Children's learning in focus: Creating value through diversity and transdisciplinary work in design, digital fabrication, and making with children

Marianne Kinnula, INTERACT Research Unit, University of Oulu, Finland, marianne.kinnula@oulu.fi
Netta Iivari, INTERACT Research Unit, University of Oulu, Finland, netta.iivari@oulu.fi
Jerry Alan Fails, Boise State University, Boise, Idaho, United States, jerryfails@boisestate.edu

Abstract

Educators and researchers with varied backgrounds and expertise share a common vision of helping children expand their horizons and capabilities through learning design, digital fabrication, and making skills. We highlight the collaborative and transdisciplinary nature of these endeavors, underlining the perspective of value co-creation where value needs to be realized for all stakeholders. We encourage all to utilize this lens to continue to advance the field and benefit children as they learn and create.

1. Introduction

It is widely agreed that design, digital fabrication, and making offer children valuable skills for the 21st century and empower them to manage and master their technology-rich future life. Children have been invited to engage in design, digital fabrication, and making in various settings, ranging from formal schooling with diverse classroom settings (e.g. [4, 7, 27]) to informal learning and leisure-time settings such as libraries, museums, community centers and Fab Labs including Maker Spaces of various kinds (see e.g. [24]). Due to this diversity, a variety of adult participants have also been involved, including teachers, instructors, makers, parents, designers, and different kinds of domain experts (see e.g. [18]). The breadth of stakeholders involved in these activities has been broadened to include policy makers at various levels – reflective of a general desire to influence children's education and society's approach towards beneficial and impactful digitalization [23].

We discuss in these editors' notes the significance of value creation to all stakeholders who engage in the (transdisciplinary) collaborative work, where the focus is on children learning design, digital fabrication, and making skills. This Special Issue for 'FabLearn Europe – an international conference on Creativity and Making in Education' includes a collection of the best papers from the FabLearn Europe 2019 conference, bringing together seven articles that illustrate well the diversity in that community. The community is a young one, with the first of this annual conference being held in 2014 as a sister venue to the Global Flagship FabLearn conference that has been conducted regularly at Stanford University, USA. FabLearn Europe scientifically aims for diversity. It brings together a community of teachers, practitioners, technologists, designers, and academics around a shared interest in technology and children's hands-on learning for the

This is a preprint of the accepted paper. Please cite the paper as:

Kinnula, M., Iivari, N., and Fails, J.A. (2020) Children's learning in focus: Creating value through diversity and transdisciplinary work in design, digital fabrication, and making with children. International Journal of Child-Computer Interaction, Vol. 28, June 2021, 100246.

21st century. Different activities, happening in various educational contexts, related to digital technology design and making, digital fabrication, and entrepreneurship are in the focus of the conference.

Regarding the diversity of participants and spaces in this special issue, Sánchez Milara et al. [25] focus on teachers and principals as important participant groups enabling design, digital fabrication, and making for children, and consider how they could be supported by a Community of Practice consisting of stakeholders of a local educational community. Dittert et al. [9] propose a new pedagogy for kindergarten teachers to facilitate children's creativity and collaboration. Pitkänen et al. [28], then again, address the perspective of technology-oriented facilitators in Fab Labs, offering insights on how they could support children's learning better. Tisza et al. [30] study instructors working in varying kinds of informal and non-formal learning settings with children. Community perspective is important also for Einarsson and Hertzum [10] who concentrate on practitioners in library maker spaces in formal, non-formal and informal learning contexts, and scaffolding the learning of their different users. Kinnula and Iivari [20] give suggestions to the organizers of the design and making activities, in particular related to the form and organizing of children's participation. Mehto et al. [22] research is the only article that focuses on children, i.e., on young learners engaging in maker-centered learning activities in school context, with their analytic focus on materiality and sociomaterial aspects intermingled with making. Interesting to observe is the emphasis on adult actors of different kinds in this special issue. We agree that the adult actors are pivotal in enabling children's engagement.

