



FREE UNIVERSITY OF BOZEN - BOLZANO  
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Ph.D. Thesis  
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# Participatory Game Design and Children

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## ABSTRACT

This Ph.D. thesis revolves around participatory design with children for the early design of games for them. The Ph.D. research aimed at developing a method and guidelines for participatory game design with children. The Ph.D. work adopted an empirical research approach for developing the method and guidelines.

The method draws from prior work, from different research areas, to propose new ideas or relationships between existing constructs. Specifically, different research areas from design and education were cross-fertilized in the method in order to sustain engagement, learning and collaboration during a participatory game design experience, prolonged and fragmented in time. Principles of gamification of learning and gamified probes were used for sustaining engagement throughout the experience, and cooperative learning was introduced for fostering democratic collaboration. The method emerged iteratively through field studies, gathering both qualitative and quantitative data, and it matured through an iterative learning process.

This Ph.D. thesis presents firstly the relevant work on which the method breeds, secondly the method itself, and subsequently the major field studies. Finally, the thesis presents guidelines for conducting a participatory game design experience with children, and resulting from findings of field studies.





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*Alessandra*

## PUBLICATIONS OF THE AUTHOR

### PUBLICATIONS RELATED TO THE TOPIC OF THE THESIS

In the following is reported the list of the author's publications that are related to the topics discussed in the thesis (updated to April 2016).

#### *International Journals*

- Brondino M., Dodero G., Gennari R., Melonio A., Raccanello D and Torello, S. "I am Happy, I am Social, I've Realized Quality Games" or Why Children's Emotions Matter in Co- Design. Submitted to Special Issues of the International Journal of Human-Computer Studies. Elsevier. (Second round revision).
- Gennari R. , Melonio A., and Torello, S. From Gamified Probes to Gamified Tangibles for Cooperative Learning: A Case Study. Special Issue of the International Journal of Multimedia Tools and Applications, Springer, IF = 1.346. Guest editors: M. De Marsico and D. Fogli. DOI: 10.1007/s11042-016-3543-7. Forthcoming in 2016.
- Brondino, M., Dodero, G., Gennari, R., Melonio, A., Raccanello, D., and Torello, S. (2014). Achievement Emotions and Peer Acceptance Get Together in Game Design at School. ADCAIJ: Advances In Distributed Computing And Artificial Intelligence Journal, 3(4), 1-12. DOI:10.14201/ADCAIJ201434112.
- Di Mascio,T., Gennari, R., Melonio, A. and Vittorini, P. Designing Games for Deaf Children: First Guidelines. In International Journal of Technology Enhanced Learning (IJTEL), Vol. 5, Nos. 3/4, pp. 223–239, Inderscience Enterprise Ltd., 2013.

#### *International Conferences and Lecture Notes*

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- Dodero G., Gennari R. , Melonio A., and Torello, S. "There Is No Rose Without A Thorn": An Assessment of a Game Design Experience for Children. In Proceedings of the 11th Biannual Conference on Italian SIGCHI Chapter (CHIItaly 2015). ACM, New York, NY, USA, 10-17.
- Corral,L., Fronza, I., Gennari, R. and Melonio, A. From Game Design with Children to Game Development with University Students: What Issues Come Up?. In Proceedings of the 11th Biannual Conference on Italian SIGCHI Chapter (CHIItaly 2015). ACM, New York, NY, USA, 30-33.
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- Melonio A. Gamified co-design with cooperative learning at school. In Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play (CHI PLAY '14). ACM, New York, NY, USA, 295-298.
- Del Fatto, V. G. Dodero, R. Gennari, A. Melonio, Montali, M., Razniewski, Torello,S., Wang, X. and Zini, F. Gamified children universities: an exploratory study. In Proceedings of the first ACM SIGCHI annual symposium on Computer-human interaction in play (CHI PLAY '14). ACM, New York, NY, USA, 409-410.
- Dodero G., Gennari R. , Melonio A., and Torello, S. A Lean Experience of Game Fabrication: From School to University and Back. In Technical Proc. of the FabLabs in Educational Context Workshop, part of Fablearn Europe 2014, co-located with IDC 2014.
- Dodero G., Gennari R. , Melonio A., and Torello, S. Gamified co-design with cooperative learning. In CHI '14 Extended Abstracts on Human Factors in Computing Systems (CHI EA '14). Acceptance rate: 37.5%. ACM, New York, NY, USA, 707-718.

- Di Mascio, T., Gennari, R. and Melonio, A. Gamify your Field Studies for Learning about Your Learners. In Proc. of 3rd International Workshop on Evidence Based and User centred Technology Enhanced Learning. September 2013. Springer, 135-142
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- Melonio A.. Game-based Co-design of Games for Learning with Children and Teachers: Research Goals and a Study. In Proceedings of the CHIItaly 2013 Doctoral Consortium co-located with the 10th International Conference of the Italian SIGCHI Chapter (CHIItaly 2013), Trento, Italy, September 16, 2013. <http://ceur-ws.org/Vol-1065/paper3.pdf>
- Melonio, A. and Gennari, R. How to Design Games for Deaf Children: Evidence- based Guidelines. In proceedings of 2nd International Workshop on Evidence-based Technology Enhanced Learning (Salamanca, Spain, May 2013), Vol. 218 (Advances in Intelligent Systems and Computing). Springer, pp 83-92.

## PUBLICATIONS NOT RELATED TO THE TOPIC OF THE THESIS

List of the author's publications that are not related or that are marginally related to the topics discussed in the thesis.

### *International Journals*

- Di Mascio, T., Gennari, R. and Melonio, A. and Tarantino, L. and Vittorini, P. Supporting Children in Mastering Temporal Relations of Stories: the TERENCE Learning Approach. In Special Issue of the International Journal of Distance Education Technologies (IJDET) on Visual Aspects in Technology Enhanced Learning, Vol. 1, in press in 2016.

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- Cecilia, M.R., Di Mascio, T. and Melonio, A. The 1st Release of the TERENCE Learner GUI: the User-based Usability Evaluation. In proceedings of 2nd International Workshop on Evidence-based Technology Enhanced Learning (Salamanca, Spain, May

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- Di Mascio T, Gennari R, Melonio A, Vittorini P. The User Classes Building Process in a TEL project. In proceedings of International Workshop on evidenced-based Technology Enhanced Learning (Salamanca, March 28-30 2012), vol. 152, (Advances in Intelligent Systems and Computing). Springer. 107-114.
- Alrifai, M., Di Mascio T, Gennari R, Melonio A, Vittorini P. and De la Prieta, F. The Learners' User Classes in the TERENCE Adaptive Learning System. In proceedings of Advanced Learning Technologies (ICALT), 2012 IEEE 12th International Conference on , vol., no., pp.572-576, 4-6 July 2012.
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- Melonio, A., Tarantino, L. and Di Mascio, T. Towards ICT support for elderly displaced people: looking for natural gestures. In proceedings of the 8th Conference of the Italian Chapter of AIS conference (ITAIS 2011, Rome) (Information Systems: Crossroads for Organization, Management, Accounting and Engineering). Springer, 135-143.

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# 1

## INTRODUCTION

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### 1.1 RESEARCH MOTIVATION AND CONTEXT

The topic of my thesis has grown out of my previous experiences as a university student. During my university studies, I gathered some experiences in **Human Computer Interaction (HCI)**. In particular, I was attracted by the idea of designing products for people, with people at the center of the design process, so as to improve the quality of the product and to maximize the user satisfaction.

After graduating, I spent one year as junior researcher in **Child Centered Interaction (CCI)**, a sub-area of HCI, since I was involved in the European FP7 **TERENCE** research project. **TERENCE** aimed at developing an adaptive learning system, for improving reading skills of children aged 7–11 (hearing and deaf) who also were considered poor comprehenders. **TERENCE** devised learning material and a pedagogical plan adapted to need of such learners ([TERENCE consortium, 2010](#)). The **TERENCE** material consisted on stories, and **educational games** for reasoning about stories. I was involved in several stages of the project: (1) analyses of the context of use, using HCI data gathering methods for children and with children, for specifying their requirements; (2) (early) design of games with game design experts; (3) evaluation of games with children.

During the context of use, data gathering and evaluation sessions with children, I witnessed how children were willing to express their ideas for creating “their” own educational games. This fact was very stimulating for me, so I shifted my attention to the possible involvement of children in the early-game design process itself, instead of

letting designers develop games starting from children requirements as in traditional HCI. This is why I decided to enroll in the Ph.D. programme at the Free University of Bozen-Bolzano, at the end of my activity within TERENCE, and to pursue a research topic in such area.

The research aim of my Ph.D. thesis became **designing games with and for children**. My Ph.D. activity started considering the various variables and issues to face when children are involved in the game design process.

After a thorough literature review and discussions with CCI experts, **participatory design (PD)** stood out as the HCI comprehensive method that allows designers to work with any end-user. In case products are games for children, having children as co-designers should help in producing more playable games, meeting the requirements of nowadays children. More generally, PD brings advantages in terms of innovation and appropriateness of design, which can outweigh the fact that PD is time consuming and requires several resources (Nesset and Large, 2004).

My Ph.D. work adopts PD of digital games for children, with children, and in **learning contexts**. PD in learning contexts counts several studies, but a uniform reading of co-design for nowadays learning contexts, e.g., school, was missing. Several open questions and challenges emerge when adapting PD in learning contexts, such as how to empower all participants, children and designers, bringing learning benefits and engagement, and including all children in early design activities.

Due to the complexity and the constraints of learning contexts, the need to design and conduct exploratory **field studies** emerged. These studies gave me the opportunity to highlight the factors to explore, and the criteria to use, in order to effectively include all children, and to empower all participants. Moreover, working in the school context required to acquire knowledge of instructional design, as well as to actively work with researchers and practitioners in the education field.

The analysis of a multitude of studies reported in literature, together with my own experience in the field, created the basis for **designing games with children in learning contexts, so as to empower children and designers, and include all children**.

### 1.2 RESEARCH CONTRIBUTIONS

This section overviews the research contributions of this Ph.D. thesis. It describes the main research goal and objectives, as well as the main research contributions of this thesis.

