s talk descriptions of the work done and of their own role in that, likes and dislikes expressed, perceptions of own learning, expressions of future interest or the lack thereof, and descriptions of the progress of the project and relationships among the participants. First, individual analyses were carried out by authors separately, after which the data was combined to form an overall understanding. The data was abstracted to a table form for comparison. During this phase, the data was extensively discussed among the authors to ensure that the analysts agreed with the interpretations. This data was compared with the data from the questionnaires and field diaries to see whether they provided congruent or conflicting evidence [11]. In the last phase, the discourse lens was adopted and children’s descriptions were viewed as offering evidence of how they positioned themselves in relation to design and making and what kind of discourses they relied on in doing so (inspired by [26, 45, 56]). As a result, a set of subject positions the children adopted and a set of discourses within which the children approached design and making were identified. When writing this paper, the authors translated the quotations from the data from Finnish into English.

EMPIRICAL INSIGHTS

In the following, children’s experiences on design and making as expressed in the interviews are described, after which a number of positions and discourses within which children approached design and making are discussed.

Children's experiences on design and making

When describing their learning in the project, the children heavily emphasized certain tools and equipment: laser cutting was mentioned most often, while also Makey Makey and Touch Board were brought up by several children and 3D printing and 3D design were also mentioned by some. Additionally, a couple of children reported of learning programming, building/making or design. Interesting was also that some children mentioned imagination, inventiveness, group work and team spirit as something they had learned in the project.

As for longer-term impacts, around one third of the pupils considered this project to sparkle further interest in this type of work including design and making. However, many of them were very unclear or hesitant in their answers: “Well maybe a small [sparkle].” “Yes, I could do things again with Touch Board and Makey Makey.” “It was very nice but I’m not sure.” “Maybe a little, not that much.” Two thirds of them still reported in the second questionnaire that they had “learnt something useful” in the project. Two children particularly pointed out the value of this work for their future: “Yes, you can get inside university laboratories.” “Yes, I learned to program and it can be useful when I’m older.” One child pointed out an important issue as regards making and maker identity – he had learned that: “You can make games yourself, too, you don’t have to buy them.”

In addition to their learning, the children described more generally their experiences in the design and making project. Interestingly, many challenges were reported. Figuring out the idea for the own game spot was one of those. Either it was difficult in general, reaching a shared understanding was the problem, or figuring out an innovative, interesting idea was challenging: “When someone expressed an idea,
everyone had an own version of it, we were not talking about the same thing." "You know, it was kind of rally track type of [game spot]. ... You know, there was this controllable robot so that it was not kind of basic ... Well, we could have developed it some other way, it is kind of boring maybe, but ok." "We did not plan much, we just tried out... We didn't have any idea to begin with (laugh)." For some groups, however, that was not difficult. The field notes tell that some children had "a very clear idea" already in the first session.

In many accounts of the children, the importance of implementation with concrete materials was emphasized as helping to crystallize their idea: "In the beginning we could not figure out anything, finally we started inventing. At some point of time we did not know what we were doing, but it started to clarify then." "Finally [the shared understanding] emerged quite quickly as we had to make something." "Not probably in the beginning, but then when we started writing, not immediately, but when we managed to get to making the cardboard box we figured it out [the shared understanding]." In line with that, in her field notes one researcher tells how "it was great to see how things becoming concrete started to guide the working." Some children needed the Fab Lab visit before they were able to get to an agreement for what they were going to build: "I don't know, we did not have any kind of goals ... [The shared understanding emerged] kind of when we were in the Fab Lab." This was mostly due to this group’s difficulties in group work. The Fab Lab visit seemed to make the target more real for also these children and help their process.

The need of negotiation had also become obvious to many children: "Well (laughing), because we had so many disagreements, it kept on changing all the time, so that the outcome in the end was not in my mind the kind I would have wanted it to be." "It was kind of controversial, sometimes someone wanted to do something and someone else wanted to do something else ... I don't know, we somehow managed to make them talk to each other."