Another significant group of participants in these endeavours is researchers. Design, digital fabrication, and making with and by children has emerged as an arena of interest for a multitude of disciplines and research fields. A variety of disciplines around the topic can be identified, ranging from engineering, design, and arts to psychology, computer science, and beyond. Most notably, researchers working within or at the intersection of educational sciences and Child Computer Interaction (CCI) have shown interest in this topic. This special issue includes an interesting mixture of studies concerning the disciplines involved. Many of the studies include a combination of researchers from different disciplines: educational sciences, engineering, Human Computer Interaction (HCI), and CCI (Sánchez Milara et al. [25], Dittert et al. [9], Pitkänen et al. [28], Mehto et al. [22], Tisza et al. [30]).

As for the variety of disciplines involved, we argue that research on design, digital fabrication, and making with and by children works within an arena where *transdisciplinary research and design* can truly emerge and be nurtured: the actors in an intersection of different disciplines and areas of expertise having a shared interest. Within that something beyond individual disciplines and areas of expertise can be collaboratively generated. Along the way individual disciplines and areas of expertise can also be transformed and renewed (cf. [6]). The significance of transdisciplinary focus has already been acknowledged in HCI: transdisciplinary design has been brought up as the fourth design paradigm of interaction design education, scholarship, and practice [5]. In CCI, the need and value of multidisciplinary research has been recently foregrounded as well; for example, Kawas et al. [19] address it from the viewpoint of our utilization of theories and methods from diverse disciplines such as education, social science, and humanities; they recommend joining with and fertilizing ideas with research communities working on related topics. While CCI has involved children in design in various ways – many of which have been transdisciplinary [11], we call for future in-depth studies on transdisciplinary collaboration and design emerging and being nurtured within design, digital fabrication, and making with and by children.

2. Creating value for the variety of stakeholders

In concert with a stakeholder perspective, we suggest seeing children's learning as a collaborative process that aims for transdisciplinary understanding. We also suggest focusing on value creation for the various (multidisciplinary) stakeholders who have their own perspectives and expectations for the work. More specifically, we refer to the concept of value co-creation as it is used in the marketing field within the Service-Dominant Logic perspective [31] where all stakeholders focus on a shared goal and the intention is to create value to *all* stakeholders in order for them to be interested in continuing the collaboration, (i.e., pursuing the goal together; in this case, children's learning), despite their possibly varying motivations and drivers. Central in this view is the *perceived value* -- i.e., the value from the perspective of the actors. Only the actors themselves can define whether they experience value (something beneficial, worth something) in the collaborative action or not, regardless of the intentions of other stakeholders (e.g. organizers or facilitators) [32]. Value is also always context dependent [15] – what is considered to be of value in one context, might not be in another context (e.g. at school vs. in leisure time or hobbies). The experienced value can be something that was intended or planned to happen in collaboration, but it can also be totally unintended [12, 13]. Personal expectations and the needs of the stakeholders also shape what kind of value they experience. In addition, external needs and expectations set by for example institutional or organizational roles of the participants (e.g. a child as a properly behaving Pupil at school, or a Teacher responsible for children's learning) can have an effect [21]. With the value co-creation lens, it is possible to reveal when value is created or not created for some central stakeholder, and react accordingly. This enables stakeholders' goals to be disparate, but yet align and yield – within this context – continual engagement in various design and making activities.

