Empowering Children through Design and Making: towards Protagonist Role Adoption

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ABSTRACT

Inviting [1] children to adopt a Protagonist role regarding technology has recently become advocated. Such a role embraces the original political participatory design (PD) agenda and aims at empowerment of children through design and making. However, so far the literature is limited in exploring the adoption of this role by children. While studies have reported experiences of engaging children in design and making activities, in-depth inquiries on children's experiences and challenges involved are lacking. We also maintain that the PD community has so far neglected education of children – in participation, design and technology – as our task and duty. This study reports findings from a design and making project aiming at empowerment of children, carried out in school context. We show that adopting the Protagonist role is not easy and there is a lot of variety between children. We present children's experiences and reflect on the challenges involved in progressing towards Protagonist role adoption.

CCS CONCEPTS

CCS → Human-centered computing → Human computer interaction (HCI) → Empirical studies in HCI.

KEYWORDS

Making, children, design, empowerment, materiality, participation

1 INTRODUCTION

The idea of empowerment of users, or more specifically workers, in technology design originates from the Scandinavian tradition of systems design and is in the core of participatory design (PD). During the past years PD has entered significantly different design contexts compared to the early days, when computer systems were designed for workers and the workplace (see e.g. [1-3]). Nowadays technologies are created for and by people representing very different age groups and life situations, varying from children to senior citizens, neighborhoods and various kinds of communities that pose new challenges for PD (e.g. [4-9]). Empowerment of users is still a concern in the current PD literature, even if the design contexts and goals differ from the early days (e.g. [10-14]).

In this paper, we focus on the user group of children and the context of school. Our standpoint, in line with [15], is that learning and competence development are powerful tools for empowerment. Children should be provided skills, competencies, and agency to manage and master in the future technology-rich everyday life. The society around us is digitalizing at a fast pace and it is ever more important for the citizens to be not only competent technology users but also to have skills to shape and make technology as well as to feel empowered to use those skills [15]. Schools today are increasingly integrating technology into teaching and countries are integrating programming and other Science, Technology, Engineering and Mathematics (STEM) subjects into their national curricula [16-18], but there are multiple challenges involved, and schools and teachers are seriously in need for help [19-22]. Additionally, we see that in STEM education important PD topics remain unattended: engineering, programming, and technology are foregrounded, whereas creative design remains less acknowledged [5, 23-25] as well as the original PD concerns such as democracy, power, politics, and agency.

We see as our task and duty as well as the entire PD community's task and duty to enter the context of school – the institute for democratization – and empower children by educating them about participation, design, and technology. This is well in line with the enduring democratic value orientation of Scandinavian PD as well as with the aims of the first PD projects where a 'knowledge base' of technology-related skills to draw on was seen as central for workers and their organizations to be able to contribute to systems design [4, 26-28]. Now, as designing and making digital technology are possible for anybody due to the developments in physical computing, digital production and personal manufacturing technologies (e.g. [5, 24, 29]), it is even more important to provide those skills democratically to all, to prevent the digital divide.

The PD community has already acknowledged that children

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are a participant group among others who should be allowed to take part and have a say when technology is designed for them (e.g., [30-36]). Participatory design and children is a topic extensively addressed also within the Interaction Design and Children (IDC) community, where the early work by Druin (e.g., [8]), heavily inspired by PD, has been very influential basis. The original PD values have been called for in the IDC community also more recently (e.g. [37, 38]) similarly as in PD community [4]. Many IDC researchers also apply PD in their participative studies in the school context and e.g. ponder how to set learning goals for PD activities in school [39]. However, this does not equal children's empowerment through learning during and about the PD process, as discussed in [40] and [41], which is the general interest in this study. Therefore, we argue that PD literature is limited in acknowledging the importance of educating – that is, empowering – children early on in issues that lie in the very heart of PD agenda, i.e., participation, design, and technology.

Very interesting recent work addresses this topic and introduces a new role we should offer children as regards technology: the Protagonist role, in which children are empowered to shape technology development and critically reflect on the role of technology in their practices [41]. Adoption of the Protagonist role has been aimed at through engaging children in creative design and making activities [41]. In line with this, we see a lot of potential in the maker movement with the associated maker mindset, maker spaces, and Fab Labs in children's education and empowerment. Maker movement brings to the table concrete building of technology that involves material activities and outcomes (e.g. [42, 43]). In the IDC community, children's participation in making activities has been addressed quite extensively already (e.g. International Journal of Child Computer Interaction vol. 5). The maker movement has also become embraced in the PD community as an exciting site and educational resource for participation, design, and empowerment [10, 14, 44].

However, there is a lack of research on empowerment of children in and through making and on the associated Protagonist role adoption of children. So far, only one article addresses the Protagonist role and we feel that a more structured approach to the characteristics of the Protagonist role would be valuable. Moreover, to our knowledge, there are no studies on the adoption of the Protagonist role by children from the perspective of children themselves: there is a lack of studies addressing how children approach and experience such an empowering endeavor that entails creative design and making activities, as well as utilizes the power of materiality – a particular characteristic of making (e.g. [42, 43]). Thus, this study addresses the following research question: *how do children experience adoption of the Protagonist role in educational settings when they are engaged in a creative maker activity that utilizes the power of materiality?*

The structure of the paper is as follows. Next section introduces related research on empowerment of people through design and making – addressing both adults and children. Section three discusses the project involved in this study as well as the procedures of data collection and analysis. The fourth section discusses the empirical insights, the fifth section outlines their implications and the sixth section concludes the paper.

2 EMPOWERMENT THROUGH DESIGN AND MAKING

As there so far is only one article [41] addressing the Protagonist role adoption of children, this section will scrutinize related studies that address more generally empowerment of people, including children, through design and making

2.1 Addressing Adults

The maker movement emphasizes that making is an integral element in being a human. We all make physical things; human beings have made such thorough our existence. However, the more recent maker movement has started to flourish through the emergence of cutting edge computing and manufacturing technologies available for people (e.g. digital fabrication and physical computing technology). The maker movement is strongly connected with democratizing innovation: it relies on the technological competence of ordinary people as they innovate, design, engineer, and program by themselves and make use of cutting edge design and construction technology that nowadays is available for them. They are empowered to build, craft, and make technologies for themselves, not only use them. Making is about creation of (digitally enhanced) physical objects – hence, materiality is strongly integrated with making. Making of personally meaningful objects and tools is highlighted; makers are often enthusiasts or hobbyists, passion being strongly connected with making. A communal aspect is also strongly connected: makers collaborate and share their work with the like-minded, benefitting from others help and insights. Maker movement builds on open source software and hardware, and hacker and Do-It-Yourself movements (see e.g. [5, 24, 29, 42, 43, 45]).

From PD viewpoint, there seems to be quite strong engineering orientation in the maker movement. The movement does not specifically address participation or design, while it emphasizes the empowerment of maker to build and craft personally meaningful objects for their own use as well as for the use of others. When acting as a maker, design may be intimately intertwined with making, but no explicit emphasis is placed on (creative) design (cf. [46, 47]). In the literature on making, there does not seem to be discussion on design – as a reflexive practice, a problem-solving activity that involves creativity, exploration, reflection, sense-making, wicked problem solving, iteration, improvisation and making sense of things [23, 25, 48]. Even if the maker is creating choices (cf. [6]), it seems that no particular attention is put on generating many alternatives or brainstorming. Moreover, while the maker is certainly selecting a choice and concretizing it (cf. [6]), evaluating the results of a choice is again less emphasized (cf. [6]): The maker is using the tools they have themselves made and experiencing the consequences of their choices, but no emphasis seems to be on reflection on this matter.