Another theme emphasized when discussing the working process was group work – mostly it was thanked, although some criticism also emerged, e.g., in relation to the continuous disagreements and all not contributing equally to group work: "[Relationships to other group members was] good, they were all from the same class and you could kind of ... Yes, you could more easily discuss and design [together]." "Good, we are all friends." "I am not going to say names but those did not take it seriously, they played all the time." One researcher tells in her notes how she "was ordering [certain children] continuously [and telling them that this kind of working is not effective]."

When asked about the nicest thing in the project, the Fab Lab visit was emphasized a lot. The children had enjoyed visiting university overall as well as seeing and experimenting with different kinds of interesting things in the Fab Lab (e.g. laser cutting, 3D printing, robots). Moreover, as mentioned, the Fab Lab visit was for some groups an important step in finally settling and concretizing the overall idea of what to build. One child also happily explained how he enjoyed the evolution of ideas that also the Fab Lab managed to generate: "[Working with the game] it was kind of exiting, it was all the time evolving ... And in the Fab Lab it was fun to do 3D printing ... [In the Fab Lab] we accomplished pretty much, we made the police there and then we gained ideas for the game, totally new ones, it was probably the funniest part [of the project]." "[The nicest thing in the project was that] we got to go to the Fab Lab to see all the things and then we got to do proper things [with the equipment]." "It [Fab Lab] was the main thing." "[The nicest thing in the project was] probably making that basket in the Fab Lab." The children had enjoyed our project also in general, as 28/31 children reported in the questionnaire that they had had "fun" or "great fun" and most of them described the project also as "interesting," "exciting," or "entertaining."

Positions and discourses as regards design and making
When examining the interview data, we were able to identify differences in children’s positioning in relation to design and making as well as different discourses they utilized when describing design and making.

As for the positions the children adopted in relation to design and making, we must note that some children did not position themselves in any particular way but they still were able to identify different phases of the project and their activities within the phases. They identified more abstract ‘design’ work and more concrete ‘making’ (i.e. implementation) work, to which both or either one they had contributed: "First there was this design on how to go on implementing it and when it was done, when it was finished, then the implementation, we started doing it and it took some time and then it was finished and then it [the resulting game] was played." "[I have] designed and after that implemented a little bit ... Mostly I made the labyrinth." "[We have] built it and figured out what we can do."

Interestingly, some of the children placed themselves or some other children in distinct positions as regards design and making (see Fig. 6). Some positioned themselves or some other child in their team as Inventors: in this role children were inventing what to design and make. They also emphasized the importance of imagination and invention as something significant that they learned during the work: "I have kind of invented things more and Will has been doing more implementation then." "You invented the whole idea [Carl]." "[I have learned] imagination and inventiveness."

Our field notes also identify a particular child who “was active in trying out ideas”.

While the inventor position was not that common among the children, one can say that an Implementer/Builder position clearly was. Implementation and building were mentioned by most of the children when describing the project and many of the children preferred especially the building part of the project: "[Nicest thing was] building and playing." “For me it was also the building.” This showed also in their working:
the field notes describe that for many children the practical building work was important and they were disappointed when they had to stop: “Peter was clearly annoyed [because the group was not able to finish their work in time].” “Girls were annoyed because the curtains [of the house] were left unfinished.” Building also enabled those children, who did not have a clear vision of what to do themselves, to contribute to group work: “Finally Matt started to cut pieces for the crosswalk.” In relation to building the game spots, furthermore, many of the children, when inquired about their own role and contribution in the project, instead of using any label associated with the building phase, still offered very concrete examples and answers that were very much implementation related: “At least I was making these questions with Tom.” “[I have been] gluing and cutting.” “I made this ramp and the box in which it was.” “Well I was kind of leading it, kind of told what is included and where.” She was among the ones complaining about the clowning in the group. The field notes also indicate that in some other groups there were leaders struggling with the same issue: “One boy is leading the process and is frustrated as others do not contribute but rather make fun [of everything].” In another, somewhat dysfunctional, group one of the boys “had a clear vision and he was furthering it” but the other group members did not value that but rather complained that “you always need to have it your way.”