Value creation has been addressed in CCI research from different perspectives. The examples include legitimation of children's participation in technology design in school contexts where children's learning is the added value [2]; considerations on what kind of value collaboration brings to different stakeholders (children, teachers, principals, and researchers) [21]; and, exploring the question of whose value experience is in focus – designers' or other stakeholders' – and if the focus is on the value created in the collaborative process or related to the outcome of the process [3]. The studies in this special issue show value creation to various stakeholders, even though they do not explicitly take a value creation perspective. At the meta level, a primary goal for all the papers (whether explicit or implicit) is value created for children in the form of learning, although in many cases this means that adult actors need to first make changes in their work practices and/or learn new skills or adopt new mindsets by themselves to be able to participate in value co-creation. Mehto et al. [22] discuss this from the perspective of the collaborative design process between children, where children need to learn to handle the complex and abstract design process. Einarsson and Hertzum [10] examine how different forms of scaffolding are related to value created for learners (i.e., what skills they acquired) and how objectives/expectations of different stakeholders shape the process, and through that limit or allow the development of new skills. Kinnula and Iivari [20] focus on value created to children, in the form of their empowerment, through the histories, motivations, and actions of everybody, including children themselves, taking part in the collaborative process. Dittert et al. [9] and Pitkänen et al. [28] address the significance of adult actors as enablers, facilitators and participants in children's learning. Dittert et al. [9] focus on nurturing children's significant 21st century competencies of creativity and collaboration, connected with the engagement with digital technology, while Pitkänen et al. [28] address

scaffolding of children's learning in digital fabrication activities to serve STEM (Science, Technology, Engineering, Mathematics) education and to prevent the digital divide. The studies do not explicitly address the value gained by the adult actors, but they seem to assume the adult actors are motivated in their professional roles to serve children's learning the best way possible as well as the more specific goals mentioned above. Sánchez Milara et al. [25] explore how a local community of practice formed by various stakeholders can provide value in the form of training, resources, and encouragement to overcome challenges integrating digital fabrication in formal educational settings. Tisza et al. [30] examine the relationships between co-creation participant characteristics and the activities they engage and how certain patterns enhance the value to communities in various informal and formal settings.

3. Values affect what value is created – we need to look for the underlying values

Not only is the value of the co-created artifacts to the various stakeholders or the co-creation process significant to consider, but also the underlying values, i.e. the guiding principles in our lives that drive the actions of the stakeholders [29] in the value co-creation process. Our intrinsic values shape what we consider as value or worth [8]. CCI research has reflected on the importance of values in technology design with and for children and children's digital technology use (e.g. [1, 14, 16, 17, 26, 34]). The values driving the research work in the CCI community have also been examined [19, 33]. These studies show that empowerment and agency of children, child-centered research, and broad participation (inclusiveness and diversity) are valued in the community as well as high quality research [19]. Moreover, innovative and self-reflective methods that support children's learning, development, creative growth, and play are considered valuable in CCI research [19, 33].

The studies in this special issue align well with the general CCI values. The studies are heavily focused on supporting children's learning; scaffolding of learning and socio-material aspects involved in making based learning (Sánchez Milara et al. [25], Einarsson & Hertzum [10], Dittert et al. [9], Pitkänen et al. [28], Mehto et al. [22], Tisza et al. [30]). Children's voices are included in this special issue only through one study (Mehto et al. [22]); all the other studies address the perspective of significant adults involved. Hence, this special issue can be linked with the desire to influence children's education and society's approach towards beneficial and impactful digital transformation on a more general level. The studies also underscore the significance of broad participation of children for equality, social inclusion and prevention of the digital divide (Pitkänen et al. [28], Kinnula & Iivari [20]). One study [20] particularly advocates children's empowerment, agency and genuine participation.

4. Conclusions and way ahead

Coming back to children's learning as the main goal of the FabLearn Europe community, we maintain that the variety in the contexts, actors, and disciplines – also with the motivations and expectations – is needed in order to scaffold children's learning of design, making, and digital fabrication skills. Building on Bekker and al. [3] and Kinnula et al. [21] we propose in Figure 1 a lens for how to address children's learning as a collaborative (transdisciplinary) value co-creation process. The lens acknowledges different stakeholders and diverse contexts, and takes into account participants' values, motivations, and expectations. It considers also what kind of value the stakeholders experience either during the process or related to the outcome of the process, which can be e.g. a material object. Children's learning is expected to emerge as an intended

value for the participants, but both children as well as other stakeholders can have varying expectations for other kinds of value that will emerge from the collaborative process, and additionally some unintended value may emerge as well.