## 1.2.1 Research Goal

The **overall goal** of this thesis is to adapt and refine PD methods and techniques for (early) designing games with children and for children in learning contexts, so as to empower children and designers, including all children in the design process.

## 1.2.2 Objectives and Research Questions

The main research question related to the thesis goal is as follows:

**RQ.** How to co-design games with children in learning contexts, so as to empower and include all?

In order to answer the above question, this was split into the following more specific questions:

**RQ.1** How to include all learners' game design ideas? In other words, how to foster democratic collaboration among children and with adults so that all children "have a voice" in the design process?

**RQ.2** How to empower children in terms of engagement in game design?

**RQ.3** How to empower children in terms of learning, about of early game design?

**RQ.4** How to empower designers in terms of learning about children's game design ideas?

To answer these questions, this thesis addresses different objectives:

1. **PD and game design literature review.** The first objective was to gain an in-depth understanding of PD and game design methods used with children for involving them in the game design process. This objective was addressed through the review of the related literature.
2. **Analysis of the learning context.** The second objective was investigating challenges and constraints that learning contexts impose on participatory game design with children. This objective was addressed through an empirical research approach via exploratory studies.
3. **Specifying the method.** Abstracting from lessons learnt by tackling the above objectives, this Ph.D. work aimed at specifying the method for co-designing games with and for children in learning contexts. This objective was addressed using an empirical research approach for iteratively refining the method.

4. **Set of guidelines.** Finally, drawing upon the results of field studies, this Ph.D. work aimed at compiling a set of guidelines for conducting participatory game design studies so as to include and empower all participants.

### 1.3 THE EMPIRICAL RESEARCH APPROACH AND ITS EVOLUTION

My Ph.D. work adopted an empirical research approach aimed at generating a participatory game design method.

The method is generated as “intermediate theories” are generated (Edmondson and McManus, 2007): it draws from prior work, from different research areas, to propose new ideas or relationships between existing constructs. It emerges through field studies, appropriate for exploratory endeavors to stimulate new ideas. In this thesis, data gathered in field studies are hybrid: qualitative and quantitative. The design method matures through an iterative learning process that requires a mindset in which feedback, rethinking, and revising are embraced as valued activities. How the method was developed is explained in details in the following.

The **first step** was a review of participatory design and game design literature studies, focusing on working with children.

The **second step** required an investigation of learning contexts where to conduct participatory game design studies. For gaining a deep understanding of learning contexts (participants, tasks, environment), we conducted exploratory field research studies with children in different settings, namely, university children laboratories and summer schools. In parallel we also did brainstorming meetings and inquiries with domain experts of educational psychology and pedagogy researchers, interaction design and children, and game design.

The knowledge acquired from the analysis of learning contexts allowed us to move towards a first instance of a new participatory game design method. This required to actively involve education researchers and education practitioners, such as primary-school deans and teachers. Studies conducted in 2013 in primary and middle schools allowed us to test the preliminary version of the method.

Specifically in 2013, two primary school classes were involved in co-designing game starting from a story<sup>1</sup> read in class. The activity was centred in a short-time (2 hours per class), and teams of children co-designed prototypes of games, by resolving missions. The design

<sup>1</sup> A story can be defined as a narrative, either true or fictitious, in prose or verse, designed to interest, amuse, or instruct the hearer or reader; tale.

activity was conceived as a game in itself, i.e., it was gamified. During the co-design activity, each team of children was supported by a designer, with a scaffolding role (Dodero et al., 2014b). Then designers observed, tracked and analysed game elements that children understood and frequently inserted in their game design, e.g., rewards, levels, characters. Such knowledge as well as literature findings (other studies conducting game design with children) led a revision of the method and protocols for the subsequent studies.

The **third step**, in fact, was deriving from this field study a more mature version of the participatory game design method. The new version of the method better specified roles of designers and teachers. Teachers, as experts of education and of school contexts, became responsible for coaching and scaffolding group work. As for experts, the new version of the method reduced their presence in the design team. The aim was to improve the quality experience of children, by allowing them to fully express their ideas, as independently as possible from designers.

The new version was suited for developing game design activities spanning across several school days, so as to bring children learning benefits. Maintaining participants' long-term engagement became important and challenging. To this end, a step further by mixing together gamification and co-design was done: gamified probes were used for creating engagement throughout the experience, stimulating positive activating emotions, such as enjoyment and relaxation. Cooperative learning was also introduced for fostering democratic collaboration during participatory game design. A field study was thus conducted in two primary schools during 2014.

In the **fourth** and final **step**, the method was further refined through a second field study, run in 2015. The goal was to enhance children's engagement towards the end of game design because this turned out to be cognitively demanding and created a certain degree of anxiety in the 2014 study. In particular, the gamified probes that supported children's teamwork were made interactive in a non-intrusive manner, and capable of storing data concerning children's progression through game design and their collaboration.

In between the third and second step, and the related field studies in 2014 and 2015, we executed another study with the aim of developing children's products. Specifically, children's products, namely game design documents with low-fidelity prototypes released at the end of the 2014 study, were picked up as-is by university students so as to develop children's ideas into high-fidelity interactive game prototypes.

This research process resulted in the definition of guidelines for conducting participatory game design studies so as to include and empower all participants.

## 1.4 OUTLINE OF THE THESIS

The Thesis is structured as follow:

**Chapter 2** presents an overview of PD and game design, and a literature review of related methods and studies in the area of design for and with children. The chapter ends with open challenges found in literature about how children are involved in co-design of games, and recaps related theories that help us in tackling such challenges. The challenges are related to the research questions presented in this chapter.

**Chapter 3** presents the participatory game design method (GaCoCo) for tackling the emerged challenges, and guiding children to conceive and create prototypes of games for children at school. The method is developed as a PD method that a designer can use to plan, conduct and assess an early game design experience with children.

**Chapter 4** describes the field study executed in two primary schools in 2014 and the lessons learnt from them. The study adopts the method with children at school, and focuses on empowering both children and designers, including all children.

**Chapter 5** describes the field study executed after the 2014 study. The chapter explains how children's products, namely game design documents with the related low-fidelity prototypes released at the end of the 2014 study, were picked up as-is and developed by computer-science university students.

**Chapter 6**, drawing from knowledge acquired by the 2014 study, presents the 2015 study, with its last refinement of the participatory game design method. In particular, building on top of the 2014 study results, it presents changes and new outcomes.

**Chapter 7** develops a set guidelines, emerged from the experience gained through field studies, and that should guide researchers and professionals to early game design with children in learning contexts.

**Chapter 8** recaps the research work reported in this thesis, with our answers to the research questions, a discussion of the achievement of research objectives set in this introduction, and a summary of the research contributions. The chapter and the entire thesis, concludes with considerations of the limitations of the research work, and directions for further research.

# 2 | BACKGROUND

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In order to clarify the scientific background of this work, this chapter presents a review of related research in HCI and Game design, with and for children. Section 2.2 deals with the User Centred Design (UCD) methodology as the evolution over time of the Interaction Design discipline and its process, in order to provide the rationale behind the PD approach, presented in Section 2.3. Section 2.4 includes an overview of game design, and how to design games with and for children. The chapter ends with Section 2.5, that describes open challenges when children are involved in co-design of games, and the related theories that help us in tackling them, in Section 2.6.

## 2.1 APPROACH TO THE LITERATURE REVIEW

In order to determine the background for the thesis research, we proceeded with a literature review in two main steps. In the first step, we conducted an exploratory review of the literature concerning PD and game design with children. In order to conduct this review, we searched through general databases, such as Scopus, ACM Digital Library, Google Scholar, Science Direct and IEEE Xplore Digital Library.

The majority of relevant papers were found in proceedings of conferences or workshops related to HCI, with a focus on CCI, and Interaction Design (ID). A few studies were found in journals, conferences, workshops or symposia concerning Game Based Learning (GBL), Technology Enhanced Learning (TEL), PD. We analyzed the retrieved papers and retained only those relevant for the thesis research. Then, we investigated the references of the retained papers to enrich our literature review.

Afterwards, we clustered papers into two main category: PD with children and game design with children. The relevant work concerning PD with children is presented in Section 2.3, and it is placed in the more general context of user centred design (Section 2.2). Game design work with children is presented in Section 2.4.

Literature analysis highlighted potential challenges for participatory game design with children. They were for the first time published in (Dodero et al., 2014a). In the second step, we extended our literature search for tackling the aforementioned challenges. To this end, we searched again through general databases and conferences considering the following keywords: PD with children, co-design with children, game design and children, game design engagement, co-design engagement, co-design game collaboration, performance PD children, PD learning and children. Moreover, as introduced in Chapter 1, we organized brainstorming meetings with domain experts and researchers of ID and children, game design, educational psychology and pedagogy.

The result of this second step were revised open challenges, presented in Section 2.5, as well as specific theories that can help in tackling the open challenges, presented in Section 2.6. These challenges and theories inform the participatory game design method presented in Chapter 3.



## 2.2 FROM DESIGNING FOR PEOPLE TO DESIGNING WITH PEOPLE

### 2.2.1 UCD Main Ideas

In the 1970s, UCD emerged as an HCI approach characterized by the reproduction or translation of user knowledge into principles and prescriptions that designers may work with. According to Preece et al (Preece et al., 2002), in UCD users are central information sources. UCD aims at "... finding out a lot about the users and their tasks, and using this information to inform design". In UCD, during the process lifecycle, designers should focus on what is being designed (e.g., product, interface, service), looking for ways to ensure that it meets the user needs (Sanders, 2002).

The ultimate goal of UCD is to optimize a user's experience with a system, product or process. UCD aims at realizing this goal ,by considering the user perspective and cognitive factors, during all phases of the design process—users are placed at the center of the design and development lifecycle. Moreover, considering users' perspectives and requirements from the beginning, users become an essential part in the design process. In (Nisbett and Wilson, 1977), the authors claims that more useful and relevant design ideas might emerge by giving an active central role to users. In addition, by this approach it is possible to eliminate the gap between the way the system actually works and the way users perceive and interact with it.