Finally, there were pupils that seemed to position themselves merely as Pupils, without assuming any other role in the project. Both of the citations below emphasize the pupils merely ‘doing what was told’, the first one also seemingly aiming at the minimum performance: “[I have done] quite little work, but still enough.” “It was a pretty nice task to do as we were told to do it.”

We must conclude that even if positions of an Inventor, a Designer, and a Builder were adopted by the children, still no evidence on the emergence of identities of a Maker or a Designer in these children can be offered. Inventing, designing, and building were preferred activities by some children or some had, for some reason or the other, at least taken the responsibility of those activities. Then again, the children mostly offered very short answers to our questions and they did not show too much excitement on the project or the topics discussed. Hence, we do not see their answers as offering sufficient evidence of them considering themselves as competent or eager Designers or Makers (see e.g. [8, 10]).

As for design, however, we wish to point out that the children seemingly recognized many important characteristics of it: they saw it as a challenging social and conflictual process with varying interests and ideas. It involved constant negotiation and solving of fuzzy problems with ideas evolving and being negotiated among stakeholders, and the emergence of a shared understanding in a design team many times waiting until the concretization of the design ideas. This characterization comes interestingly close to the characterization of design in the research literature.

A noteworthy finding is also that for many, making appeared as a very concrete activity involving cutting, gluing, and assembling things, and describing it heavily relied on discussing many high-tech and low-tech tools, materials, and equipment such as scissors, glue, cardboard boxes, and Legos as well as laser cutters, 3D printers, Touch Board, Makey Makey, and programmable robots. Particularly for making, we must say that very concrete building activities and technological tools dominated in the answers, while we do not consider this to be enough of a sign of an emergence of a Maker identity yet.

All in all, based on the findings, we argue that among the participating children, at least four discourses on design and making emerged. The children were relying on them and producing them, sometimes also switching between them. The children positioned design and making as:
1) fancy tools and equipment (a Tool View) – evidenced by the children mostly listing tools and equipment when inquired about the project and their learning within,
2) an imaginative, creative invention process (an Invention View) – evidenced by the children emphasizing imagination, invention and creativity in their description of the project and its outcomes,
3) a conflict laden and fuzzy collaborative negotiation process (a Social and Political View) – evidenced by the children highlighting constant negotiation, conflicts and disagreements as characterizing their work, or
4) empowerment and agency to make your own tools (an Agency View) – evidenced by the children explicitly pointing this out as their learning or reporting on future interest on design and making.

In the end, we claim that our data indicates that some interest aroused in some children and we managed to offer some interesting takeaways probably to all of the children as regards design and making. Even if some children, especially those positioning themselves as Pupils or Clowns, may not necessarily think they themselves derived very much from the project, we argue that all the children gained something, particularly related to making. First, they were all exposed to a possibility to create something for their own use by themselves, not needing to buy that, and starting from an idea of their own. Second, they were exposed to the experience of collaborative development and implementation of ideas and objects, utilizing very advanced equipment and machinery as well as more mundane tools.

**CONCLUDING DISCUSSION**

**Summary of the results**

In this study, we wanted to understand what happens when children initially encounter design and making in educational context. In the spirit of genuine participation of children [24], we were particularly interested in examining the variety of ways by which children approach design and making and develop a meaningful relationship to those when they encounter this type of activities for the first time. We see this as valuable information in supporting different try-outs of design and making projects. We utilized the study by livari and colleagues [26] as our analytical lens. We identified six positions (a Designer, a Pupil, a Clown, an Inventor, a Leader, a Builder) the children had adopted in their design and making project as well as four discourses within which they approached design and making (a Tool View, an Invention View, a Social and Political View, an Agency View). Some of the children adopted different positions and discourses during one and only interview (in line with [26]).

We maintain, however, that none of the children developed a Maker or a Designer identity during the project, and we think it would have been quite unrealistic to even expect that to happen, considering the timespan and activities involved. Then again, we maintain that potential and varying kinds of seeds for the emergence of such identities were identifiable among the children. Further nurturing of these seeds is definitely needed, albeit this study also argues that such seeds need to be seen as a valuable outcome as such.

