Young smart thing designers

Eftychia Roumelioti[1]

[1]Free University of Bozen-Bolzano, Faculty of Computer Science, Piazza Domenicani 3, Bolzano 39100, Italy

Abstract

Smart thing design can benefit children in several ways, such as by augmenting their understanding of technology, stimulating their creativity and allowing them to participate in collaborative activities. This paper outlines the research gap, and presents the research questions, methodology, main actions and results of a PhD research dedicated to investigating how to frame smart thing design with children.

Keywords

smart thing, game, card, toolkit, model, framework, design, making, children, action research

1. Introduction

Smart things are things, physical objects, augmented with computing capabilities [1]. The concept of “smart things" is often difficult to be grasped by children. This situation changed in the latest years, thanks to physical computing toolkits for children (e.g., [2, 3]). Most of the times, however, researchers focus on engineering and programming aspects of such toolkits, whereas creative design remains less addressed [4]. Recently, there has been an effort to include a “designerly" approach to physical computing and prototyping by combining design thinking, making and reflection (e.g., [5, 6]). In spite of that, there is a lack of research for guiding children in using this kind of technology in a creative way, for their own purposes.

This PhD is about enabling children to design their own smart things. A design model and a toolkit, namely SNaP, were specially created towards this goal. The model and toolkit for smart thing design evolved through action research experience, with 70 children, 8–16 years old. Each action took the form of smart thing design workshops. Data were gathered and analysed, in relation to the model and toolkit, but also in relation to children’s benefits, throughout the 4 years of the PhD. An overview of the actions and main results are presented below.

2. Related Work

Engaging children in design has been extensively explored in the Child-Computer Interaction community. Lately, researchers voiced the need that design with children should not only focus on the tangible outcomes, but also on children’s benefits [7]. Design, where children and their benefits are the center of attention, requires thus a special approach. Towards this goal, specially adjusted frameworks and models were introduced that engage children across

CHItaly 2021 Joint Proceedings of Interactive Experiences and Doctoral Consortium, July 11–13, 2021, Bolzano, Italy
eftychia.roumelioti@stud-inf.unibz.it (E. Roumelioti)
0000-0003-3293-4521 (E. Roumelioti)

exploration, ideation, programming and prototyping stages (e.g., [8, 5, 6]). In most cases, however, physical computing toolkits for children have more of an optional or supportive role. In a process, however, in which children are expected to implement their ideas by using such toolkits, e.g. for designing smart things, the process should consider the characteristics of them and guide children accordingly. Proper scaffolding that guides children in ideating and programming with physical computing toolkits should thus be part of the design model.

Design toolkits, that traverse the entire design process, can also support this direction. Cards, for example, that represent input and output devices of physical computing toolkits and things to be made smart, can help children be aware of and get familiar with the technology involved in the process [9]. In addition, toolkits can guide children in programming their solutions with simple if-then rules, as they do for adults [10], besides adding playfulness [11]. Design toolkits for smart thing design by children, however, are missing from the literature.

Overall, design with children remains a fertile area for further research, in general, and smart thing design, in particular. The goal of this PhD is to cover this gap and investigate how to frame smart thing design with children, by considering children's benefits out of this process.

3. Research Questions

The main research questions related to this PhD are as follows:

RQ1. What is the **design model** that can allow children design their own smart things?
RQ2. What is the **design toolkit** that can allow children design their own smart things?
RQ3. What are **children's benefits** by designing their own smart things?

4. Methodology

The term Action Research (AR) was first introduced by Kurt Lewin as "a spiral of steps, each of which is composed of a circle of planning, action, and fact-finding about the result of the action" [12]. AR studies are usually conducted through multiple cycles, each of which involves the identification of practical problems, the solution of those problems, and reflection on the part of the researcher. The goal, in general, is not to arrive at the solution of a given problem, but to create a solution that is better than the previous ones, and at the same time, to allow all participants derive benefits [13]. For the purposes of this research, the model and toolkit for smart thing design evolved through AR, by including the following steps (see also Fig. 1):

1. **Development**: Different versions of a design toolkit in the form of a game, SNaP, were developed based on past reflections. A design model was also created based on existing models and re-adjusted in each cycle according to new identified needs of children.
2. **Actions**: Actions were workshops with 8-16 y.o. children designing smart objects in the span of 3 years. They adopted the latest evolution of the design model and the SNaP game (e.g. see Fig. 2). Moreover, across all actions, data were processed by considering children's benefits in terms of engagement and learning, besides their overall experience. Data were collected with a mixed-method research design, by means of observations (direct and

indirect), questionnaires (e.g. [14]), and children's products. See [15, 16, 17, 18, 19] and Table 1 for an overview of all main actions.