Over the years, several research fields and disciplines adopted the UCD approach in the design process: education, architecture, business, visual design, interaction design and usability. UCD became a multidisciplinary approach that includes application of knowledge and techniques on human factors and ergonomics. This application to the design of interactive systems enhances their effectiveness, improves the human labor conditions, and contrasts the possible adverse effects of their use on health, safety and performance. The presence of different types of expertise in design teams becomes fundamental for the creation of usable products: experts of different fields sit together with designers, and collaboratively create products, so that the role of a designer "begins to evolve towards design facilitation [...] [so as to work] on the best solutions in an ongoing way"(Gothelf, 2013).

At present, UCD is not a specific design methodology, but a general approach to design. It can be concretely developed in many ways, depending on the nature of the products to be made, and the characteristics of the organization that realizes the project.

### 2.2.2 The UCD Process

UCD was defined by a standard ISO in 1999. This standard, numbered 13407, specified the fundamental principles at the basis of UCD — “The goal of the standard is to ensure that the development and use of interactive systems take account of the needs of the user as well as the needs of the developer and owner... to name but a few stakeholders.” (ISO 9241-210, 2010).

The standard ISO 13407 was updated and re-issued as ISO 9241 – 210: “Ergonomics of human-system interaction, Part 210: Human-centred design for interactive systems”. This is a process standard, aimed at holding people responsible for managing design processes. It presents a high level overview of activities that are recommended for human centered design.

The standard describes 6 key principles that will ensure that a given design process is user centered: (1) the design is based upon an explicit understanding of users, tasks and environments; (2) users are involved throughout design and development; (3) the design is driven and refined by user-centered evaluation; (4) the process is iterative; (5) the design addresses the whole user experience; (6) the design team includes multidisciplinary skills and perspectives.

The rationale for following UCD principles is that a UCD process delivers products that are easier to understand and use (ISO 9241-210, 2010).

The UCD process implementing those six principles, and it can be summarized into four main general phases (see Figure 1 ): (1) **analysis**: identify people involved and the context of use ; (2) **specification**: identify requirements or user goals (3) **design and prototype**: create design solutions through stages, from a rough concept to a complete design; (4) **evaluation**: user feedback, ideally through usability testing.

There are many variations of the UCD process. Depending on the needs, the UCD process can become waterfall, agile, lean. Designers can select among many different methods and techniques, and regardless if they are exploring requirements or testing a solution, the same method can be adopted in many different design situations (Westlund et al., 2003; Bevan, 2009) in a design process. In a traditional UCD engineering process, users were mainly involved in the system requirement phase and in the usability testing. They were not involved in the design phase and in the prototype realization, phases that were mainly carried out by designers and professionals.

Growing attention has been given to the Lean User eXperience (Lean UX) approach, a branch of UCD. Lean UX design makes a heavy use of the notion of minimum-value products, such as low-fidelity proto-

## 2.3 PARTICIPATORY DESIGN (PD)

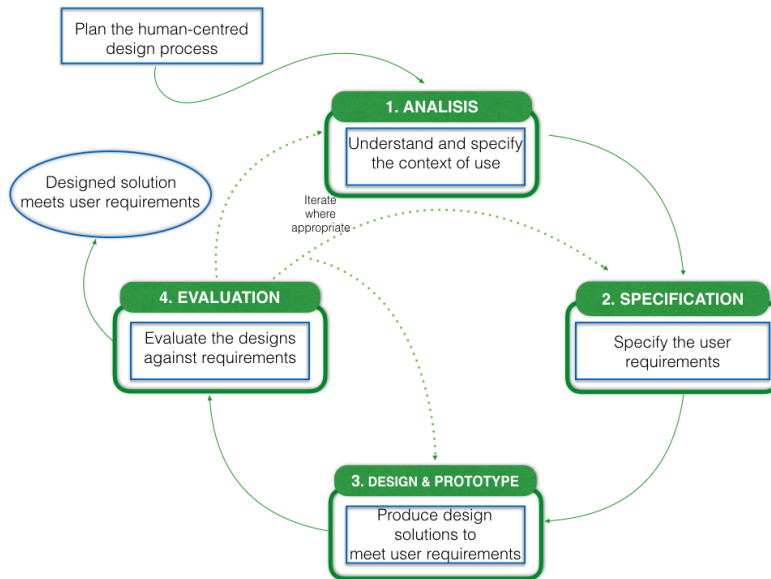


Figure 1: Design lifecycle from ISO 19240-210

types. These are used to create or evaluate alternative ideas with users, as quickly as possible, and as often as possible.

## 2.3 PARTICIPATORY DESIGN (PD)

### 2.3.1 PD: Main Ideas

*Participatory experience is not simply a method or set of methodologies, it is a mindset and an attitude about people. It is the belief that all people have something to offer to the design process and that they can be both articulate and creative when given appropriate tools with which to express themselves (Sanders, 2002).*

The idea of PD appeared in Scandinavia in the 1970s partly due to the labor union push for workers to have more democratic control over changes in their work (Ehn and Kyng, 1987). In PD, the user involvement reaches a deeper level: users are actively involved in the design process and might also be a component of the design team (Ehn and Kyng, 1987; Greenbaum and Kyng, 1992; Schuler and Namioka, 1993).

Sanders defined PD as a new attitude to design that requires new ways of thinking and working. Moreover, she introduced the term co-design, intended as people that design together. In this way, people

have the opportunities to collect and expand a larger set of ideas (Sanders, 2002).

Nowadays, PD is defined as a set of theories and practices that emphasize the role of the end-users as full participants in the design process; in essence, users are co-designers. The term **co-design** has begun to be increasingly used, considered as a step forward from UCD, and closely associated with PD.

The consequence is that the co-design term is overloaded. In a recent work (Mattelmäki and Visser, 2011), the authors addressed the terminological challenge of identifying the relationship among co-design and several other related terms, including co-creation and PD. They summarized the various uses of co-design and co-creation as follows: “Co-design is a process, and the planning, adjusting tools and facilitation is built on a mindset based on collaboration . . . Co-creation can take place within co-design processes but focuses much more on the collective creativity of involved users and stakeholders” (Mattelmäki and Visser, 2011).

In this dissertation, co-design builds on PD, and it is used in the sense of (Sanders and Stappers, 2008): collective creativity during a design process.

### 2.3.2 PD: How to Use It

Over the years, research into PD and co-design has attracted increasing interest. PD has been explored in several contexts and carried out within different projects. Examples include education (Guha et al., 2005; Alborzi et al., 2000; Könings et al., 2014), home (Westerlund et al., 2003), public environments (Fosh et al., 2014; Derboven et al., 2015; Vines et al., 2013), healthcare (Sjöberg and Timpka, 1998), social science, action research (Foth and Axup, 2006; Greenwood and Levin, 2007), design and art (Muller and Loke, 2010), open source platforms and social media (Ehn, 2008; DiSalvo et al., 2014).

During the latest ten years, PD has gained momentum for designing novel systems. There is no single way of doing co-design with users, but there are numerous methods and activities which can be carried out in all stages of PD lifecycle. The methods used depend on the design purpose and on the specific context where the designer will adapt the methods and techniques.

Already in the early '90s, Muller et al. presented a brief guide for designers and practitioners that includes the first taxonomy of all the practices involved in PD (Muller et al., 1993). It focuses on the use of PD in different stages of the design process, and with different degrees in user involvement. In (Muller et al., 1993), Muller et al. survey

methods and techniques of PD that can lead to *hybrid experiences*. The hybrid experiences is defined in (Muller, 2003) as “a fertile environment in which participants can combine diverse knowledges into new insights and plans for action”. This environment creates the optimal conditions for reducing power relations, and allows everyone to feel in an equal position and free to express oneself.

In 2008, Lee and Bichard (2008) proposed a framework for supporting designers during PD, focusing on the level of involvement of the different stakeholders, and on their role in the design process. By increasing involvement, roles of users change from passive to active. During this changing, designers and users work together as partners in a “design collaboration stage”.

Subsequently, in 2010, Sanders et al. in (Sanders et al., 2010) proposed a practical and useful framework that organizes several tools, techniques and methods for PD. This framework helps the PD community to decide which tools and techniques are most relevant for a specific situation.

Recently, Frauenberger et al. in (Frauenberger et al., 2015) proposed a conceptual framework namely a “tool-to-think-with”, which guides designers, researchers and practitioners in incorporating PD in their work in a reflective way, more focussed into knowledge construction. The tool proposes four lenses to critically reflect on the nature of a PD effort: epistemology, values, stakeholders and outcomes. “This tool aims to provide a language that enables us to have a debate about what works when and why ... and avoids PD being judged against positivistic standards it was not designed to meet.”

### 2.3.3 PD: What to Use or Not to Use

As reported in (Kujala, 2003, 2008), PD can bring benefits to designer, the product under design and its users. Design with users, as experts in their own work context, can only be **effective** within that context, and if these experts are allowed to contribute actively to the design (Dix et al., 1997). The involvement of users, in discussing problems and solutions together, assures that the **product** will be **suitable for its intended purpose** in the environment in which it will be used. In the reminder, positive and negative aspects of using PD are presented.

#### *Positive Aspects*

PD has several key advantages. It might promote **constructive reflection and dialogue** when all users work together towards shared

goals. PD forces designers to look at things from **another point of view** and to **respect others' opinions**—co-design requires everyone to be creative: researchers, designers, clients, stakeholders and final customers. Moreover, PD might help designers to gather several other facts about design situations they may not have been aware of. For instance, co-design forces designers to confront with the realities of customer emotions, and the motivations behind their behavior.

When people take part in the creation of a product they develop a sense of **personal ownership** in the success of the project. This is strictly related to the sustainability of the project itself. A co-design process brings potential for **sustainability** if people's involvement in design contributes to foster a sense of project ownership (Ramirez, 2009). Moreover, as reported in (Sanders and Stappers, 2008), co-design promotes and relies on **social and mutual learning**, due to the collaborative nature of the co-design process. Learning takes place through participation in group settings, and through exchange and sharing of ideas (Sanders and Stappers, 2008).