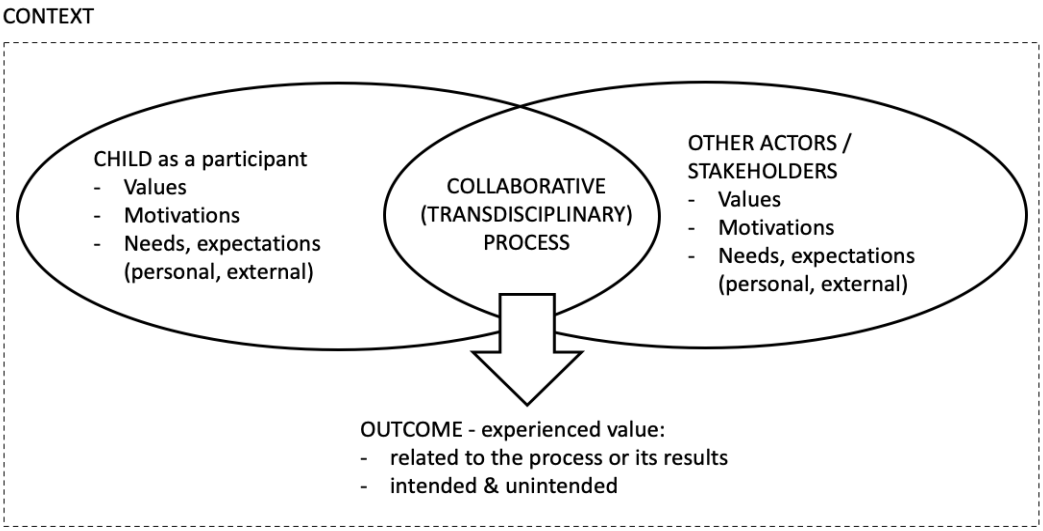

Figure 1. Approaching children's learning through the lens of co-creation of value in a collaborative, transdisciplinary process

As to the next steps for the FabLearn Europe community and also for the wider CCI community, we suggest the following:

- Increasing research related to diversity and inclusiveness, aiming for children's – and all stakeholders – empowerment and agency.
- Performing a systematic values analysis of the FabLearn Europe community, to understand better what drives and motivates the research and practice. While some of the values may align with the umbrella (or companion) field of CCI, further analysis may yield useful further understanding.
- Explicating and celebrating in our research and practice the transdisciplinary nature of our engagement in design, making, and digital fabrication in collaboration with children. These activities, considered in the past as something special for children during their leisure time, are now penetrating the formal education contexts of children, as skills everybody should learn. This would not have been possible without a variety of different stakeholders – both practitioners and researchers alike, from different disciplines – bringing their knowledge to the shared pool. Further examination of this is still needed.
- Enhancing our research analyses by utilizing more the lens of multidisciplinary stakeholders and examining what kind of values, motivations, needs, and expectations lay behind their participation in a collaborative process. This lens will allow stakeholders to more clearly see the diversity in value experiences for stakeholders, and see the value created for them either during the collaborative process or as a result of it (see Figure 1). Interesting would also be to observe what kind of unintended value may emerge for the participants involved - adults and children alike. The intended value, related to the noble goals of design, digital fabrication, and making with and by children, hopefully is observable, while also unexpected, surprising, controversial findings on the

value co-created may emerge, offering interesting opportunities for us to reflect on, question and refine our practice

We argue that by taking diversity of value and experience as a focus and in conjunction with the lenses of value co-creation and values, researchers and practitioners interested in inclusion and empowerment can further advance the FabLearn field of impact. We encourage and invite all to utilize these lenses and perspectives and build on the great research being conducted in our field so that our field can have a more impactful, lasting, beneficial effect on children.