As for empowerment, one can say that the maker is empowered with technology in the mainstream, functional empowerment sense [49], i.e., the makers are empowered to develop useful tools by themselves for themselves (see also [15]), while also the critical research tradition and the critical notion of empowerment can be connected with making: critical making aims at more power for the oppressed as well as at challenging the oppressing conditions of status quo and the taken-for-granted assumptions (e.g. [50, 51]).

As for the adoption of the Protagonist role, one can claim that the maker movement seems to encourage people to take a strong role in shaping technology development: the maker is seen as an active agent and Protagonist, not a participant in an activity defined, owned, or initiated by someone else. However, in the maker movement, there seems to be less emphasis on encouraging people to critically reflect on technologies as part of their everyday life and practices. Moreover, from the perspective of PD tradition, engineering aspects may picture too strongly, while creative design and reflection have received little attention.

2.2 Addressing Children

There has been an extensive interest in involving children in technology design in the IDC research community. During the early days, the focus was on children as users of technologies, while later the focus moved to involving children in the design process as testers, informants and design partners, consequently [9]. Especially Druin's work, advocating the design partner model, has been influential and widely cited within the field, explicitly relying and deriving inspiration from the PD tradition.

Children's empowerment in technology design has been a prominent topic and goal in IDC studies, too. Children's participation in the design process has been seen as one way to empower them [15, 41], as 'giving children a voice in the design' and 'empowering children as co-developers' [52]. Lately, calls for following the original Scandinavian values when working with children have appeared [37, 38, 53]. Researchers argue for genuine participation of children, where children actually have power of decision and influence, contrasting that with tokenistic and decorative forms of participation [40, 54]. For the genuine participation to emerge, the application of Scandinavian values in the design process is emphasized [38]. Along these lines, also the Protagonist role for children is identified and advocated [41].

Making has been seen as a powerful tool for empowerment of children and, when integrated into children's education, it can help in combatting the digital divide (e.g. [55]). It is argued that technology has such an important impact on society that it is pivotal to provide children understanding of it [23, 25, 56]; technology can even be seen as an emancipatory tool [5]. In the field of education, there has been an extensive interest in the topic. Making is seen to arouse children's interest in STEM subjects and to give them the desperately needed 21st century skills and competencies [23, 56, 57]. Children's personal growth and learning are essential: maker mindset or identity is to be nurtured rather than a set of skills [24, 58, 59].

Children's making activities can also be critically scrutinized from the perspective of their empowerment. Children's possibility to act as decision makers in their making projects and their graduated development of competence are in line with the empowerment ideals (see e.g. [5, 24, 56-59]): children's skills and competences are to be nurtured and children are to be prepared also for the future, giving them skills, knowledge, and facilities to continue the work by themselves. However, also problems can be identified in children's making projects: power differences between adults and children have not been acknowledged in all projects – adults may have been in too influential positions in children's making activities [55]. Studies on making with children can also be criticized for their too narrow focus on the needed skills, lacking focus on design, learning, and development of a maker mindset or identity [24, 55, 58, 59]. The need of adopting a broader designerly approach to problems has also been brought forth in the studies [23, 25, 48].

Different forms of empowerment have been identified when working with children and technology. Kinnula and colleagues [15] offer a thorough review of different views and traditions that can be associated with the concept and identify five different forms of empowerment: critical, mainstream, functional, democratic, and empowerment as learning and competence development. As for children's empowerment, one can argue that functional empowerment [49] seems to be emphasized in making; children are empowered to develop useful tools by themselves for themselves. Their empowerment in the sense of competence development [15] seems also to be highlighted. However, the critical research tradition and the critical view of empowerment seem to be neglected in the work addressing children.

To summarize, as for the adoption of the Protagonist role by children, the maker movement seems to encourage children to take a strong role in shaping technology development, while the movement seems to neglect critical reflection on the role of technology in children's everyday life. In children's education, creative design seems nevertheless to be integrated with making activities – at least in some studies. However, in this literature base the empowerment of children in the sense of critical tradition seems still to be neglected, even if empowerment of children in a more mainstream sense is otherwise discussed a lot. Overall, as the Protagonist role has very recently been introduced into the literature, there still is a lack of studies examining it – particularly from the perspective of children themselves or the challenges involved in such a role adoption.

2.3 Analytic Lens

The extant literature informs us on the importance of empowerment of children through design and making as a contemporary phenomenon, potentially democratizing innovation and renewing children's education. However, there are several distinctions related to empowerment of children through design and making that have not yet been thoroughly addressed in the literature. Our initial data analysis and the review indicated the following perspectives and distinctions as useful:

Regarding participation, children can take part in technology

development in a number of **roles**: as users, informants, evaluators, design partners, designers, makers and/or Protagonists (e.g. [9, 41]). For the Protagonist role, children should become main agents driving the design process and learn to critically reflect on technologies and their role in their lives. Children should carry out a complete design process with process and product reflection as integral parts of it. This should result in children gaining "new insights into design and digital technology and reflective stance toward technology in their life." [41: 30]

Creative **design** and **making** activities are recommended for the purpose. Design is to be approached as a reflexive problem-solving activity involving creativity, exploration, reflection, sense-making, wicked problem solving, iteration, improvisation, and making sense of things [46, 47] as well as to entail creating choices, selecting among them, concretizing them, and evaluating the consequences of them [6]. Concretizing the choices and associated materiality is particularly linked with making – i.e., making of material things, engaging with material objects. Materiality, then again, is strongly linked with creativity. Jacucci and Wagner [60] argue that materiality contributes to creativity by expanding communicative resources, providing resources for action and purely by being part of performative action. Kinnula and colleagues [61], by relying on Vygotsky, maintain that our ideas are based on elements taken from reality and previous experiences, and that ideas need to be externally embodied and shared in material form to generate further creativity [61]. Following Schön, they also underlie the importance of materials in situ as triggering creativity – previous experiences and familiarity with the materials contributing to this, too [61].

As for **empowerment**, the main goal to be aimed at with children, important is to acknowledge that different forms can be identified. Many times the concept is used in a self-explanatory way without any reflection on it. Kinnula and colleagues carried out a critical review on the concept and identified critical, mainstream, functional, democratic, and learning and competence development views on empowerment [15]. The mainstream form emphasizes giving some power of decision to the power-weak, whereas the critical form sees this as insufficient and instead emphasizes the oppressed combating the oppressors and gaining more power this way [62]. The functional view of empowerment sees empowerment as improvement of life conditions of people while maintaining the status quo, e.g., through development of better tools for people to use, whereas the democratic view emphasizes people's ability to affect decisions concerning their life [49]. Finally, empowerment as learning and competence development emphasizes giving people skills and competencies that enable people to flourish and control their destinies [15].

These conceptual tools and distinctions will be used when making sense of children's initial experiences when they were offered the Protagonist role as regards technology. Some successes were identifiable, but also clear shortcomings emerged.