#### *Negative Aspects*

A disadvantage of PD is that, during PD, users' thinking can be constrained by what they know (Preece et al., 1994, 2002), limiting them to focus on what they have already experienced. Kujala (2008) reported that involving users is not an easy task for designers, and demonstrated the importance for product developers to early involve users, under the condition that the user and its roles are carefully considered. When users are involved in the design of a product, they have **expectation** about the product. If the product cannot be realised as expected by the user, the designer should take it into account in order to avoid higher expectations and subsequent frustration.

Due to the involvement of different users from widely different domains and disciplines, another difficulty for a successful experience of PD is the **communication** between participants. Members of the team have to learn to communicate effectively and to respect each other's contributions and expertise. This can be time-consuming, it adds costs to the process and cannot guarantee high quality of the end products. In (Ehn, 1992), Ehn reported that "... in the beginning all you can understand is what you already have understood" and how it is difficult to create a design language that makes sense to all participants. Due to the fact that different perceptions and situations might arise between involved users, use of low-fidelity material, e.g., mock-ups or paper-based prototypes, is recommended; not because they mirror "real things", but because they support interaction and reflection.

Therefore, PD can be quite **costly** and it requires both **financial and human resources**. Additionally, it needs of time to gather data from and about users.

In addition to the several contexts and domains in which PD is applied, PD has also considered different users, such as children, and different roles, depending on the project purpose and the contexts. In the remainder, we focused on PD and children.

#### 2.3.4 PD and Children

This part focuses on work concerning PD with children. Firstly it explains why involve children in PD process. Secondly it overviews the theories related to the children's development and their needs. Thirdly, it describes different children's degree of participation in PD, and the PD methods and techniques found in literature. Finally, it focuses on what aspects (advantages and disadvantages) to take into account during PD with children.

##### *Why PD with Children*

Co-designing with children is an area of research that grew in parallel with co-designing with adult users. Since the 1990s, children, as a growing target group in terms of number and economic potential (Bekker and Markopoulos, 2003; Markopoulos et al., 2008; Guha et al., 2005), are one of the specific groups of technology users that designers have started to focus on. Different PD methods and techniques for different purposes foresee the involvement of children as designers, with different degrees of participation (Fails et al., 2013; Nesset and Large, 2004; Read and Markopoulos, 2013). In spite of its several success stories, PD with non-designers in general, and with children in particular can be challenging to conduct (Mazzone, 2012) and difficult to communicate (Frauenberger et al., 2015).

When children become active "users" in a design process, designers must shift their focus on children needs and their context of use. An important gift of a child is his or her creativity. Children have unconventional viewpoints, regardless of the topic, even for the most complicated matters, and are always ready to share their thoughts. Young people, compared to other generations, are more skilled about technologies, and have differing abilities to express their ideas and to follow structured tasks. For this reason, methods for collecting information and generating solutions should be sensitive to their skills. The younger ones are interactive, information active, socially and interna-

tionally aware, and highly mobile: “children are natural partners for co-design” (Guha et al., 2013).

In the literature, there are several theories and guidelines useful for designers to get oriented on children needs, and to understand how to involve them in a proper way in the design process. Although PD with children can be challenging to manage (Mazzone, 2012; Van Mechelen et al., 2014, 2015; Frauenberger et al., 2015), children as co-designers, with their creativity and different perspective, become a valuable resource for interaction design.

### *Children’s Cognitive Development*

One of the first aspect to consider when designing for children, is that they differ from adults in cognitive development. Cognitive development theories offer important guidelines to designers. The theories we focuses for this thesis are in the following.

As reported in (Piaget, 1952), **Piaget** considered different stages of development, in relation to age. At each stage, a child is “constantly creating and re-creating his own model of reality, achieving mental growth by integrating simpler concepts into higher-level concepts”. The stages go from the sensory-motor stage (until 2 years) to the last stage, the formal operational one (from 12 to 15 years old) when the child’s thinking involves abstract reasoning. Piaget highlights the importance of individual and subjective repetitive experiences in order to develop an understanding of the world and to move from stage to stage. His goal was to persuade the educational system to adapt its activities to this new thinking. In our research we focus on children between 8 and 11 year old, that is, they belong to the concrete operational stage, when intelligence starts to be logical but still refers to concrete things. Moreover, Druin in (Druin, 1999) reported that, children in the age 7–11 belong to the best suited development stage as young partners in co-design.

Also r related to cognitive development of children is the **Vygotsky’s** theory (Vygotskiĭ, 1978). Vygotsky supports a view of development as more domain-specific: he regarded development as highly “situated”, and believed that, to understand cognitive development, the time and place where skills are acquired should be considered as well. According to Vygotsky, learning happens through interaction with adults, and it is based on two concepts: the zone of proximal development, a characteristic of a specific relationship between learner and tutor; scaffolding, a type of assistance to help learners accomplish a task that they would not have been able to do on their own (Vygotskiĭ, 1978).



Several researchers stressed the importance to consider children's cognitive development in PD studies that involve children and wrote specific guidelines for designers.

In (Chiasson and Gutwin, 2005) authors presented a catalogue of design principles for children's technology, oriented towards the designer needs. The catalogue is based on the analysis of a wide range of research into children's technology and it is organized following the three categories of children development: cognitive, physical, and social/emotional. The authors found the addressing of emotional needs especially problematic, due the strict relationship between motivations and engagement.

Other guidelines for designers, aiming at involving children in the design process, were provided by Gelderblom (2014). In (Gelderblom, 2014), Gelderblom, throughout a literature investigation, reported about 300 guidelines for the design of technology for children aged 5–8 years. The guidelines were organised in six categories, that integrate the relevant theoretical fields and provide practical support for designers.

More general guidelines, concerning involvement of children in a co-design project, were provided by Mazzone. (Mazzone, 2012) outlines elements, such as children's roles and space, that are crucial in co-design sessions with children. Mazzone adopted six dimensions for defining a theoretical framework aiming at supporting practitioners in their decisions when coordinating co-design sessions. Each dimension, outlined as wh/hw questions (what, who, when, where and how ), focused on a specific element: (1) the involvement of users and their roles, (2) space location features and (3) time management in terms of duration of co-design practice. In addition, the framework presents a list of the (4) most common techniques used in co-designs sessions, and (5) issues concerning ethics and security. The last dimension refers to the (6) design scope and session's objectives.

#### *Children's Degree of Participation in PD*

During the design process, children can be involved with different degrees of participation (Fails et al., 2013; Nettet and Large, 2004; Druin, 2002). Druin considered different roles for children: users (Kaplan et al., 2006), testers (Hanna et al., 2004), informant (Scaife and Rogers, 1998) and design partners (Druin, 2002; Guha et al., 2005). Moreover, Garzotto in (Garzotto, 2008) outlined another role for children, that is the role of experience design innovators in discovering creative ways of interacting with digital artifacts.

At different stages in a product development cycle, co-designing with children may include some combination of these roles. This thesis focuses mainly on including children in the design process as in-

**formants** and **design partners**. It is critical to support children in the design process, because adults do not experience the world as children, and they do not have the same insights into the world as a child.

In the role of informant (Scaife and Rogers, 1998), the child plays a part in informing the design process and s/he is not involved in the whole process. For instance, before a product is developed, designers may observe how a child behaves/interacts with existing technologies. Children may be asked to give input as paper sketches. Once a technology is developed, a child may again offer input and feedback. Within this role, a child plays a part in the design process at various stages, namely those where researchers believe they need information from children.

In the role of design partner, children are involved in creating design solutions. They guide design decisions and evaluate intermediate results. For instance, in the design of a new technology (Guha et al., 2005; Garzotto, 2008), a child is an equal stakeholder, and when s/he has this role, experimenters collect data and initiate children's ideas. Druin found that, when children accept their role as design partners, they perform better their role in evaluating and redesigning computer-related technologies (Druin, 2002).

#### *Methods and Techniques for Co-designing with Children*

In a co-design session all design partners (children and adults) establish common goals and participate in collaborative development activities. Different co-design methods have been devised for designing with children. In the majority of such methods, intergenerational teams are created, with children and adult researchers.

A method that involves children as equal members is the *cooperative inquiry method*, developed by Allison Druin and her team at the University of Maryland (Druin, 1999; Guha et al., 2013). It involves working with groups of children over long term period — usually for a long time, once or twice a week, in out-of-school contexts. Cooperative inquiry (based on PD and contextual inquiry) for co-designing with children (Druin, 1999) offers a chance for in-depth involvement of children in the (early) design process. Cooperative inquiry can be used to create, in principle, any type of technology with children. It largely focuses on the importance of creating a long-term partnership between adults and children working in group for creating together. Cooperative inquiry includes several tangible material to use during the project: bags of stuff (splices or low tech prototyping) that children and adults use together in order to “sketch” ideas for designing new technology or enhancing current technologies; layered elaboration that allows small design groups to expand on each other's ideas by

layering transparent sheets over initial concepts to add extensions and new ideas to designs without affecting the original. (Walsh et al., 2010). Over the years, cooperative inquiry was adapted in a more challenging context, such as the school context (Rode et al., 2003).

Another method, developed by Kafai (1996, 2003) involves *Children as Software Designers* and developers. Teams are formed only by children and adults intervene minimally during the design process, that is, are not intergenerational. An essential component of this kind of design is that children are programmers of software for their peers (Kafai, 2003) which is different from design partnerships where adults and children work together.

In *Blueballs* children are involved in specific design stages, whereas adults are responsible for analyzing the result of children's work and implementing it as an interactive prototype (Kelly et al., 2006). More precisely, *Blueballs* has two design stages with children: a brainstorming for starting the topic; a prototyping stage using paper for creating the product (a web site). Playful activities, such as hide-and-seek, are used to engage children in prototyping with paper-based material, and these activities tend to be carried on at school so as to include the entire class. Each class gets involved in short-term activities and children assess, as evaluators, interactive prototypes which are developed by adults.