Acknowledgements

This research is connected to the GenZ project, a strategic profiling project in human sciences at the University of Oulu. The project is supported by the Academy of Finland (grant agreement No. 318930) and the University of Oulu. This research was additionally funded the European Union's Horizon 2020 Research and Innovation programme (grant agreement No. 787476, COMnPLAY SCIENCE) and the Academy of Finland (grant agreement No. 324685, Make-A-Difference).

References

[1] Antle A.N., Warren J.L., May A., Fan M., Wise A.F., Emergent dialogue: eliciting values during children's collaboration with a tabletop game for change, Proceedings of the International Conference on Interaction Design and Children (IDC'14), ACM, 2014, pp. 37-46.

[2] Barendregt W., Bekker T.M., Börjesson P., Eriksson E., Torgersson O., Legitimate Participation in the Classroom Context: Adding Learning Goals to Participatory Design, Proceedings of the International Conference on Interaction Design and Children (IDC'16), ACM, 2016, pp. 167-174.

[3] Bekker T., Barendregt W., Skovbjerg H.M., Landoni M., Nicol E., Rubegni E., Editorial: Special issue on assumptions about the concept of childhood and the roles of children in design, International Journal of Child-Computer Interaction, 19 (2019) 89-92.

[4] Berman A., Deuermeyer E., Nam B., Chu S.L., Quek F., Exploring the 3D printing process for young children in curriculum-aligned making in the classroom, Proceedings of the International Conference on Interaction Design and Children, ACM, 2018, pp. 681-686.

[5] Blevis E., Koskinen I.K., Lee K.-P., Bødker S., Chen L.-L., Lim Y.-k., Wei H., Wakkary R., Transdisciplinary interaction design in design education, Extended Abstracts on Human Factors in Computing Systems (CHI'15), 2015, pp. 833-838.

[6] Choi B.C., Pak A.W., Multidisciplinarity, interdisciplinarity and transdisciplinarity in health research, services, education and policy: 1. Definitions, objectives, and evidence of effectiveness, Clinical and investigative medicine, 29 (2006) 351-364.

[7] Chu S.L., Deuermeyer E., Martin R., Quek F., Berman A., Suarez M., Zarei N., Nam B., Banigan C., Becoming Makers: Examining Making Literacy in the Elementary School Science Classroom, Proceedings of the International Conference on Interaction Design and Children (IDC'17), ACM, 2017, pp. 316-321.

[8] Deci E.L., Ryan R.M., Intrinsic motivation and self-determination in human behavior, Plenum, New York, 1985.

[9] Dittert N., Thestrup K., Robinson S., The SEEDS pedagogy: Designing a new pedagogy for preschools using a technology-based toolkit, International Journal of Child-Computer Interaction, 27 (2020) 100210.