3 METHODS

Our research group has worked with the topic of participatory design with children for a decade already. An overall aim of the work has been to empower children through design: to offer children useful skills and competencies to master in the increasingly digitalized world. Much of the work has been conducted in the context of school with the aim of educating children in design and technology. Recently, maker movement has inspired our work a lot, and we have integrated the Fab Lab of our University into our work. This paper reports on one of such projects: a research and development project we carried out with our Master's students in collaboration with a local school. One important goal of the project was to offer children programming education that we wanted to combine with education on design and making. In Finland, programming has recently been added as a compulsory part of curriculum of basic education. Therefore, teachers and schools are very interested in help in integrating programming into education, and we utilized this opportunity to introduce also design and making to children. As empowerment of children and their genuine participation have been the goals of our work for many years already, children's agency and impact, their competence building, and their invitation to project evaluation and reflection featured strong in our project (see also [63]). PD methods and tools were also essential in children's design and making activities. After the project ended, we recognized a lot of similarities between our work and the Protagonist role introduced in the literature [41]. Hence, in this particular paper we decided to reflect on our successes and failures as regards the Protagonist role adoption by children, and particularly introduce the perspective of children into the discussion.

Two classes of children took part in the project that was conducted in the context of an elective mathematics class. The teacher for that class volunteered for the project in a Fab Lab presentation event. There were 20 fifth graders (aged 10-11, 18 boys and 2 girls) and 18 sixth graders (aged 11-12, 16 boys and 2 girls) involved in the project. In addition, four Master's students (2 female and 2 male) in the final phase of their studies participated in the project. They worked independently as a group and each of them spent ca. 260 hours for the project autumn 2016. The students were majoring in a combination of software engineering, information systems, and human-computer interaction. There were three senior researchers and the teacher in the steering group for the project. The researchers made the initial plans for the project and the steering group guided the students' work further during the project and made major decisions. Particularly guidance was given in relation to how to work with children, including design and making with children.

The project idea was to create by both classes an interactive board game with multiple game spots. The participating classes were divided into groups of 4-5 children and each group was supposed to ideate, design, and implement one game spot. The game spot was to include problem solving and utilize the Fab Lab facility. The whole game was supposed to include programming as well. The children had a possibility to use many playful tools in their game spots including robots, Legos, and MakeyMakey.

The game spot was built inside a cardboard box (see Fig. 1).

During the 11 weeks of project work, the two classes both had separately: 1) an introductory meeting with discussion and a survey on children's current interests and expertise, 2) a meeting introducing technology development process to the children, 3) two design sessions, 4) five making sessions including two sessions in school crafts facilities, a Fab Lab visit, and a finalizing session. In the end of each session children were asked to write down what they had achieved and learned in the session.

After that, the Master's students created the 'board' for the game on the floor of the school library and each class played their game in separate sessions. Children moved between game spots by programming a robot to follow the 'track' on the floor from one game spot to another (Fig. 1). After playing, the children evaluated the game spots giving constructive feedback and improvement ideas for each of them. Finally, they filled in a feedback questionnaire and took part in interviews either in pairs or in groups of three.

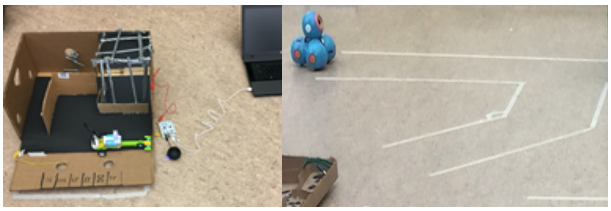

Figure 1: Left - one of the game spots; Right - the programmable robot and the gaming board on the floor, leading to a game spot.

Research material collected of the project includes videos of all the workshops with children, children's design and making related material and field notes, project management related data, field notes and reports from researchers, videos of the interviews, and two sets of questionnaires filled in by the children. In the first questionnaire, the children were asked about their previous interests and experiences related to information technology, gaming and programming. In the second questionnaire, there were smileys (seven options) and one or more adjectives (30 options) for describing their feelings in the end. The interview themes were: What did they do in the project and how they experienced the project work; what kind of roles they had; interaction between group members; the project and the end result – goals and own possibility to affect; most challenging and nicest things; what they achieved and learned; and significance for own future.

Noteworthy is that even if our general aim has been empowerment of children through design and making, we did not originally have an explicit aim of introducing the Protagonist role to children. However, we recognized during our data driven, iterative data analysis that our work included a lot of elements needed for introducing this role to children: children were invited to shape technology development as well as to critically reflect on that technology in their practices, combined with our general aim of empowering children to master in their digitalized everyday life (cf. [41]). However, it was obvious that our project included also shortcomings in the Protagonist role adoption among children. We wanted to appreciate both successes and failures in our work and analyzed the data from both perspectives. The primary research material utilized in this study are the group interviews, as this study focused on how children experienced and interpreted our endeavor and the Protagonist role adoption.

During our data driven analysis process, we first reviewed the interview data to get first observations of children's reflections on design and making related issues. Based on those findings, we created our analytic lens to be used as a sensitizing device in the second round of analysis where the focus was on locating evidence on how children approached the work as regards participation (particularly roles of children), design, making and materiality, and empowerment. A lengthy table that included all relevant statements from the data was created, using the four main categories with sub categories. Finally, the characteristics of the Protagonist role were utilized to make sense of our data. The findings were extensively discussed among the authors to form a shared understanding.

4 FINDINGS

4.1 Experiencing Different Roles

In our project, children participated in various roles: they acted as players of the game, i.e., as users of technology, as well as inventors, designers, makers, and evaluators of the game. In a certain sense, they acted as Protagonists, too. This section inquires children's own perceptions and experiences on the roles.

As for the role of players, all children took part in playing the game in the end, whereas in their interviews, only some of them reflected upon it in any way. In these cases, the children brought up playing the game as the most enjoyable part of the project: "[*The most enjoyable thing in the project was] that playing [the games in the play session].*" Even if this is a nice outcome as such, this is unfortunate from the perspective of Protagonist role adoption [41]: most children did not even mention playing the game and those who did, merely stated it was enjoyable – there was a lack of critical reflection on technology within their practices. In the interviews, however, when discussing the process and children's satisfaction with the outcome, some critical reflection emerged. We will return to this in the following section.

As for the Protagonist role adoption, the aspect of children taking a stronger role in shaping technology development [41] was more visible in our data. In their interviews, some children went through the different phases of the project, in which they had acted in different roles, i.e., as designers, makers, and players of the game – showing variety in the roles they had adopted in the project: "*First was that designing, for how to start implementing [a game spot] and then after we had done that, when it was ready, then [came] the implementation [phase], we started to do it and it took some time and then we finalized it and then we played it [the game].*" "*First we designed it and pondered what the*

story could be like and then we started to implement it, handcrafting."

As for design, some children had clearly adopted a designer role in the project and/or they reported specifically enjoying this role: "*Designing was fun.*" "*Arthur's [responsibility] was kind of design of everything.*" "*Well I also kinda designed it.*" However, many challenges were also brought up relating to design, to which we will return in the following section.