In *Bonded Design*, children bond with adults on the design team playing the roles of informants and design partners (Large et al., 2006). Children participate for an intense short period of time, and utilize techniques typical of informants or design partners, e.g., brainstorming. *Bonded Design* often takes place in schools, but the intergenerational teams work on a product outside the classroom, and teachers are not involved in the design process. The rationale behind these choices is that the presence of teachers may recreate a teacher-student relationship, and working in classroom could suggest that the design activity is school activity. Moreover, *Bonded Design* is carried on during a time that is not traditionally reserved for instruction.

*Bridge* adopts different techniques for different design purposes, and relies heavily on PD (Iversen and Brodersen, 2008). It considers not only the cognitive development of children but also the social one, making children work in groups of four in a playful manner.

Vaajakallio and colleagues applied co-design methods in two design studies: *Design Game* and *MakeTools* (Vaajakallio et al., 2009). Their design sessions were organized with a game-like structure, with turn-taking and rules for supporting equal participation. Both in *Design Game* and *MakeTools*, researchers made children work in small groups

in relation to an instructional school activity. Moreover, they used tangible objects for prototyping so as to engage children.

#### *What To Do and What Not To Do*

Including children in the design process has interesting advantages but it is also challenging and it presents some disadvantages (Read and Markopoulos, 2013).

As reported in (Nesset and Large, 2004), co-design with children requires to establish a range of roles that children will be required to fulfill, and to manage their contributions. Children can come up with **ideas** that adults cannot envisage of Druin et al. (1998). As a downside, they might design things that are impossible to realize.

**Communication**, as reported in Section 2.3.3, becomes important when different types of users are involved. Certainly, it becomes more challenging when co-design partners are children. The use of terminology that children do not understand could isolate children from the process, and their creativity may be inhibited by wrong communication, for instance by constantly reminding them that certain things cannot be built. It is important to use a multidisciplinary team approach, in which to provide opportunities for creativity and to manage expectations of participants. In this way participants understand the constraints but, at the same time, they have freedom to innovate. There are ongoing debates in the literature about issues related to power relations between adults and children in co-design. Child-adult relations, and the environment created by adults for children, have a direct impact on which children the adults listen to, what they can talk about and what effect their opinions will have (Gelderblom, 2014).

Moreover, when children are actively and continuously involved in the design process, they grow ownership and responsibility for the tasks they perform (Iversen and Smith, 2012). Therefore, it is very important to develop effective working relationships with well-defined key decision makers and well-defined roles. For instance, if decisions of children are overruled by the (development) team, the situation is frustrating for children.

Another point to be stressed is the **context** where to involve children. While Druin, in (Druin, 2002), suggests to arrange extra-scholar activities, the school system, intended as a learning context, is the most direct way to access children aged 7–10 (Rode et al., 2003; Read and Mazzone, 2008). Co-design at school poses its own challenges, listed also in (Dodero et al., 2014a), which can affect the experience of co-design participants.

**Schools** pose **logistic** and **practical** constraints which designer should take into account when organizing the learning space and equipment.

For instance, they have limitations due to rigid time schedule and space arrangement (Vaajakallio et al., 2010). Moreover, the school context tends to be associated to boring rote by learners, who are used to more entertaining digital interaction. Extra efforts are related to the phases before, during and after the co-design activity: making arrangements with parents, teachers and carers; running design session in a school with its time and space constraints; interpreting data gathered from children.

When co-design happens in learning contexts, another dimension needs to be explored: the **learning benefits**, in terms of how co-design can foster learning, how can it be evaluated, and how much it engages children (Garzotto, 2008; Dodero et al., 2014a). Typically, co-design studies explore the satisfaction of children with co-design activities (Guha et al., 2005) and, often, the investigated skills are related to collaboration and discussion. Assessment of such skills is left to the evaluation of teachers alone, e.g., see (Garzotto, 2008). Different studies (Cavallo et al., 2004; Garzotto, 2008) involve children in learning projects, with learning goals for children, in terms of learning achievements and personal motivation. Since design activities with children can provide meaningful contexts for learning, children collect a rich learning experience, also in terms of developing collaboration skills or critical thinking capability (Garzotto, 2008). When co-design is applied in learning contexts, another important role, often neglected, is that of **teachers**. Roles and requirements of teachers vary across co-design studies, and are not always clearly specified (Garzotto and Gonella, 2011; Mazzone, 2012). Mazzone recommends involving education experts, e.g., teachers, when working with children, so as to ensure in the planning phase that the selected approaches are suitable for children, and for the setting they are applied into (Mazzone, 2012).

Moreover, when groups of children are involved in co-design activities, another relevant issue is how to organize **collaborative groups with balanced skills**. Children, having diverse learning styles and social skills, should be grouped together thus potentially enabling a fruitful collaboration and cooperation, but such collaboration can be difficult to achieve. The management of dynamics within groups of children and, more generally, the management of social relations among children is another important factor to consider when co-designing at school (Van Mechelen et al., 2014; Vaajakallio et al., 2009; Santos et al., 2014b,a). The more diversified are children, the harder the task, as a general rule. This diversity is intrinsic in the public school system in countries like Italy, and it is amplified by unavoidable globalization trends of today's society.

**Engagement** of children and its general definition are important and debated. A comprehensive definition of engagement considers it as an integrated user experience (Reeve et al., 2004; McCarthy and Wright, 2004)—“the emotional, cognitive and behavioral connection that exists at any point in time and possibly over time, between a user and a resource” (Attfield et al., 2011).

Engaging children, with fun, in a co-design activity in learning contexts meets the same challenges as any learning activity proposed by teachers. Including diverse children and positively engaging them in co-design at school might be difficult, and might be determinant for the success of (co-)design in such a setting (Prensky, 2005). The design material, such as paper-based material or prototypes, should allow both children and adults to clearly express their ideas and share opinions (Mazzone, 2012). Moreover, Iversen et al. (Iversen et al., 2010, 2013) describe how the participation of children in the design process can be used as a mean to engage with values.

#### *Children with Special Needs*

At present numerous designers have included children with special needs in technology design processes, and children with a wide range of disabilities have participated in design processes, to different degrees (Guha et al., 2008; Brederode et al., 2005; Tarrin et al., 2006; Mazzone et al., 2008; Garzotto and Gelsomini, 2015).

Children with special needs, who have been involved with designing technologies, include children who are blind or visually impaired (McElliott and van Leeuwen, 2004), children with physical or learning disabilities (Brederode et al., 2005; Walsh, 2009), children who are deaf or have hearing issues (Henderson et al., 2005; Iversen et al., 2007; Potter et al., 2014), children who are on the autistic spectrum (Barry and Pitt, 2006; Benton et al., 2014; Weiss et al., 2013), and children with behavioral issues (Jones et al., 2003; Mazzone et al., 2008).

Co-design of technology with children with special needs is always challenging and at the same time the life, worlds, and lived experiences of children with disabilities are way remote from the experiences of typical designers or researchers; giving children with disabilities a stake in the design of technology gives them an even greater sense of ownership and empowerment (Garzotto and Gelsomini (2015).

Inclusion of children with disabilities in the design process of interactive technologies, however, does not come without further risks and challenges (Guha et al., 2008; Mazzone et al., 2008). When designing technologies for children with disabilities, the focus is to alleviate the burden of the disability, and either enable children with disabilities to learn, or perform actions they would not be able to do without the tech-

nology. In (Guha et al., 2008), the author suggests an inclusive model for involving children with special needs as design partners in technology design process. According to Guha et al., (Guha et al., 2008), it is possible to involve children with disabilities as full design partners, as long as the researchers take into account both the nature and severity of the disability as well as the availability and intensity of support to the child.

To successfully ground design, during the design process, it is necessary to consider theories related to the specific disability, developmental theories from both cognitive and social perspectives, HCI theories, and learning theories. When the design process involves children with special needs, it is better to introduce technology as late as possible so as to free users from conforming to existing probes. The use of low-tech tools, such as pen and paper is more accessible and versatile, and low-tech prototyping material must provide natural means of communication and expression. Similarly, relationships and ethical issues require particular sensitivity to ensure that participants feel safe and able to contribute meaningfully to the design process.

## 2.4 GAME DESIGN

Game design has made great progress in HCI. HCI researchers have considered games since the 1980s, when Malone (1982), basing on the concept of fun in a games, proposed some guidelines for designing enjoyable user interfaces. This section overviews research in HCI and game design. It is organized as follows. It presents what games are, and benefits that playing games can bring. Then this section overviews what game design is, and the main stages of game design. Then the section changes track, and focuses on game design with children.

### 2.4.1 What a Game Is and Why Playing It

Over the years researchers in game design attempted to define the word “game”. In (Salen and Zimmerman, 2003), the authors examine several of these definitions and most make reference to rules, goals and play. The definition of Adams (2013) refers to a game as “a type of play activity, conducted in the context of a pretended reality, in which the participant(s) try to achieve at least one arbitrary, nontrivial goal by acting in accordance with rules.”

By definition, a game is an activity involving one or more players. Such an activity can be defined by either a goal that the players try to reach, or by some sets of rules that determine what the players can or



cannot do. Games are played primarily for entertainment or enjoyment, but may also serve as exercise or have an educational, simulative or psychological role.

Games and video games have become an integral part of the “human cultures”, and an essential part of childhood and adolescence (Greenberg et al., 2010). Several researchers explore what children can gain from video games (Egenfeldt-Nielsen, 2005; Olson, 2010; Tan et al., 2011; Akbal et al., 2014). They started to look at the positive impact of games both in a general way and for learning in particular. Several benefits, and positive and negative aspects, can be identified when kids play video game: promotion of a wide range of cognitive skills, e.g., spatial skills; promotion of an effective motivational style and positive emotions; and acquisition of social skills (Granic et al., 2014). Other reason would be, for example, challenge, expression of creativity, curiosity, discovery, or learning (Olson, 2010).