[10] Einarsson Á.M., Hertzum M., How is learning scaffolded in library makerspaces?, International Journal of Child-Computer Interaction, 26 (2020) 100199.
[11] Fails J.A., Guha M.L., Druin A., Methods and techniques for involving children in the design of new technology for children, Foundations and Trends in Human–Computer Interaction, 6 (2013) 85-166.
[12] Grönroos C., Service logic revisited: who creates value? And who co-creates?, European business review, 20 (2008) 298-314.
[13] Grönroos C., Value co-creation in service logic: A critical analysis, Marketing theory, 11 (2011) 279-301.
[14] Hartikainen H., Iivari N., Kinnula M., Children's Design Recommendations for Online Safety Education, International Journal of Child-Computer Interaction, 22 (2019).
[15] Heinonen K., Strandvik T., Voima P., Customer dominant value formation in service, European Business Review, 25 (2013) 104-123.
[16] Iversen O.S., Halskov K., Leong T.W., Rekindling Values in Participatory Design, Proceedings of the Biennial Participatory Design Conference (PDC'10), ACM, 2010, pp. 91-100.
[17] Iversen O.S., Halskov K., Leong T.W., Values-led participatory design, CoDesign, 8 (2012) 87-103.
[18] Katterfeldt E.S., Dittert N., Schelhowe H., Designing digital fabrication learning environments for Bildung: Implications from ten years of physical computing workshops, International Journal of Child-Computer Interaction, 5 (2015) 3-10.
[19] Kawas S., Yuan Y., DeWitt A., Jin Q., Kirchner S., Bilger A., Grantham E., Kientz J.A., Tartaro A., Yarosh S., Another decade of IDC research: Examining and reflecting on values and ethics, Proceedings of the International Conference on Interaction Design and Children (IDC'20), ACM, 2020, pp. 205-215.
[20] Kinnula M., Iivari N., Manifesto for Children's Genuine Participation in Digital Technology Design and Making, International Journal of Child-Computer Interaction, 100244.
[21] Kinnula M., Iivari N., Isomursu M., Laari-Salmela S., "Worksome but Rewarding" – Stakeholder Perceptions on Value in Collaborative Design Work, Computer-Supported Cooperative Work, 27 (2018) 463-494.
[22] Mehto V., Riikonen S., Kangas K., Seitamaa-Hakkarainen P., Sociomateriality of collaboration within a small team in secondary school maker-centered learning project, International Journal of Child-Computer Interaction, 26 (2020) 100209.
[23] Meissner J.L., Jarusriboonchai P., McLaughlin J., Wright P., More than the Sum of Makers: The Complex Dynamics of Diverse Practices at Maker Faire, Proceedings of the Human Factors in Computing Systems (CHI'19), ACM, 2019, pp. 1-13.
[24] Mersand S., The State of Makerspace Research: a Review of the Literature, TechTrends, (2020) 1-13.
[25] Sanchez Milara I.S., Pitkänen K., Laru J., Iwata M., Orduña M.C., Riekki J., STEAM in Oulu: Scaffolding the development of a Community of Practice for local educators around STEAM and digital fabrication, International Journal of Child-Computer Interaction, 26 (2020) 100197.
[26] Nouwen M., Van Mechelen M., Zaman B., A value sensitive design approach to parental software for young children, Proceedings of the International Conference on Interaction Design and Children conference (IDC'15), ACM, 2015, pp. 363-366.
[27] O'Brien S., Hansen A.K., Harlow D.B., Educating teachers for the maker movement: Pre-service teachers' experiences facilitating maker activities, Proceedings of the 6th Annual Conference on Creativity and Fabrication in Education (FabLearn), 2016, pp. 99-102.
[28] Pitkänen K., Iwata M., Laru J., Exploring technology-oriented Fab Lab facilitators' role as educators in K-12 education: Focus on scaffolding novice students' learning in digital fabrication activities, International Journal of Child-Computer Interaction, 26 (2020) 100207.
[29] Schwartz S., Universals in the Content and Structure of Values: Theoretical Advances and Empirical Tests in 20 Countries, Advances in experimental social psychology, 25 (1992) 1-65.

[30] Tisza G., Papavlasopoulou S., Christidou D., Iivari N., Kinnula M., Voulgari I., Patterns in informal and non-formal science learning activities for children–A Europe-wide survey study, International Journal of Child-Computer Interaction, 25 (2020) 100184.
[31] Vargo S.L., Lusch R.F., Institutions and axioms: an extension and update of service-dominant logic, Journal of the Academy of Marketing Science, 44 (2016) 1-19.
[32] Vargo S.L., Maglio P.P., Akaka M.A., On value and value co-creation: A service systems and service logic perspective, European management journal, 26 (2008) 145-152.
[33] Yarosh S., Radu I., Hunter S., Rosenbaum E., Examining values: an analysis of nine years of IDC research, Proceedings of the International Conference on Interaction Design and Children conference (IDC'11), ACM, 2011, pp. 136-144.
[34] Zaman B., Abeele V., Laddering with young children in User eXperience evaluations: theoretical groundings and a practical case, Proceedings of the International Conference on Interaction Design and Children (IDC'10), 2010, pp. 156-165.