**Implications of the study**

Based on the results, we can point out several interesting implications for the CCI research community. As we argue there did not emerge Designer or Maker identities among the participating children, it is yet too early to propose guidelines on such identity development. However, we can still pinpoint a number of interesting lessons learned that may be valuable in the pursuit of such identity development.

**Children make their own interpretations.** First of all, we wish to note (in line with [26]) that with one and only task assignment, one may end up with very different outcomes. Children, and people in general, approach tasks with their backpack full of skills, knowledge, preferences, and attitudes and based on those develop a relationship to the task. In our case, divergent aspects of design and making became enunciated in children’s talk: some highlighted the tools and equipment used, some the social and conflictual negotiation process, others the creative invention process. This needs to be acknowledged in CCI research offering children design and making experiences and education. We emphasize that no matter how well planned and executed, the children will interpret and accomplish the design and making activities in their own ways – shaped by various kinds of issues such as their previous experiences, assumptions and preferences and by their relationships with other participants present in situ or more distantly shaping the social action in the background [18, 26, 38, 39, 45]. We also show how varying positions to design and making the children adopted in the project. This should be kept in mind by CCI researchers wishing to educate children in design and making: they should prepare for the emergence of different positions as well as appreciate the emergence of them and examine them in depth. Then again, we acknowledge that it might also be valuable to try to guide children better in the adoption of the positions and discourses (inspired by [26]). For example, we may see the Tool View of making as undesirable or the position of a Pupil or a Clown as hindering the progress of the project, or we may just wish that each child reflects on his or her dispositions and preferences to be able to find the most meaningful position within a project (cf. [25, 26] about children adopting different positions in design and research processes). In such a situation, the variety of positions could be openly discussed with children before the project starts. Despite this guidance, we wish to emphasize the uncontrollable nature of the adoption of the positions and discourses. Even if seen as valuable or highly desirable, it will never be entirely under our control.

**Designer and Maker identities and genuine participation of children.** For the current making research targeting children, we report a case in which design was integrated with making (in line with e.g. [3, 31, 46]) and we had a novel approach considering children’s development and learning from the perspective of a Designer identity, too. We argue
that the development of a Designer identity should be on the agenda in CCI research together with the development of a Maker identity. We think Designer identity necessitates children to see themselves as members of designer community and culture that values creativity, innovation, exploration, sense-making, wicked problem solving, iteration, and reflection [5, 8, 31, 36, 37, 46], to believe in their abilities in this kind of design work as well as to have motivation and interest in engaging in such work (see [8, 10]). The same goes for the Maker identity, in which case the children should view themselves as members of maker community and culture that values technological competence, making, sharing, giving, learning, own interest and initiative, and collaboration (see e.g. [5, 12, 22]), to believe in their abilities in making as well as to have motivation and interest in engaging in it (see [8, 10]). In our case, we can say that for some children, motivation and pleasure was aroused as regards design and making, yet the project offered quite limited possibilities to competence building and development of self-efficacy regarding design and making. Particularly we see the project as limited in offering children skills in technology making – even if building things with various kinds of materials was emphasized and enjoyed by the children.

Moreover, we see many challenges as regards children starting to identify themselves a designer or maker community members. Even if we did not succeed in arousing this type of identity building in children, we see an interesting connection between our long-term aim for increasing genuine participation of children in technology design [24] and identity making: Genuine participation of children actually requires children to see themselves as competent members of design and making communities. This expected personal and social growth and development of the children aligns well with the identity requirements of self-efficacy, motivation, and interest [8]. However, the transformation from the role and identity of a school child to the role and identity of a Maker or a Designer, i.e., a member of those communities, is not easy in the educational context [10, 24]. The children in this particular case were busily making and building as well as innovating and designing something new and it seems that the seeds for identity making may be relatively easily sown in these learning experiences in educational context. We think, however, that in order to support identity making better, we also need more purposeful efforts to connect these seeds to the roles and identities within design and making and bringing something new and it seems that the seeds for identity making may be relatively easily sown in these learning experiences in educational context. We think, however, that in order to support identity making better, we also need more purposeful efforts to connect these seeds to the roles and identities within design and making and communities. The seeds need to be nurtured with continuing, perhaps more voluntary efforts of social engagement increasing children’s self-efficacy, self-identification, and sense of belonging (see also [8, 10]). We believe that by integrating the aspects of genuine participation and PD into design and making projects this potential growth and development more likely happens.