In relation to education, several studies supported the principle that games, if properly designed, can provide powerful affordances for motivation and learning. Studies have shown, for example, that well designed games can promote conceptual understanding and process skills (Annetta et al., 2009; Clark et al., 2013; Hickey et al., 2009; Klopfer et al., 2009), can foster a deeper epistemological understanding of the nature and processes through which scientific knowledge is developed (Barab et al., 2009; Neulight et al., 2007), and can increase in players’ willingness and ability to engage in scientific practices and discourses (Barab et al., 2009; Galas, 2006; Clark et al., 2013). The work of McClarty et al. (2012) reported an overview of the theoretical and empirical evidence concerning game play, claiming that the use of digital games in education can provide: (1) learning principles, (2) engagement of the learner, (3) personalized learning opportunities, (4) 21st century skills, and (5) an environment for authentic and relevant assessment. In (Gee, 2003) the author argues that games are fun because people can learn and grow as they play.

#### 2.4.2 Game Design in a Nutshell

Game design is a craft, combining both aesthetic and functional elements. Craftsmanship of a high quality produces elegance (Adams, 2013).

Designing or making games is a more complex activity than simply playing with them. It requires not only creativity but also several cognitive skills. Designing a game is a rich task and it has the potential to create a powerful learning environment (Smeets, 2005). It offers several



opportunities to exercise a wide spectrum of skills (e.g., devising game rules, creating characters and dialogues in order to create a complex artifact).

Game design is defined as a subset of game development. Briefly, game design is the process of creating and designing content and rules of a game (Schell, 2008). Schell defines game design as the act of deciding what a game should be and what determines the form of the gameplay. According to Prensky (2001), a game designer must, at first, understand the simplest forms of games and when designing a game s/he has to take into account some fundamental elements. A game should be fun and engaging so as to allow players to reach a flow state <sup>1</sup>. Moreover it is important that a game has a defined structure with rules, and a story so as to elicit emotions. Other elements are important: outcomes and feedback, that give the player learning and engagement; conflict, challenge or competition, that give player gratification and adrenaline to continue to play; problem solving so as to spark the player creativity.

Adams in (Adams, 2013) defines the work of a Game Designer as a complex set of tasks to perform so as to produce a “good” game design that transmits information to game developers and allows the refinement of the game during development and testing.

### 2.4.3 Game Design Process

There are different approaches to game design. Some designers prefer to work with their self-perceived unlimited creativity when designing games (Vanden Abeele and Van Rompaey, 2006). This approach has been called I-methodology (Oudshoorn and Pinch, 2003). Instead Adams, in (Adams, 2013), suggests designers use player centered game design, which follows UCD and places players at the center of the game design process (Sykes and Federoff, 2006). This approach is defined as a “philosophy of design in which the designer envisions a representative player of a game the designer wants to create” (Adams, 2013). Following the player centred game design approach, a game designer should focus on two game functions: entertainment of the player, and feeling empathy with the player. Designers also often release proof-of-concept prototypes with game design documents for play-testing (e.g., (Moser, 2013)).

In general, designing a game goes through the following main stages: (1) the analysis of the goal of the game and a first ideation of the high

<sup>1</sup> With “flow” the psychologist Csikszentmihalyi in (Csikszentmihalyi, 1997) names the feeling of complete and energized focus in an activity, with a high level of enjoyment and fulfillment.

level concept of the game, (2) the conceptualization of the game, and (3) its prototyping (Adams, 2013).

Game designers could start with the **analysis** of the goal of the game, and with the **conceptualization** of the game idea. This requires thinking of actions for reaching the goal of the game. In case the game is structured into levels, designers have to ideate the **core mechanics**<sup>2</sup>. for the rules and for progressing across levels, besides the **aesthetics** for the interface and interaction, including feedbacks. In case the game requires a storyline, designers have to make it consistent with the overall game mechanics and aesthetics (Adams, 2013).

The related **game design documents** are the following. The **high-level concept document** for the game concept that records the key ideas of the game. Depending on the game, other documents can be implemented and included in the high-level concept document: the character design document, that records the design of one character who appears in the game, and the **world design document**, that is a sort of background information about what the world contains. If the game has more than one level, the **storyline and progression level document** is necessary to give a general outline of the player's experience from the beginning to the end. Another important document is the **core mechanics document**, specifying the game rules and challenges.

#### 2.4.4 Game Design with Children

Whereas the previous part of this section concentrates on the design and on effects of playing, the following part overviews work concerning game design with children. First it explains why game design can be beneficial with children. Then it overviews the founding work of (Harel, 1991; Kafai, 1996, 2006). Finally it zooms on more recent approaches to designing games with children.

##### *Why Game Design with Children*

Designing even early prototypes of games with children means stepping through the aforementioned game design stages (see Section 2.4.2). That means planning for a sustained experience, possibly across several days. It also means planning the associated design tasks for children, and to take care of children's cognitive abilities. Moreover, as claimed by Druin, in Druin (2002), it is crucial to consider knowledge

<sup>2</sup> The core mechanics are at the heart of any game because they generate the game-play. They define the challenges that the game can offer and the actions that the player can take to meet those challenges. The core mechanics also determine the effect of the player's actions upon the game world. The mechanics state the conditions for achieving the goals of the game and what consequences follow from succeeding or failing to achieve them (Adams, 2013)

and experience of involved children, due to the fact that children are able to contribute on “what excites and bores them, what helps them learn, and what can be used in their homes or schools”.

The involvement of children in game design may have different contexts and expected benefits: for educational computer games (Daniels-son and Wiberg, 2006; Kafai and Vasudevan, 2015), on a narrative-driven design approach (Duh et al., 2010; Benton et al., 2014), or on child-centered interaction in the design of a game (Mazzone et al., 2008; Tan et al., 2011; Moser, 2013).

Since children are the first audience of most digital games, after the constructionist theory has been established in game design research, researchers moved their attention into learning contexts, e.g., school, and into how to involve children in designing games (Kafai, 2006).

Several studies showed that designing games can have learning benefits (Baytak et al., 2011): designing games allows learners to represent their understanding in concrete and personally meaningful ways, moreover learners can learn to ask and to provide help. Game design not only encourages diversity of ideas in a classroom community, and enhances a sense of classroom community, but it also support the notion that learning by designing computer games promotes engagement during learning, regardless of gender, and also can lead to productive social interaction. Steiner et al., in (Steiner et al., 2006), concurred with this constructionism view and also claimed that, “children as design partners improve the technologies they consume as well as gain educational benefits from the experience” (p. 137). In their studies, the authors confirmed that with sufficiently accessible tools, children can build satisfyingly complex and playable games (Steiner et al., 2006).

#### *The Constructionist Approach*

Designing and developing video games, rather than playing them, applies a constructionist approach to learning with games (Robertson and Good, 2005). Rather than embedding lessons directly into games, the constructionist approach promotes the idea that learners can actively construct their own learning. The constructionist approach to learning involves two activities: the construction of knowledge through experience, and the creation of personally relevant products or artifacts. Moreover, the authors stressed the use of appropriate tools, objects and materials sufficiently accessible and easy to learn so to adequately allow children to realize their design.

Making a game actively engages learners, because they construct their own game rather than experiencing them passively. Constructionism also emphasizes the social nature of learning. Learners can learn autonomously and they can embody their creative ideas in a testable

way in their game: by trying the game they evaluate their ideas. Furthermore peer collaboration is a necessary component. The purpose of making a game is to create an artifact which somebody else will enjoy. Thus, inviting others to play test the game is a natural part of the process. Hence, artifact development should entail exposure to activities that promote collaboration and sharing.

### *Recent Approaches to Game Design with Children*

When designing games with children as game designers would do, methods involving children or their ideas in design work are often used (Nesset and Large, 2004; Danielsson and Wiberg, 2006). Traditionally, children were treated solely as testers, who give developers feedback on prototypes. Other researchers focused on obtaining children's input only on specific game design feature such as storylines or characters, leaving out important knowledge about children's experiences, e.g., cultural values (Duh et al., 2010). However, a growing body of research looks at ways to better incorporate children's ideas into the design process.

In recent years, usage of PD for game designing has been receiving an increasing attention (Danielsson and Wiberg, 2006; Vaajakallio et al., 2009; Walz, 2010; Giaccardi et al., 2012; Lange-Nielsen et al., 2012; Walsh et al., 2013; Garde, 2013; Moser, 2013; Vasalou et al., 2012; Khaled and Vasalou, 2014; Perry and Aragon, 2014), also with children with special needs (Brederode et al., 2005; Walsh, 2009; TERENCE consortium, 2010; Potter et al., 2014). The PD approach to game design spouses the theory of constructionism and offers opportunities for constructivism, and for problem-based learning within the game design process. As described in the previous Section 2.3, actively including stakeholders in the design process has several benefits, such as experiences in interdisciplinary team work that is essential for designing a game.

When PD methods are used for designing game with children, children can have different roles in the process: from users to testers, to informants and finally design partners (Druin, 2002). In any case, children are critically contributing to the design with their ideas, as experts of their experience.

In (Khaled and Vasalou, 2014), children were involved in PD of a serious game. They concluded that children were most effectively able to participate as co-designers during middle stages of the game design process. Moreover, they stressed the fact that to maximise the

chances of successful ideation from participants, it is necessary to devise boundary objects<sup>3</sup> that relate to children expertise.

In a recent work, (Moser, 2013) outlines several methods of CCI that can be applied when children co-design games. Her approach follows a Child-Centred-Game-Design framework, using PD in several case studies, and requires an active user involvement, where researchers and developers give children a more responsible role (Scaife et al., 1997). Her framework is designed so as to inspire game researchers, designers, or developers on how to involve children through different design stages. Children in (Moser, 2015) are not equal design partners, as in the end game researchers, designers, and developers take the final decisions.

Another framework for designing games with children was presented in Tan et al. (2011). In this study the authors presented the CALSIUM framework for CCI in game design. The framework serves to assimilate tenets of UCD, concept of meaningful play, and pedagogical principle into PD from children. Children in their study were involved in the early part of the design process: they play-tested the game prototype, using story-boarding and low-tech prototype, and participated in focus group discussion.