As for making, for many children very practical making activities were emphasized in the project: many brought them up as their main activities in the project and/or saw them as the most enjoyable activities. "*I [worked with] that ramp and the box.*" *"I crafted our platform for that, [my role was to] glue and cut.*" "*I painted the basket to look good.*" *"[I liked most] making that basket, there in the fab lab.*" *"[The nicest thing was] when we had to build it.*" Many brought up art and craft activities in the classroom, but many also emphasized the Fab Lab as a site where things were really accomplished and where they enjoyed working: "*It [Fab Lab] was quite nice, we got quite a lot [of work] done, that robot thing was quite funny ... we needed to create those parts... with those 3D printers and with that other printer and then with the one used for making the wooden things [a laser cutter].*" "*It was nice to do 3D printing in the Fab Lab.*" "*We got quite a lot of work done there, that police was created there.*"

Interestingly, in addition to the roles discussed above, there also seemed to be some pupils who saw their role to be an inventor: "*I have more like invented things more and Franz has implemented things more.*" "*Little bit of that inventing, you know, [I have] needed to fetch those things from different places ... been inventing with the others [other group members].*" "[*Saying to another group member] you were the one who invented the whole idea [of the game spot].*" Some children saw their role to be inventor, while many pointed out challenges in inventing what to build: "*The most challenging thing was [to get] the idea, [to invent] what we'd do.*"

As for the evaluator role, the game playing session ended up in the pupils reflecting upon the game spots and giving constructive feedback to other groups. However, the children did not consider this as evaluation or testing and none of them even mentioned this activity in the interviews. Only one group of pupils even used the term, when mentioning there was a lack of testing. When asked whether the final game was what they had had in their minds they told us: Tom: "*No, it wasn't.*" Andrew: "*Well no.*" Tom: "*Because it didn't work, we didn't have time to test it properly.*" These findings can be connected with our earlier finding on the children not critically reflecting on the role of technology in their practices – the evaluation session in the end of playing session clearly was not enough for children to arouse this. In addition to the children not reflecting much on the outcome, the children did not reflect much on the process either [41]. Even if they were asked to reflect on their work process and learning after each design and making session, the children were quite reluctant to do so. Their notes were very short, if written at all.

Overall, we must admit that we do not see the children fully adopting the role of Protagonist in our project. However, some children took quite dominating positions in their teams, leading the work: "*Well I was kind of leading it, kind of told what is included and where.*" Moreover, quite many children were heavily shaping the development of this particular game and in this sense adopting the Protagonist role in a certain, yet limited, sense.

4.2 Experiencing Design

In this section, we delve into how children perceived and reported on (creative) design in their interviews. As mentioned, many children mentioned design as part of their project, some children had adopted particularly a designer role in the project and some reported specifically enjoying this role. However, relating to design, the children reported also many challenges.

Some children highlighted creativity and invention when they talked about the process and outcome of the project, but they did so mostly from the perspective of how challenging those were to achieve: "*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 ... We could have developed it some other way, it is kind of boring maybe, but ok.*" "*We didn't plan much, we just tried out... We didn't have any idea to begin with (laugh).*" "*In the beginning we could not figure out anything.*" Hence, at least for a couple of children creativity and invention were considered significant in this work and they critically commented on the outcome from that perspective.

It had also become clear for some children that design necessitated a lot of negotiation, even if they reported of truly enjoying group work: "*When someone expressed an idea, everyone had an own version of it, we were not talking about the same thing.*" "*It was kind of controversial, sometimes someone wanted to do something and someone else wanted to do something else.*" "*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.*" Some children here also critically reflected on the outcome: it was not like they would have wanted it to be.

Iterative design became also emphasized in the sense of children reporting gaining new ideas along the way as well as in the sense of needing to make compromises due to implementation problems and constraints: "*We needed to make compromises when everything did not go as we assumed, [it led] the game to be somewhat different.*" "*Well like ... the banana box was so small so we first made the Lego robot and not the other one.*" *"[It wasn't like we planned] as in the beginning our plan was to make a [garbled audio] but it did not work out.*" Hence, also practical constraints, not only people factors, were reported of hindering the achievement of the desired outcome.

As can be seen, in the interview talk there was evidence on design being experienced as a creative, iterative, conflictual negotiation process, even if the children did not articulate this in such a sophisticated manner themselves. Their discussion of the project shows that in their work they were generating choices of different kind as well as negotiating around them a lot [6]. The concretization of their choices will be discussed in the following section. As for the design process, we must conclude that the

children placed quite little emphasis on reflecting on and evaluating the consequences of their choices [6]. Even if they reflected on the process and outcome in the interview situation, they did not engage in much reflection during the process and the interviews were not very fruitful in this respect either. Moreover, they did not seem to remember their playing and evaluation sessions when describing their experiences of the project – particularly the evaluation session was forgotten.

4.3 Experiencing Making and Materiality

For many children, practical making activities were emphasized in the project: many brought them up as their main activities in the project and/or saw them as the most enjoyable activities. The material objects created were significant for many children. When they were asked in the beginning of the interview what they did in the project, some of them described the whole project as something related to making of material objects: "*We built with Legos.*" *"[I did] quite a lot, for example those gates.*" "*I made those car pieces and cut windows and painted the basket to look good.*" Along the same lines, the visit in the Fab Lab was also described in terms of the material objects created: "*We made that man and the Lego car.*" "*Well we were able to make that snowman [in the Fab Lab].*"

Quite many of the children's comments concerned the material aspects involved with making; hence, the significance of materiality in making emerged in many senses in the interview. It was related to the concretization of the choices (cf. [11]) that enabled building a shared understanding – the Fab Lab visit and the art and craft materials were essential in settling a shared understanding about the game spots. Many children pointed out that their idea or the shared understanding of the group did not crystallize before they started implementation with concrete art and craft materials: "*Finally it [the shared understanding] emerged quite quickly as we had to do something.*" "*When we were able to start working with that cardboard box.*" "*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].*" This showed also in connection to the Fab Lab visit: "*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.*" The Fab Lab was also thanked for allowing making clear progress in work as well as for generating even more choices: "*It was like a good place, good working place … we made that figure there and then we designed those Lego robots there*" *"[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].*" "*We could have done lots of more there if we had had the actual game with us, [then] we could have invented something else as well.*"

Hence, for children the materials and material objects inspired, guided and focused their work. They also pointed out the importance of knowledge of material resources available: "*The implementation was quite difficult as I did not myself know what [resources] we had in our use.*" The children had encountered implementation problems and practical constraints with the materials and those had necessitated iterating their solution and making compromises: "*Well maybe the most challenging thing was that when throwing the ball and there is that trough, how to make it. It was difficult to kind of get it [the ball] to stay in it [in the trough].*" One boy reported somewhat annoyed: "*If we had had a larger base then we could have made it [the game spot] larger and added things [to the game].*" Another boy continues in the similar vein: "*Yes, there could have been more and then [playing] the game would have taken more time, but it became like that.*" The children also pondered the problematic size of the cardboard box, as "*because the banana box was so small we needed to make the Lego robot and not the other [game idea] … at first our plan was to make such kind [garbled audio] but it didn't work out.*" Another child nodded to that and showed with his hand flying down motion.

In the description above, also the bodily engagement with materiality becomes evidenced. The pupils, when describing their game spots in the interview situation, engaged in bodily choreographies, their game spots in many cases including physical activity, e.g., throwing balls. Another example, related to previously mentioned problematic trough for a basketball similarly showed the significance of materiality as part of performative action of design: *"[I learned in the project how that] kind of a wooden ring can bend when you laser cut it [shows using his hands].*" This quote also shows how the children reported on learning about the nature of the materials they had used – even if not too many children reported on this aspect.