3. **Reflections**: Every time the model and game were developed and used in actions in the field, designers reflected on results of actions. Reflections triggered decisions about the next evolution cycle of the model and the game: if the model assisted children in designing smart things and learning during the process, if the game was understandable, engaging and helped children design.

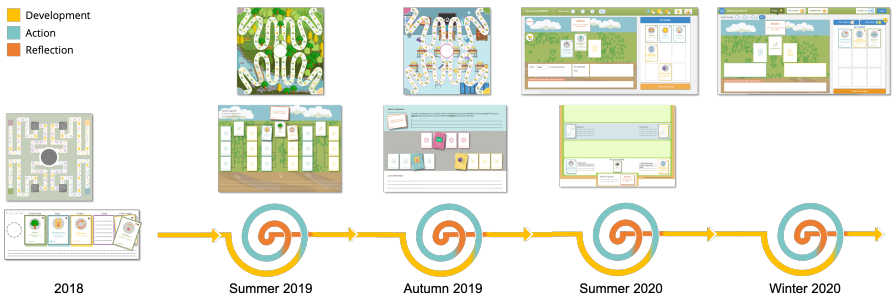

Figure 1: The action-research evolution of the SNaP toolkit along spiralling cycles

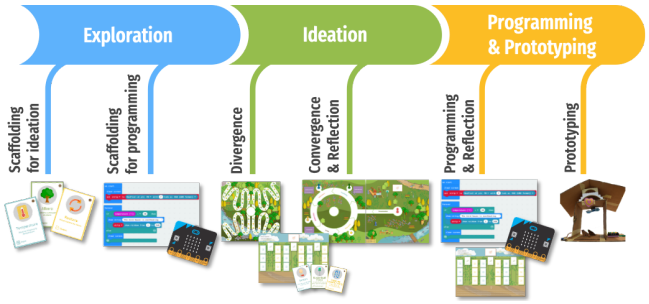

Figure 2: The SNaP toolkit and design model of Summer 2019 action

5. Main Results

Results regarding children's smart thing design competence, learning and engagement are overall positive. They indicate that the game-based structure of the workshops can help children in developing the skills for smart thing design, in terms of ideating and programming, and keep them engaged. What is more, SNaP can help children in reflecting towards their solutions through structured insights and make them evolve, besides fostering children's creativity. A step-by-step scaffolding, enabled by SNaP and the design model, allowed younger children who had never designed smart things, to grab how to ideate and program these, whereas more experienced children preferred a more open-nature version of the toolkit for creating more complex ideas. Overall, SNaP-based workshops can enable children to design smart things and over-time become independent in doing so, with minimum help from adults.

When	How	Where	Data	Instruments	Participants
2018	In presence	Athens, Milan, Bolzano	engagement, learning, experience	observations, questionnaires, products	12 (8F, 4M)
Summer 2019	In presence	Bolzano	engagement, learning, creativity	observations, questionnaires, products	27 (10F, 17M)
Autumn 2019	In presence	Bolzano	engagement, learning, experience	observations, products, interviews	4 (1F, 3M)
Summer 2020	Hybrid: at a distance, in presence	Ioannina, Milan, Bolzano	engagement, learning	observations, products	7 (3F, 4M)
Winter 2020	At a distance	Salerno	engagement, learning	observations, questionnaires, products	20 (7F, 13M)
				Total n. of participant children:	70 (29F, 41M)

Table 1
Information concerning actions with SNaP

6. Conclusions

Despite the recent interest in integrating design thinking and making, there is still a lack of research for guiding children on how to design with physical computing toolkits creatively. This 4-year PhD has this goal, enable children to design their own smart things. This paper reports briefly on relevant literature and presents the research questions, the methodology and actions conducted up to the 4th year of a PhD research. Main results are also briefly presented.

Acknowledgments

Sincere thanks go to my supervisors, Dr. Rosella Gennari and Dr. Alessandra Melonio, for their guidance, to Dr. Mehdi Rizvi for his technical assistance, and to all the participating children.

References

[1] G. Kortuem, F. Kawsar, V. Sundramoorthy, D. Fitton, Smart objects as building blocks for the internet of things, IEEE Internet Computing 14 (2010) 44–51. doi:10.1109/MIC.2009.143.

[2] M. E. Foundation, micro:bit, https://microbit.org, 2019. Accessed: 2021-03-20.

[3] S. Labs, Sam labs, https://samlabs.com/, 2020. Accessed: 2021-03-20.