In conclusion, there is a variety of approaches for the different game design and development phases (Moser, 2013; Walsh et al., 2013). Despite the proliferation of design studies with children, at present, the “number of studies that provide a deeper understanding of the complex process of the design of games [with children] is limited.” (Moser et al., 2014b). In practice children are often brought into the game design process just as informants in the analysis phase or for conducting early-design choices of games.

## 2.5 OPEN CHALLENGES

As widely reported in Section 2.4.4, conducting a participatory game design activity with children at school means dealing with several challenges related to different factors, such as their long-term engagement in their traditional learning environment, learning benefits or other constraints due to game design per se (Fredericks et al., 2004; Fredericks and McColskey, 2012; Doderio et al., 2014a; Brondino et al., 2015; Van Mechelen et al., 2014). Open challenges for conducting participa-

<sup>3</sup> Boundary objects are those objects that both inhabit several communities of practice and satisfy the informational requirements of each of them. Boundary objects are thus both plastic enough to adapt to local needs and constraints of the several parties employing them, yet robust enough to maintain a common identity across sites. They may be abstract or concrete. Bowker (2000)

tory game design, which are relevant for this thesis, are recapped and deepened in this section.

#### 2.5.1 Collaboration

In PD, children are expected to critically contribute to design with their ideas, as expert of their experience, while adults are expected to turn into reflective practitioners, so that design becomes an act of knowledge construction or negotiation of values, through scaffolding dialogues (Frauenberger et al., 2015), see Section 2.3. A key value of PD is then **democratic collaboration** for co-creating knowledge and mutual learning. To this end, PD researchers usually divide children in teams for conducting design work, and typically there is also an adult per team or one adult for all teams (Druin, 1999; Moser, 2013; Vaajakallio et al., 2009). However democratic collaboration, among children and with adults, is challenging to achieve due to the difficulty of managing social relations and especially of balancing power structures, as recently recognized in (Dodero et al., 2014a; Van Mechelen et al., 2014). Social theories are needed to support true democratic collaboration for mutual learning.

#### 2.5.2 Empowerment of Children

PD researchers embark on a co-design “journey” or “experience” with potential users, which aims at empowering all participants (Frauenberger et al., 2015).

When co-design involves children, empowering them also means that children are given the opportunity to **learn** about early design through the design practice itself (e.g., (Sanders and Stappers, 2014)). Then co-design becomes a *competence-relevant activity*, with learning goals, besides bring a design activity with its own product design goals. **Engagement** is another empowerment opportunity. In PD studies, engagement is usually considered in relation to products under design or used for designing (Dindler et al., 2010; Robertson and Good, 2005; Read, 2008). Few PD studies investigate participants’ engagement in the design activity itself, e.g., (Garzotto, 2008; Mazzone et al., 2011). With children with special-needs, engagement in the PD activity is considered “a form of learning per se”, e.g., (Garzotto and Gelso-mini, 2015), see Section 2.3.4.

However children’s empowerment, as their engagement and learning through the design experience, can be challenging to achieve: when design requests are cognitively complex, and they can be perceived as tasks threatening children’s self-efficacy; or when design work is frag-

mented over extended periods, they are hampering the promotion of focused attention on tasks (Schmidt and Vanderwater, 2008). That is often the case with game design. Designing a game requires not only creativity but also several cognitive skills, ranging from working memory to logic and problem solving, the maturity of which vary according to children's age and skills, see Section 2.3.4. Co-designing prototypes of games with children means stepping through different design stages—ideation, conceptualization, prototyping (see Section 2.4.3). That means planning for a prolonged, possibly fragmented, game design experience. This is a further requirement to consider, with special attention to learning benefits for children if co-design is conducted at school during regular classes.

Moreover, engagement and learning are challenging to evaluate. They are complex constructs, which need to be operationalized for being properly assessed. PD studies are usually context-bound (Frauenberger et al., 2015), and hence engagement or learning are often qualitatively evaluated by PD researchers (Duh et al., 2010; Karimi and Lim, 2010).

### 2.5.3 Empowerment of Adults

In PD, empowering adults means bringing them knowledge of children's design ideas (see Section 2.3.3). It is thus crucial to give children design means for expressing their ideas so that **adults learn from children**, and so that children's "design products" can be carried over in the development process, independently of whether products are considered as "sources of inspiration", user requirements or early design conceptualizations (Nesset and Large, 2004).

In case of games, PD is differently inserted into the lifecycle of games, and failure development stories are also reported, e.g., due to the innate complexity of conducting game design with children (Moser et al., 2014b). Some PD studies did not aim at carrying to development children's design ideas (Vaajakallio et al., 2009; Walsh et al., 2010; Moser, 2013). In some other cases, children were involved in the design of parts of the game, such as the storyline (Duh et al., 2010; Benton et al., 2014; Tan et al., 2011), recorded by adult with photos and videos, then games were realized by adults (Khaled and Vasalou, 2014). In other PD studies, instead, children's game design ideas were regarded as expressions of children's expectations, they were recorded in video-formats and then realized by adults (Moser et al., 2014a).

There is thus a variety of approaches to designing parts of games with children, however the majority of PD work tend to let adults develop children's game design products. It is thus worth investigating how far game design can be carried over with children, and specifi-



cally which design means can promote children's expression of game design ideas. It is also worth assessing how their game design products can be inserted into the game lifecycle, and possibly developed by adults not participating in game design work with children.

## 2.6 RELEVANT EDUCATION THEORIES FOR TACKLING CHALLENGES

By treating a PD activity with children as a competence-relevant activity for children, we have the advantage of exploiting several education theories that help in supporting collaboration and empowerment of children through the activity. Such theories are briefly overviewed below in relation to collaboration and empowerment.

### 2.6.1 Collaboration: Cooperative Learning

Cooperative learning can help in achieving democratic collaboration, for learning by doing, together. Cooperative learning is a learning methodology based on constructivism, in which knowledge is shaped through experience (Slavin, 1991). In cooperative learning, classes are structured into small groups of learners, working together and mutually helping each other, towards a common goal. Teachers become reflective teachers and have the role of directors of the learning process, mainly through scaffolding dialogues.

Cooperation is not just that: it requires teachers (or the domain expert) to structure the learning context through specific cooperative learning strategies (also known as techniques), roles and rules. Strategies, rules and roles for groups involve five key elements of cooperative learning: (1) clearly perceived positive interdependence; (2) considerable promotive face-to-face interaction; (3) clearly perceived individual accountability and personal responsibility to achieve the group's goal; (4) frequent use of relevant interpersonal and small-group skills; (5) frequent and regular group processing of current functioning to improve the group's future effectiveness, see (Johnson and Johnson, 2002).

### 2.6.2 Empowerment: Gamification and Engagement and Learning Assessment

Engagement and learning are both complex constructs. According to the underlying theory and activity, they are differently defined. Some



definitions emphasize a single dimension, e.g., such as attention (Chen et al., 2011) or enjoyment for engagement Garzotto (2008). Others are more comprehensive. For example, learning can be measured directly, in relation to the subject topic, or indirectly, e.g., by considering learners' self-efficacy. That can be done through: formative assessment, possibly provided in a timely way, so that students receive input and guiding feedback on their relative performance to help them improve; summative assessment, such as surveys used for measuring learners' performances, considering what students have learned at the end of a task or activity. As for engagement, Fredericks et al. (2004) posited that early studies defined student engagement primarily by observable behaviors; lately research focusses on emotional or affective aspects, e.g., enjoyment, or cognitive engagement, such as students' perseverance in facing challenges.

In traditional educational activities, engagement is considered as a facilitator of learning (Fredericks et al., 2004; Fredericks and McColskey, 2012). In the remainder, we survey relevant recent approaches or theories for promoting and assessing engagement, as well as learning, in educational contexts.

#### *Promotion: Gamification*

Education theories differently promote learners' engagement. Gamification of learning has recently emerged in the education literature as a means for making learning activities more enjoyable and engaging, thus favouring learning and retention through tasks.

Gamification, broadly defined, is the process of defining the elements which comprise games, make games fun and motivate players to continue playing (Deterding et al., 2011). Gamification uses game elements in a non-game context to influence behaviour (Deterding et al., 2011). Such a definition implies that gamified products are not full-fledged games: they use only some elements of game design (e.g., progression maps), outside of a game context, so as to engage people. Typically gamification use the competition instinct to motivate and encourage "productive" behaviours and discourage the "unproductive" ones. However, the same mechanisms can be used to encourage collaborative and cooperative behaviours (Glover, 2013).

The rationale behind gamification is that games are "a form of participatory, or interactive, entertainment", and learning as a participatory process can benefit from incorporating game concepts within it (Adams, 2013).

Educational gamification or gamification of learning, specifically, embeds game design or game-like concepts into learning processes so as to actively engage learners, in relation to their natural learning con-

texts (Kapp, 2012; Glover, 2013). The goal of gamification of learning is thus to “maximize enjoyment and engagement through capturing the interest of learners and inspiring them to continue learning” in their contexts (Huang and Soman, 2013). Gamification has the potential to be a “disruptive innovation” in education, with the prospects of altering practices in a positive way (Christensen and Raynor, 2003; Glover, 2013).

The literature review by (Hamari et al., 2014) shows that, depending on the context and types of players, gamified activities can empower players by engaging them. Contexts, in fact, can determine whether the usage of specific game elements will engage or disengage. For instance, Deterding et al. (2011) argued how a leaderboard used in a work context could easily lead to competitive dynamics. The perception of performance comparison at work could augment the sense of being controlled “thwarting experienced autonomy and hence, intrinsic motivation”, creating disengagement instead of engagement.

Gamification of learning is based on incorporating game-mechanics within an educational activity or process. Specifically, three basic game components should be taken into account (Dickey, 2005): (1) goal-focussed activity: the shared focus on achieving specific goals, is a mean to increase the amount of time dedicated to learning tasks, and consequently it increases engagement and motivation; (2) reward mechanisms: the use of leaderboards, and prizes for powerful motivation, and (3) progress tracking: it is important to have ways for identifying the steps to take in order to to improve or advance in the future.