Finally, we wish to point out children's background and experiences in relation to these material objects as significant, driving their work. The children had in their disposal very familiar tools and toys: Lego kits, robots, and familiar art and craft materials. The children did not particularly comment on this aspect, but we assume they benefitted from familiarity with them. They were often mentioned in the interviews, indicating that these familiar objects and tools had played a vital role in children's design and making activities. Some children summarized the whole project or the visit to the Fab Lab merely by saying: "*We built with Legos.*" "*We made that man and the Lego car.*"

4.4 Experiencing Empowerment

The underlying motivator for this project was our wish to empower children through design and making. In the interviews empowerment as a theme was not explicitly discussed with the children; however, we can identify some evidence on it still.

As for the role of the Protagonist and the viewpoint of children feeling empowered to shape technology development, the children were inquired about their perceived influence on the game spot. Each group was allowed to ideate their own game spot and within groups, most pupils felt they were able to influence it "*pretty much*" or "*just enough*", even if disagreements were also reported. Many times, decision-making was a negotiation process as described in the previous sections. Only one child viewed herself as having a lot of influence, as mentioned: "*Well I kind of led it, kind of saying what will go where.*" Then again, even if not necessarily recognized by the children, when they were acting as inventors, designers, or

makers, they were indeed making many decisions in practice. This was acknowledged by some, as shown in a discussion where two boys were asked about their own influence: "*[I was able to affect the design] quite a lot.*" "*For example we got to make those barriers.*" "*I made those strings on the edges and those barriers.*" Hence, in this sense, there was a clear indication of the sense of ownership and agency amongst the children, which we connect with the role of the Protagonist.

Thus, regarding the different forms of empowerment [15], we maintain that there was empowerment in the democratic sense in the project, even if only in a very limited sense: relating to decision-making as regards the own game spot. We must admit that in our project empowerment in the sense of critical research tradition was not evidenced: we did not encourage children to critically scrutinize the status quo, to challenge the oppressing conditions of the status quo or to combat the oppressors. Functional empowerment of children can, then again, be connected with this project: the children gained a nice, self-made game to play to serve their learning purposes (e.g. programming education), and they learned a lot along the way. Hence, empowerment in the sense of learning and competence development was also evident in the project. We must, however, note that what the children reported of learning was not necessarily what we hoped they would have reported of learning: many children brought up in their answers very concrete means and tools they had experimented with: laser cutting was mentioned most often, while also MakeyMakey and Touch Board were brought up by several children and 3D printing and 3D design by some. Additionally, a couple of children reported of learning programming, building or design. Few children mentioned imagination, inventiveness, group work and team spirit. Around one third of the pupils thought that this project had aroused further sparkle in them. Some even considered information technology field as their future career choice. However, many of them were quite unclear or hesitant as regards the sparkle: "*Well maybe a small [sparkle].*" "*It was very nice but I'm not sure.*" Only two children were certain that this project had been valuable for their future: "*Yes, you can get inside university laboratories.*" "*Yes, I learned to program and it can be useful when I'm older.*" We also see it as very important that one pupil reported of learning that: "*You can make games yourself, too, you don't have to buy them.*" We see this as a clear evidence of the Protagonist role adoption: recognition that one can shape and make technology, not only to buy and use that.

5 DISCUSSION

The aim of this paper was to examine how children experience adoption of the Protagonist role in educational settings when they are engaged in a creative maker activity that utilizes the power of materiality. We involved two classes of 10-12-year-old children in a design and making project with the general aim of empowering children by offering them design and making skills. Our philosophy behind this is that by educating children in these topics we combat the digital divide. We also see that general understanding of how children could themselves design and make digital technology in the future increases their agency in broader spectrum. We wanted to critically examine our project from the viewpoint of the Protagonist role adoption [41] and understand in more detail what such role entails. That role has been very recently identified in the literature and it has not yet been examined from the perspective of participating children. We developed an analytical lens for a fine-grained analysis of what the Protagonist role may mean and entail. Next, we summarize the findings and discuss their implications. We also consider how our study could serve the PD agenda more generally.

5.1 Protagonist Role Adoption by Children

The findings of our study are summarized in Table 1. In the Protagonist role [41] adoption of children, some successes were identifiable, but also clear shortcomings. We argue that children gained valuable experiences of different **roles** relevant in technology development: they were positioned into the roles of users, designers, makers, inventors and evaluators. The designer and maker roles are central in this type of a project and these indeed became recognized by the children. These active and influential roles together with the inventor role hopefully gave children insights into the possibility to take part in and affect technology development more broadly, along the lines of the Protagonist role [41]. However, the user and evaluator roles were hardly recognized by the children. We recommend an open discussion together with children on the role repertoire available for them in this type of a project, to make the roles more understandable and visible for them.

Regarding **creative design**, we maintain that the children gained valuable experiences of design as a creative, iterative, conflictual negotiation process (in line with [5, 23-25, 41]). However, we must point out that not all children described design along these lines (e.g. those that described the entire project as being about building with Legos) and none of them articulated their understanding in the manner we do, even if traces of this type of experiences could be identified from their talk. We suggest making the nature of creative design process even more visible for children, e.g., by explicitly discussing it with them. As for generating choices, negotiating around them and concretizing them [6], all children in our project gained first-hand experiences on them, while especially the concretization of choices became foregrounded by the children. The children saw this as a valuable step in creating a (shared) understanding of what they and their compatriots were up to. Evaluating the consequences of the choices was not discussed much by the children, however, even if some of the children unhappily reported that the outcome could have been different. For some reason, the children had forgotten the evaluation session we organized in the end, including giving and receiving feedback. We suggest very visibly encouraging children to reflect on the choices made, on their justifications as well as on their consequences.

The importance of making and associated **materiality** emerged in our data in multiple senses. Making of material objects clearly interested and entertained children. Materiality

enabled making abstract plans concrete, helped to reach a shared understanding among children, inspired to see new choices, and allowed to explore in practice what works, forcing iteration and trying out new solutions. External embodiment of ideas [61] was significant for a shared understanding to emerge. Materiality expanded communicative resources and was an essential aspect of performative action of design (see [60]). Engaging with and altering the material world around oneself makes design visible and concrete, even involving bodily choreography and movement. We also speculate that previous experience and familiarity with the materials was beneficial and valued by the children (see [32, 61]). For children, we underscore materiality as an integral element when educating them about technology and design. Hence, we argue making suits children's education very well.

Table 1: Summary of the findings

Protagonist role	Our approach	Children's experiences
Process reflection an integral part of the process	In the end of each session children reflected together on what they did and what they learned; Reflection in the interview	This was challenging: the children mostly neglected the task assignment during the process and in the interviews it was also difficult for them to reflect on what they did in the project (cf. "we built with Legos")
Product reflection an integral part of the process	In the end of each session children reflected together on what they did; Evaluation after playing the game; Reflection in the interview	This was challenging: the children mostly neglected the task assignment during the process and they did not consider the playing or evaluation sessions from this perspective. In the interviews, some contemplation on their own satisfaction as regards the outcome emerged
Children as main agents driving the design and making process	Children were given instructions for each session but they ideated, designed and made the game spots independently, adults only facilitating the process	Children variably recognized their own role in the project (i.e. designer, maker, inventor, user), some particularly adopting or enjoying one of those roles. Children recognized their own influence as regards the outcome. One child perceived herself as having a lot of authority
Acquiring new insights into design and making	Children were familiarized with technology development process and experienced an entire design and making process from ideation until evaluation and reflection	Children variably recognized the different phases of the project and their own role within, some particularly adopting or enjoying one of those roles. Some children recognized design as a creative, iterative, conflictual negotiation process. Making and materiality emphasized: concrete materials, creation of material objects, materiality inspiring, guiding and focusing the work. Some explicitly mentioned learning programming, design, building, imagination, inventiveness, group work, or team spirit
Acquiring new insights to digital technology	Children made an interactive board game and experimented with many making tools and Fab Lab facilities	Children heavily concentrated on the making tools and Fab Lab facilities they had encountered. Little reflection around the technology they had developed or digital technology in general emerged
Acquiring reflective stance toward techno-logy in their life	Children were familiarized with technology development process and made and reflected on an interactive board game	Impossible to know the long-term impacts, so far limited data on this aspect. One child recognized he could make games himself, not only buy those. Quite many stated the project aroused further interest, but the children were vague in their answers. Two children saw this as a career option
Empowerment through design making	Children gained experiences of empowerment in functional, democratic, and learning and competence building senses	Children gained an enjoyable game to play and learn programming; they were invited as active agents into technology development; they gained experience of having some decision-making power in technology development; they learned a variety of things during the process