Although we conclude that the involved children did not adopt Designer or Maker identities in the project, they gained something valuable. Our results show that within this type of educational context it is possible, at least to an extent, to make it visible to the participating children and teachers what is involved in design and making practices, the connection between these two, and some of the challenges involved in them. The participants become familiar with some of the tools and materials and they built initial skills and competencies needed within these practices.

More generally we need to consider and settle what kind of identities we want children to adopt and develop as regards technology. Should they be empowered to adopt the role of a Protagonist to shape technology development and critically reflect on the role of technology in their practices (see e.g. [29, 33]) or should they settle with User, Informant, and Evaluator roles? In the longer timespan, we think that the development of Designer and Maker identities in children should be the target of our work. This necessitates offering children longer-term experiences in design and making and thorough integration of them into the curriculum (in line with [7, 10]). While in many places this has not yet happened, one still needs to start somewhere. This paper describes one case on how to do that.

School as a context for making activities. As for the work in the context of school, we see definite benefits in entering and engaging with children in schools (in line with [6, 7, 9, 10, 24, 47]). Schools and teachers excel in the education of children and they may be knowledgeable in critical and constructivist educational approaches [5, 27, 31, 49] as well as in practice based, experimental, unstructured, self-directed, collaborative and design based learning, learning by doing and learning by making [1, 2, 3, 5, 8, 27, 31, 41, 54]. They should be seen as valuable partners in our quest of educating children in design and making.

Moreover, if expertise in design and making is considered valuable for the future generation, schools are an excellent setting to reach a larger number of children. In schools their engagement is not dependent on their own or their parents’ interest, but everyone in a class gets a chance to try such activities and form opinions on them. We think that good results can be gained when making is thoroughly integrated in schoolwork and existing curriculum (see [3, 7, 9, 10, 46]). However, we also argue that even short-term projects, where working-time with children is only a couple of hours, days or weeks, are important in sowing a seed of thought in the children’s minds; most likely we all can remember significant events in our lives that caused us to choose some path for our future. If even a couple of children recognize the importance of their own agency as regards technology and develop their imagination and inventive skills and competencies, we think that the projects are worth the effort.

For researchers and educators aiming at integrating design and making into children’s education, we emphasize the following aspects: Such work can be initiated with smaller projects involving a couple of months and for example an elective class that does not have very strict learning goals and
teacher thus have more freedom in the classes. Regardless of
the type of a class, teachers are still responsible of children’s
learning and hence it is critical to cooperate with teachers so
that children’s learning goals are addressed in the project.
Teachers can, for example, be invited into the steering or
advisory group of the project to cater for learning related
aspects. It is also essential to have teachers present in the
classrooms to cater for many practical issues such as dividing
children into groups and ensuring order in the classroom.

In addition, we see working in a cross-subject mode valuable
regardless of the size of the project – even if that was not
required in the local curriculum. In different subjects such as
arts, crafts, languages, and mathematics useful design and
making related activities are accomplished and may be
already included in the curriculum, too. Arts and crafts
classes are well in line with a creative (game) design process,
while mathematics might include children’s technology
education as one component. In our earlier projects (see e.g.
[24]) (native, foreign) language classes have aligned very
well with our game design projects through the concepts of
new and multi-literacies and children’s development and
learning as regards them. Overall, we wish to point out that
there are valuable things already happening in schools and
we should appreciate and build on that rather than try to offer
alternative solutions; children develop valuable design and
making related skills and competencies already in their
classes on various subjects (e.g. group work skills, artistic
skills, possibly also making skills). Despite that, also our
effort is definitely needed: design and technology education
in schools – in Finland as well as elsewhere – is all but
perfect and teacher education is quite limited as regards it.