[4] N. Iivari, M. Kinnula, Empowering Children Through Design and Making: Towards Protagonist Role Adoption, in: Proceedings of the 15th Participatory Design Conference: Full Papers–Volume 1, PDC '18, ACM, New York, NY, USA, 2018, pp. 16:1–16:12. doi:10.1145/3210586.3210600.

[5] T. Bekker, S. Bakker, I. Douma, J. van der Poel, K. Scheltenaar, Teaching children digital literacy through design-based learning with digital toolkits in schools, International Journal of Child-Computer Interaction 5 (2015) 29 – 38. doi:10.1016/j.ijcci.2015.12.001.

[6] R. C. Smith, O. S. Iversen, M. Hjorth, Design thinking for digital fabrication in education, Int. J. Child-Comp. Interact. 5 (2015) 20–28. doi:10.1016/j.ijcci.2015.10.002.

[7] O. S. Iversen, R. C. Smith, C. Dindler, From computational thinking to computational empowerment: A 21st century pd agenda, in: Proceedings of the 15th Participatory Design Conference: Full Papers - Volume 1, PDC '18, ACM, New York, NY, USA, 2018, pp. 7:1–7:11. doi:10.1145/3210586.3210592.

[8] M. Van Mechelen, A. Laenen, B. Zaman, B. Willems, V. V. Abeele, Collaborative Design Thinking (CoDeT): A co-design approach for high child-to-adult ratios, International Journal of Human Computer Studies 130 (2019) 179–195. doi:10.1016/j.ijhcs.2019.06.013.

[9] R. Gennari, A. Melonio, M. Rizvi, A. Bonani, Design of iot tangibles for primary schools: A case study, in: Proceedings of the 12th Biannual Conference on Italian SIGCHI Chapter, CHItaly '17, ACM, New York, NY, USA, 2017, pp. 26:1–26:6. doi:10.1145/3125571.3125591.

[10] M. Manca, F. Paternò, C. Santoro, L. Corcella, Supporting end-user debugging of trigger-action rules for iot applications, International Journal of Human-Computer Studies 123 (2019) 56–69. doi:10.1016/j.ijhcs.2018.11.005.

[11] R. Bhaumik, A. Bhatt, M. C. Kumari, S. Raghu Menon, A. Chakrabarti, A gamified model of design thinking for fostering learning in children, in: A. Chakrabarti (Ed.), Research into Design for a Connected World, Springer Singapore, Singapore, 2019, pp. 1023–1036.

[12] K. Lewin, Action research and minority problems, Journal of Social Issues 2 (1946) 34–46.

[13] G. R. Hayes, The relationship of action research to human-computer interaction, ACM Trans. Comput.-Hum. Interact. 18 (2011). doi:10.1145/1993060.1993065.

[14] J. C. Read, S. MacFarlane, Using the fun toolkit and other survey methods to gather opinions in child computer interaction, in: Proceedings of the 2006 Conference on Interaction Design and Children, IDC '06, Association for Computing Machinery, New York, NY, USA, 2006, p. 81–88. doi:10.1145/1139073.1139096.

[15] R. Gennari, M. Matera, A. Melonio, E. Roumelioti, A Board Game and a Workshop for Co-Creating Smart Nature Ecosystems, in: Proc. of the 9th International Conference in Methodologies and Intelligent Systems for Technology Enhanced Learning (mis4TEL 2019), Springer, 2019, pp. 137–145. doi:10.1007/978-3-030-23990-9_17.

[16] R. Gennari, M. Matera, A. Melonio, M. Rizvi, E. Roumelioti, Reflection and awareness in the design process children ideating, programming and prototyping smart objects, Multimedia Tools and Applications (2020). doi:10.1007/s11042-020-09927-x.

[17] R. Gennari, M. Matera, A. Melonio, E. Roumelioti, Snap 2: The evolution of a board game for smart nature environments, in: Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts, CHI PLAY '19 Extended Abstracts, Association for Computing Machinery, New York, NY, USA, 2019, p. 405–411. doi:10.1145/3341215.3356281.

[18] E. Roumelioti, R. Gennari, M. Matera, A. Melonio, M. Rizvi, Towards making children independent in design, in: Companion Publication of the 2020 ACM Designing Interactive Systems Conference, DIS' 20 Companion, Association for Computing Machinery, New York, NY, USA, 2020, p. 227–232. doi:10.1145/3393914.3395849.

[19] R. Gennari, M. Matera, A. Melonio, E. Roumelioti, A board-game for co-designing smart

nature environments in workshops with children, in: End-User Development, Springer International Publishing, Cham, 2019, pp. 132–148. doi:10.1007/978-3-030-24781-2_9.