Regarding **empowerment**, the children felt that they could influence their own game spot (pretty much or enough) and they were indeed making of lot of design decisions during the project. They entered a new decision-making arena of technology development and were empowered to act as decision-makers within. Moreover, if we consider understanding and experience of technology design and making as valuable for all citizens in the future, we can say we empowered children in the sense of learning and competence development, at least a bit. Regarding functional empowerment [49], we might have improved children's life conditions somewhat with this project and its outcome. However, we must admit that empowerment in the critical sense or in the sense of being able to affect decisions concerning oneself more broadly [15, 49, 62], we did not do much. One child recognized that he could also make his own games, which we see as an important outcome and a step towards the Protagonist role [41]. We suggest a clear emphasis on empowerment of children.

When aiming for empowerment of children, we maintain that the empowering practices should be built in the collaborative process consciously and carefully, from the project initiation until the evaluation and reflection (see [15, 40, 54, 55]). Even if we had such practices (e.g., informing children about the project and its aims in the beginning, giving them power of decision on what to build, aiming at their competence development, inviting them into evaluation and reflection) embedded into our project, empowerment from the perspective of critical tradition and combatting the oppressors through design and making (e.g. [50,

51]) was missing. Moreover, future work is needed purely based on the fact that the participating children did not recognize or remember our practices. We therefore suggest making the practices very visible for children so that they can reflect on them and make use of them also in other situations.

Unfortunately, children's **reflection** on what they did in the project was also rather limited in our project. As reflective thinking is considered an important element in effective learning [64] as well as an integral part of the Protagonist role [41], it is useful to consider how to further scaffold children in that. We approached it as reflection-*on*-action [65]; we offered children support and tools for such kind of reflection during the process (i.e. after each session) but, obviously, even more support and encouragement would have been needed for deeper reflection to emerge. The interviews made the children to reflect a bit more on the process and the outcome, while often the interview discussion were also quite concise, despite adult encouragement and facilitation. Gourlet and colleagues [66], on the other hand, noticed that their research diary concept helped children in reflection-*in*-action [65]. They argue that reflection-in-action supports also reflection-on-action. We see merit in their approach and suggest scaffolding both types of reflection and particularly trying out different ways for reflection-in-action.

As for the **school context**, we have some open questions. It is somewhat unclear what can be learned as regards empowerment in the critical sense or as regards making in schools. In the maker movement, making is something one has proactively wanted to do and started to work on one's own (see e.g. [5, 29, 42, 45]) and the critical tradition views empowerment not as some power being given by the powerful ones to the power weak, but instead as the power weak combatting the oppressors and gaining power this way [15, 62]. In our study, the children did not critically reflect on the oppressing conditions of the status quo or combat the ones responsible for the oppressing conditions. They did not even have the possibility to say no to making. They did not start the work because they were interested in it – many of them were not particularly interested in making at all. If making is integrated into schoolwork, the situation is often the same: own interests and voluntary participation are not necessarily underlying the work (see e.g. [40, 54, 55]). If we integrate making into school work, as encouraged by many (e.g. [21, 23, 25, 59]), we need to critically reflect on the notion of empowerment we advocate in the work as well as to critically consider in detail how to nurture agency, interest, and initiative of the involved children.

5.2 Protagonist Role Adoption by Adults

Even if we discussed the Protagonist role adoption in the context of school and as experienced by children, we think our findings are valuable for other contexts and user groups, too. We think that also adults should be empowered through design and making in the similar sense than children: they should gain skills and competencies to shape technology development as well as to critically reflect on technology in their everyday life [41]. We think this type of educational design and making projects should be seen as useful for adults as well, i.e. gaining an opportunity to engage in technology design and making, and to experience empowerment in different senses in this arena. We also maintain that materiality associated with making should be seen as valuable for adults, too: we think that making of material objects likely interests and entertains also adults. Making abstract plans concrete, help in reaching a shared understanding, giving stimulus to see new choices, spurring iteration and exploration – likely these aspects are valuable also when engaging and educating adults (in line with [60, 61]). Maker movement has already been embraced in the PD community as an exciting site and educational tool for participation, design, and empowerment [10, 14, 44]. Björgvinsson and colleagues argue that "A central challenge for participatory design today, just as four decades ago, is to provide for alternative perspectives on participation and on democratization. This challenge means actively exploring alternative ways to organize milieus for innovation that are more democratically-oriented than traditional milieus that focus on expert groups and individuals." [7: 49] We argue that the Protagonist role and the maker movement fit very well with this call for alternative perspectives to participation and democratization, and for organizing novel milieus for innovation.

6 CONCLUSIONS

Inviting children to adopt the Protagonist role regarding technology has recently become advocated. Such a role embraces the original political PD agenda and aims at empowerment of children through design and making. However, the literature is limited so far in exploring how to aid children in becoming Protagonists. Moreover, the PD community has so far been negligent of education of children – in participation, design and technology. We maintain that we need to see as our task and duty to educate and empower children in participation, design and technology. We report findings from a design and making project aiming at empowerment of children, carried out in school context. The study shows that adopting the Protagonist role is not easy. We present children's experiences and reflect on the challenges involved in progressing towards the Protagonist role adoption.

The contribution of the study is fourfold: First, the study showcases to the PD community how we can support an empowering agenda in PD with children. Second, the study provides insights into the shortcomings and challenges involved in empowering children through design and making. This should be valuable for future research in developing the approach further. Third, the study concentrates on children's own perspective and experiences that should be appreciated in any PD endeavor but that have remained less studied in the extant research so far. Fourth, the study offers a more structured approach to the characteristics of the Protagonist role. Overall, the study, inspired by Iversen and colleagues, participates in the endeavor of re-accentuating the importance of a PD approach in the digitization of society and education – which must include children [41].

We also wish to point out that we are addressing a very

complex topic and we identify many unclear issues and challenges still ahead relating to the Protagonist role adoption of children. For many children, particularly in school context, making can be just one of the school tasks or very simple task ("*We built with Legos*"), not perceived as particularly fun, exciting, empowering or educating. For other children, valuable insights into creative design and making processes may still be generated and critical reflection around technology and its development aroused ("*You can make games yourself, too, you don't have to buy them.*"). It is important to see the variety in children's experiences. Regarding them all, however, we think that just by engaging in the project, some valuable experiences on design, making and empowerment are gained, and we hope these will act as seeds that in the future help increase children's agency in the technology-rich world.