We acknowledge that schools have certain limitations as a
site of making (see also [24]). We agree with Chu and
colleagues [10: 111] on: “The difficulty that formal school
contexts add is at least two-fold: first, the characteristics of
Making and of the Maker tend to be counter to schooling
cultures and frameworks, and second, in the classroom the
goal of the teacher is to teach about the specific topic or
subject matter of the class (science, language arts, history,
etc.). What then is the role of Making in such contexts, and
by which pathways may a Maker identity be fostered?” An
important element in making are own initiative, interest and
ideas [31, 41, 42]. In school context, however, children
seldom can entirely freely choose whether they participate in
the activities or not, or decide the topics of their projects. In
voluntary settings, children’s participation in making
activities is based on their intrinsic motivation; in school
context, that is not always the case [28]. Hence, when we
introduce design and making projects into schools we need
to consider why we are aiming for that – what are the values
that drive us in this endeavor? We recommend the ideals of
genuine participation of children to be acknowledged also in
the school context – as much as possible [24]. In addition,
we need to consider the context and its effects more
profoundly: if we want to bring designerly thinking and
making into a context where they do not naturally fit, we
need to consider how to do it in a culturally appropriate way.

CONCLUSION
We reveal in this study findings from a case where 10-12-
year-old children gained initial experiences in design and
making activities within an elective mathematics class as part
of their primary school education. We show that children
adopted multiple subject positions and relied on various
kinds of discourses when describing their experiences. The
data shows that the children developed a meaningful
relationship to design and making and we argue that this is a
valuable outcome per se.

Our project started with a design phase. We argue (in line
with [3, 31, 46]) that making is indeed valuable, but should
be combined with designerly thinking. For research
interested in supporting the emergence of Designer and
Maker identities in children (e.g. [8, 9, 10, 35]), we wish to
point out that there are still open questions as regards what is
in the core of a Maker and a Designer identity. Can and
should these be combined or rather children let to adopt and
appropriate one or the other based on their tendencies and
interest? These questions need to be contemplated on before
we can take this idea to different cultural contexts. We also
think that making and design should be integrated with
schoolwork, as is argued by many (e.g. [3, 5, 10, 24]), while
we call for future studies on cultural differences and on
culturally sensitive design and making projects.

The current results show how children construct design and
making in their interview talk. More detailed and
sophisticated study on the facets shaping children’s design
and making activities, perceptions and experiences is
warranted. For the future analysis of the Designer and Maker
identities and their emergence, we point out that although
these projects and associated experiences on design and
making play a central role in learning, we cannot draw
conclusions related to “identity making” based on interviews
only. Instead, we suggest richer empirical data for making
sense of emerging identity considerations and social
engagement (see [26]). Armed with this, a deeper
understanding of identity making in this type of educational
intervention could be reached. Such identity making needs to
be seen as heavily shaped by children’s own background and
experiences, by other participants and interaction with them,

as well as by varying kinds of discourses produced and
reproduced both in situ and in the society [18, 21, 26, 39].
Studies on longer-term effects are also needed: currently we
do not know whether any lasting marks were left, even if we
know that some of the children said they were interested in
continuing with the topic.

SELECTION AND PARTICIPATION OF CHILDREN
The 38 participating children were selected by locating a
volunteering teacher who was willing to experiment with a
design and making project as part of her teaching. She
indicated two classes of children to work with: the 5th and 6th
grader classes taking an elective mathematics class the
teacher was responsible of. There were 20 5th graders (18 boys, 2 girls, aged 10-11) and 18 6th graders (16 boys, 2 girls, aged 11-12) involved. The children and their guardians both gave informed consent to take part in the study. They received an informed consent form giving information on the research and asking whether the children were willing and whether the guardians allowed the participation of the children in the study.

REFERENCES