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REFERENCES

[1] G. Bjerknes and T. Bratteteig. 1995. User Participation and Democracy. A Discussion of Scandinavian Research on System Development. *Scandinavian Journal of Information Systems* 7, 1, 73-98.

[2] J. Greenbaum and M. Kyng (Eds.). 1991. *Design at Work. Cooperative Design of Computer Systems*. Lawrence Erlbaum Associates, Mahwah.

[3] D. Schuler and A. Namioka (Eds.). 1993. *Participatory Design: Principles and Practices*. Lawrence Erlbaum Associates, Mahwah.

[4] J. Simonsen and T. Robertson (Eds.). 2013. *Routledge international handbook of participatory design*. Routledge, New York.

[5] P. Blikstein. 2013. Digital fabrication and 'making' in education: The democratization of invention. In *FabLabs: Of machines, makers and inventors* J. Walter-Herrmann and C. Büching (Eds.), 1-21.

[6] T. Bratteteig and I. Wagner. 2014. Design decisions and the sharing of power in PD. In *Proceedings of the 13th Participatory Design Conference: Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium papers, and Keynote abstracts-Volume 2*. ACM, New York, 29-32.

[7] E. Björgvinsson, P. Ehn, and P.A. Hillgren. 2010. Participatory Design and Democratizing Innovation. In *Proceedings of the 11th Biennial Participatory Design Conference* (PDC'10). ACM, New York, 41-50.

[8] C. DiSalvo, A. Clement and V. Pipek. 2013. Participatory design for, with, and by communities. In *Routledge international handbook of participatory design*. Routledge J. Simonsen and T. Robertson (Eds.), Routledge, New York, 182-209.

[9] A. Druin. 2002. The Role of Children in the Design of New Technology. *Behaviour and Information Technology* 21, 1, 1-25.

[10] S. Bardzell. 2014. Utopias of participation: design, criticality, and emancipation. In *Proceedings of the 13th Participatory Design Conference: Short Papers, Industry Cases, Workshop Descriptions, Doctoral Consortium papers, and Keynote abstracts-Volume 2*. ACM, New York, 189-190.

[11] C. Bossen, C. Dindler and O. S. Iversen. 2016. Evaluation in participatory design: a literature survey. In *Proceedings of the 14th Participatory Design Conference: Full papers-Volume 1*. ACM, New York, 151-160.

[12] A. P. Correia and F .D. Yusop. 2008. I don't want to be empowered: the challenge of involving real-world clients in instructional design experiences. In *Proceedings of the 10th Anniversary Conference on Participatory Design* (PDC'08). Indiana University, Indianapolis, 214-216.

[13] M. Ertner, A. M. Kragelund and L. Malmborg. 2010. Five enunciations of empowerment in participatory design. In *Proceedings of the 11th Biennial Participatory Design Conference*. ACM, New York, 191-194.

[14] C. L. Kaiying and S. Lindtner. 2016. Legitimacy, boundary objects & participation in transnational DIY biology. In *Proceedings of the 14th Participatory Design Conference: Full papers-Volume 1*. ACM, New York, 171-180.

[15] M. Kinnula, N. Iivari, T. Molin-Juustila, E. Keskitalo, T. Leinonen, E. Mansikkamäki, T. Käkelä, and M. Similä. 2017. Cooperation, Combat, or Competence Building – What Do We Mean When We Are 'Empowering Children' in and through Digital Technology Design? In *Proceedings of the Thirty eighth International Conference on Information Systems* (ICIS'17). AIS.

[16] A. Balanskat and K. Engelhardt. 2014. *Computing Our Future: Computer Programming and Coding-Priorities, School Curricula and Initiatives Across Europe*. Technical report, European SchoolNet, Brussels.

[17] National Research Council. 2011. *Successful K-12 STEM education: Identifying effective approaches in science, technology, engineering, and mathematics*. National Academies Press, Washington.

[18] M. Pérez-Sanagustín, M. Nussbaum, I. Hilliger, C. Alario-Hoyos, R. Heller, P. Twining and C. Tsai. 2017. Research on ICT in K-12 schools–A review of experimental and survey-based studies in computers & education 2011 to 2015. *Computer & Education* 104, C, A1-A15.

[19] M. Kinnula, S. Laari-Salmela, and N. Iivari. 2015. Mundane or Magical? Discourses on Technology Adoption in Finnish Schools. In *Proceedings of the 23rd European Conference of Information Systems* (ECIS). AIS, Paper 102.

[20] L. Kuure, T. Molin-Juustila, T. Keisanen, M. Riekki, N. Iivari and M. Kinnula. 2016. Switching perspectives: from a language teacher to a designer of language learning with new technologies. *Computer Assisted Language Learning* 29, 5, 925-941.

[21] R. C. Smith, O. S. Iversen and R. Veerasawmy. 2017. Impediments to Digital Fabrication in Education. In *Information and Technology Literacy: Concepts, Methodologies, Tools, and Applications: Concepts, Methodologies, Tools, and Applications*, 301-319. IGI Global, Hershey.

[22] J. Tondeur, J. van Braak, F. Siddiq and R. Scherer. 2016. Time for a new approach to prepare future teachers for educational technology use: Its meaning and measurement. *Computers & Education*, 94, 134-150.

[23] T. Bekker, S. Bakker, I. Douma, J. van der Poel, and K. Scheltenaar. 2015. Teaching children digital literacy through design-based learning with digital toolkits in schools. *International Journal of Child-Computer Interaction* 5, 29-38.

[24] E. S. Katterfeldt, N. Dittert, and H. Schelhowe. 2015. Designing digital fabrication learning environments for Bildung: Implications from ten years of physical computing workshops. *International Journal of Child-Computer Interaction* 5, 3-10.

[25] R. C. Smith, O. S. Iversen, and M. Hjorth. 2015. Design thinking for digital fabrication in education. *International Journal of Child-Computer Interaction* 5, 20-28.

[26] M. Kyng. 1988. Designing for a dollar a day. *Office Technology and People*, 4, 2, 157-170.

[27] S. Bødker. 1996. Creating conditions for participation: conflicts and resources in systems development. *Human-computer interaction* 11, 3, 215-236.

[28] K. Nygaard and O. Terje Bergo. 1975. The trade unions – New users of research. *Personnel review* 4, 2, 5-10.

[29] D. Dougherty. 2012. The maker movement. *innovations* 7, 3, 11-14.

[30] C. Frauenberger, J. Good and W. Keay-Bright. 2010. Phenomenology, a framework for participatory design. In *Proceedings of the 11th Biennial Participatory Design Conference*. ACM, New York, 187-190.

[31] U. Kokil and J. Jeanne. 2008. Designing wearable educational games for children. In *Proceedings of the Tenth Anniversary Conference on Participatory Design*. Indiana University, Indianapolis, 320-321.

[32] L. Kuure, E. Halkola, N. Iivari, M. Kinnula, and T. Molin-Juustila. 2010. Children Imitate! The issue of recycling in participatory design with children. In *Proceedings of the 11th Biennial Participatory Design Conference* (PDC '10). ACM, New York, 131-140.

[33] S. Lindberg, M. Thomsen and M. Åkesson. 2014. Ethics in health promoting PD: designing digital peer support with children cured from cancer. In *Proceedings of the 13th Participatory Design Conference: Research Papers-Volume 1*. ACM, New York, 91-100.

[34] J. Makhaeva, C. Frauenberger and K. Spiel. 2016. Creating creative spaces for co-designing with autistic children: the concept of a Handlungsspielraum. In *Proceedings of the 14th Participatory Design Conference: Full papers-Volume 1*. ACM, New York, 51-60.

[35] H. van Rijn and P. Stappers. 2008. Expressions of ownership: motivating users in a co-design process. In *Proceedings of the Tenth Anniversary Conference on Participatory Design*. Indiana University, Indianapolis, 178-181.

[36] A. Weiss, D. Wurhofer, R. Bernhaupt, E. Beck and M. Tscheligi. 2008. This is a flying shopping trolley: a case study of participatory design with children in a shopping context. In *Proceedings of the Tenth Anniversary Conference on Participatory Design*. Indiana University, Indianapolis, 254-257.

[37] O. S. Iversen and C. Dindler. 2013. A Utopian agenda in child–computer interaction. *International Journal of Child-Computer Interaction*, 1, 1, 24-29.

[38] O. Iversen and R. Smith. 2012. Scandinavian participatory design: dialogic curation with teenagers. In *Proceedings of Interaction Design and Children conference*. ACM, New York, 106-115.

[39] W. Barendregt, T. M. Bekker, P. Börjesson, E. Eriksson and O. Torgersson. 2016. Legitimate Participation in the Classroom Context: Adding Learning Goals to Participatory Design. In *Proceedings of the 15th International*

Conference on Interaction Design and Children. ACM, New York, 167-174.
[40] N. Iivari and M. Kinnula. 2016. Inclusive or Inflexible - a Critical Analysis of the School Context in Supporting Children's Genuine Participation. In *Proceedings of the 9th Nordic Conference of Human Computer Interaction*. ACM, New York, 63.
[41] O. S. Iversen, R. C. Smith, and C. Dindler. 2017. Child as Protagonist: Expanding the Role of Children in Participatory Design. In *Proceedings of the 2017 Conference on Interaction Design and Children* (IDC'17). ACM, New York, 27-37.
[42] A. Toombs, S. Bardzell and J. Bardzell. 2014. Becoming makers: Hackerspace member habits, values, and identities. *Journal of Peer Production*, 5, 1-8.
[43] S. Lindtner, G. D. Hertz and P. Dourish. 2014. Emerging sites of HCI innovation: hackerspaces, hardware startups & incubators. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. ACM, New York, 439-448.
[44] B. Kolko, A. Hope, B. Sattler, K. MacCorkle and B. Sirjani. 2012. Hackademia: building functional rather than accredited engineers. In *Proceedings of the 12th Participatory Design Conference: Research Papers-Volume 1*. ACM, New York, 129-138.
[45] M. Hatch. 2014. *The Maker Movement Manifesto*. McGraw-Hill Education, New York.
[46] J. Löwgren. 1995. Applying design methodology to software development. In *Proceedings of Designing interactive systems: processes, practices, methods, & techniques*, ACM, New York, 87-95.
[47] J. Löwgren and E. Stolterman. 1999. Methods & tools: design methodology and design practice. *interactions* 6, 1, 13-20.
[48] P. Gourlet and F. Decortis. 2016. Inscribing the conditions for a Designerly Learning in Elementary Classrooms: Building a Frame to Open a World of Possibilities. In *Proceedings of FabLearn Europe*, 1-9.
[49] A. Clement. 1996. Computing at Work: Empowering Action by Low-Level Users. In *Computerization and Controversy: Value Conflicts and Social Choices* R. Kling (Ed). Morgan Kauffmann, San Diego, 383-406.
[50] S. Grimme, J. Bardzell and S. Bardzell. 2014). We've conquered dark: shedding light on empowerment in critical making. In *Proceedings of the 8th Nordic Conference on Human-Computer Interaction: Fun, Fast, Foundational*. ACM, New York, 431-440.
[51] S. Lindtner, S. Bardzell and J. Bardzell. 2016. Reconstituting the utopian vision of making: HCI after technosolutionism. In *Proceedings of the 2016 CHI Conference on Human Factors in Computing Systems*. ACM, New York, 1390-1402.
[52] S. Yarosh, I. Radu, S. Hunter, and E. Rosenbaum. 2011. Examining values: an analysis of nine years of IDC research. In *Proceedings of Interaction Design and Children conference* (IDC'11). ACM, New York, 136-144.
[53] J. P. Hourcade. 2008. Interaction Design and Children. *Foundations and Trends in Human-Computer Interaction* 1, 4, 277-392.
[54] N. Iivari, M. Kinnula, and L. Kuure. 2015. With Best Intentions – a Foucauldian Examination on Children's Genuine Participation in ICT Design. *Information Technology and People* 28, 2, 246-280.
[55] N. Iivari, T. Molin-Juustila and M. Kinnula. 2016. The Future Digital Innovators: Empowering the Young Generation with Digital Fabrication and Making. In *International Conference on Information Systems* (ICIS'16). AIS.
[56] D. A. Durães. 2015. Gaming and Robotics to Transforming Learning. In *Methodologies and Intelligent Systems for Technology Enhanced Learning* T. Di Mascio, R. Gennari, P. Vittorini and F. De la Prieta (Eds.). Springer, Cham, 51-56.
[57] E. L. Pucci and I. Mulder. 2015. Star(t) to Shine: Unlocking Hidden Talents Through Sharing and Making. In *Proceedings of Distributed, Ambient, and Pervasive Interactions* (DAPI 2015), Springer, Cham, 85-96.
[58] S. L. Chu, F. Quek, S. Bhangaonkar, A.B. Ging, and K. Sridharamurthy. 2015. Making the maker: a means-to-an-ends approach to nurturing the maker mindset in elementary-aged children. *International Journal of Child-Computer Interaction* 5, 11-19.
[59] S. L. Chu, R. Schlegel, F. Quek, A. Christy and K. Chen. 2017. 'I Make, Therefore I Am': The Effects of Curriculum-Aligned Making on Children's Self-Identity. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. ACM, New York, 109-120.
[60] G. Jacucci and I. Wagner. 2007. Performative roles of materiality for collective creativity. In *Proceedings of the 6th ACM SIGCHI conference on Creativity & Cognition*, ACM, New York, 73-82.
[61] M. Kinnula, T. Molin-Juustila, I. Sanchez Milara, M. Cortes, and J. Riekki. 2017. What if It Switched on the Sun? Exploring creativity in a brainstorming session with children through a Vygotskyan perspective. *Journal of Computer Supported Cooperative Work* (CSCW) 26, 4, 423-452.
[62] C. Hardy and S. Leiba-O'Sullivan. 1998. The Power Behind Empowerment: Implications for Research and Practice. *Human relations* 51, 4, 451-483.
[63] L. Chawla and H. Heft. 2002. Children's competence and the ecology of communities: a functional approach to the evaluation of participation. *Journal of environmental psychology* 22, 1-2, 201-216.
[64] X. Lin, C. Hmelo, C. K. Kinzer and T. J. Secules. 1999. Designing technology to support reflection. *Educational Technology Research and Development* 47, 3, 43-62.
[65] D. A. Schön. 1983. *The Reflective Practitioner*. Basic Books, New York.
[66] P. Gourlet, L. Eveillard and F. Dervieux. 2016. The Research Diary, Supporting Pupils' Reflective Thinking during Design Activities. In *Proceedings of the 15th International Conference on Interaction Design and Children*. ACM, New York, 206-217.