However incorporating basic game elements in a learning process cannot replace good learning design. It is crucial that the level of the activity as well the pedagogy be suitable before adding extra layers of complexity through gamification (Glover, 2013). For instance, a goal-focused activity works at best when there are clear checkpoints in such activity. These checkpoints can be used by the learner as wayfinding so as to establish own progress and identify remaining tasks. Moreover, as mentioned before, it is important that gamification elements, such as leaderboards, are completely disconnected from formal assessment of learning: gamification should only be used to increase motivation and should not be yet another mechanism to grade learners. The most famous example of the implementation of the gamification strategies within a learning process is a public school Quest to Learn, in New York City. In such school, students in grades 6 through 12 use narrative, problem-solving, and the structure of game design systems to inform its pedagogy, school culture, and curriculum (Q2L School, 2006).

*Assessment: Authentic Assessment*

**ENGAGEMENT OF CHILDREN** Learners' engagement is related to constructs such as interest, concentration, and emotions in traditional school activities. According to (Hamari et al., 2016; Shernoff et al., 2003), learners are highly engaged in an activity when they show high levels of enjoyment, concentration and interest. There are different methods for assessing such constructs, such as self-reports or observations, e.g., (Fredericks and McColskey, 2012). In learning contexts or, more generally, in competence-relevant activities, engagement has been correlated also to achievement emotions, e.g., engagement has been positively correlated to enjoyment and negatively correlated to anxiety and boredom (Kahu et al., 2015). Achievement emotions can be classified using Pekrun's control-value theory (Pekrun, 2006; Pekrun and Perry, 2014) and assessed with self-report surveys for children, e.g., (Raccanello and Bianchetti, 2016), along two orthogonal dimensions: valence, distinguishing positive emotions from negative emotions; activation, distinguishing activating emotions from deactivating emotions. In Pekrun's theory, enjoyment is classified as positive and activating, relaxation as positive and deactivating, anxiety as negative and activating, boredom as negative and deactivating. Therefore, in co-design as a competence-relevant activity, engagement can be correlated to and assessed by asking children about their achievement emotions as well, this way complementing the observation of their behaviors denoting interest, concentration and enjoyment.

**LEARNING OF CHILDREN AND ADULTS** There are different theories concerning how to evaluate children's learning, and the assessment of children's learning performances depends also on the learning activity. In case of game design, there are no standardized measures. However, authentic assessment seems a viable approach to judging if children are learning about early game design; this is possible if the game design activity is done in "an authentic manner". According to (Wiggins, 1998), a learning activity is authentic if: it is realistic; it requires judgment and innovation; it asks learners to "do" tasks; it replicates or simulates the contexts in which adults work; it assesses learners' ability to efficiently and effectively use a repertoire of knowledge and skills to conduct tasks; it allows appropriate opportunities to rehearse, practice, consult resources, and get feedback on and refine performances and products. In such case, learning can be assessed as "authentic", using adults' criteria as far as possible. Moreover, children's progress through tasks should also be evaluated as an authentic assessment (Grisham-Brown et al., 2006).

## BACKGROUND

Approaching children's products with authentic assessment can also help designers in evaluating whether children's game design products can be taken as-is in the game lifecycle, and brought to maturity by adult game developers, who thus learn about children's ideas.

# 3

## THE GACOCO METHOD

### CONTENTS

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In principles PD approaches help designers create game concepts, using contributions from children and collecting them via design sessions at school. As reported in Chapter 2, working with children in learning contexts, such as schools, poses several challenges to co-design, which can affect its success. This section presents a participatory game design method for guiding children and adults to conceive and create prototypes of games for children at school. The method is presented using as reference the framework of (Frauenberger et al., 2015). Moreover, the method combines gamification, see Section 3.2.2, and cooperative learning, see Section 3.2.1, to support democratic collaboration and empowerment. The participatory game design method is baptized *GAmified CO-design with COoperative Learning* (GaCoCo).

### 3.1 THE GACOCO METHOD

As reported in Section 2.5, conducting a design activity with children at school means dealing with several challenges. Several methods and techniques, reported in Chapter 2, can be applied when researchers aim to involve children as design partners in a research project. In addition, when a project is developed in learning contexts, new aims are triggered, which researchers must take into account.

GaCoCo is a PD method that a designer can use to plan, conduct and assess an early game design experience with children, as well as to investigate their expectations for games for children. It was first described in (Dodero et al., 2014a), and was later refined incrementally

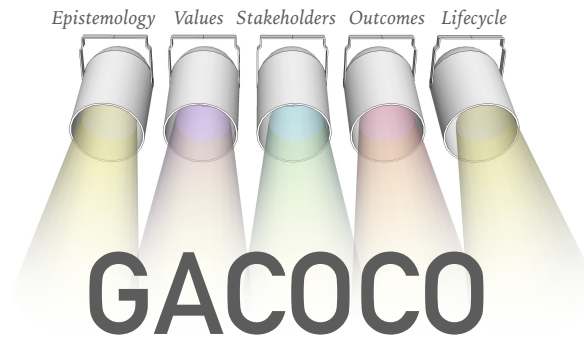


Figure 2: GaCoCo under the focus of five lenses

across studies for co-designing games at school. The transition from the first exploratory study with GaCoCo, in 2013, to the second GaCoCo, that was performed in 2014, is reported in (Dodero et al., 2014a). The 2014 and 2015 GaCoCo studies are reported in Chapters 4 and 6, respectively.

This section presents GaCoCo using the “lenses” of (Frauenberger et al., 2015):

- **epistemology**, as knowledge construction underpinning participatory design values, stakeholders’ roles and outcomes;
- **stakeholders participation** in design: they negotiate decisions with design experts and, “while power sharing is at the heart” of participatory design, a decision-making result “relies on the underlying power structure which defines how much scope for change each participant has” (Frauenberger et al., 2015, p.101);
- **values**, conceived broadly as ideas or qualities which are landmarks of a participatory design approach;
- **outcomes**, which are related to the effectiveness of participatory design, and which tend to be “the most important way to justify participatory approaches” to the design community (Frauenberger et al., 2015, p.102).

Moreover, this section adds a further overarching “lens”, important for understanding how the participatory design method can be inserted into the design lifecycle:

- **lifecycle** of designed products, and specifically how design and evaluation of products are related.

Such lenses serve to communicate: GaCoCo pillars, and what might vary across GaCoCo activities; how GaCoCo positions itself with respect to the challenges examined in Chapter 2 for collaboration, and

for empowerment focusing on learning and engagement, and for the effectiveness of the method itself—can children’s design products be used by game developers in order to develop end products (digital games), and how?

## 3.2 EPISTEMOLOGY

As in other participatory design methods, overviewed in Chapter 2, in GaCoCo knowledge is co-constructed through practice, it is context bound and it belongs to different sorts.

Cooperative learning and gamification of learning contexts both spouse such a view of knowledge. They are the two major strands of research that contribute to the GaCoCo epistemology and to the framing of its values, its stakeholders’ roles and its outcomes. Contributions are briefly overviewed in the following, and then exemplified in the studies reported in this thesis.

### 3.2.1 Cooperative Learning Contributions

GaCoCo relies on cooperative learning for achieving **collaboration** among children and with adults, which is a key value of PD. Small groups of children are created to work on co-design tasks. Groups are heterogeneous so as to foster the visibility of all children, and to take advantage of the different learning and social skills of group members (Cohen et al., 1999). Heterogeneity becomes an empowerment opportunity at diverse levels. In particular, heterogeneity serves to elicit group creativity in design: design ideas are triggered by different perspectives, which allow group members to build on various alternatives (Paulus and Nijstad, 2003). Cooperative learning comes with a variety of strategies, rules and roles for promoting collaboration in heterogeneous groups. Cooperative learning strategies for heterogeneous groups, rules and roles are all important contributions that GaCoCo adapts to the purpose of design in group.

#### *Strategies*

Cooperative learning strategies can be loosely differentiated according to what they mainly promote: discussion, reciprocal teaching, usage of graphical materials, writing, problem solving. Each strategy includes a number of potential structures to guide the development of a cooperative learning activity.

One of the most important strategies for activating students in their learning process is employing the “study groups” in the class and provide group with opportunities for discussion, exchanges of views, and question and answer session (Payne and Whittaker, 2000; Lavasani et al., 2011).

Many researchers have shown that cooperative learning strategies can be used to promote deeper understanding. Researchers and educators can use various strategies of cooperative learning along their work to enhance learning in a classroom. Moreover, the instruction and activities based on cooperative learning are creative and can be used to enhance and promote higher student achievement (Johnson et al., 1990; Slavin, 1996; Iyer, 2013).

Example of strategies used in GaCoCo studies, reported in Chapters 4 and 6 are: three-step-interview, Jigsaw, gallery tour (Barnes and O’Farrell, 1990).

### *Roles*

In GaCoCo, as in cooperative learning, roles for design are not fixed, they rotate among members, so as to train different skills in each child over time.

Assigning roles to students encourages interaction and group working. Roles might help especially students to overcome communication difficulties to get the project done and done well. Random selection of roles also combat stereotypes associated with roles - for example, teachers might want to avoid allowing males to serve as leaders, while females serve as “secretaries.” Appropriate roles will depend on group size and the nature of the cooperative learning task.

General roles used in cooperative learning are: secretary, checker, time keeper. Specific roles used in GaCoCo studies are reported in 4.2.2

### *Rules*

Besides strategies and roles, and in support of them, cooperative learning considers a set of rules needed for group work, and for including all in an act of true collaboration. Rules are concerned with social skills, such as reciprocal listening and respect of different views. Examples of cooperative learning rules used across GaCoCo studies are: taking turns in voicing opinions; rules for reconciling different views, e.g., concerning game design documents or prototypes.

GaCoCo has developed gamified objects acting as probes (Hutchinson et al., 2003a) for making roles and rules for relating to others tangible. The following section explains such probes and, more generally, how gamification is used in GaCoCo.



### 3.2.2 Gamification Contributions

In its most general acceptance, gamification means properly using game elements, such as storylines and progression bars, for a non-game goal and in a non-game activity (Seaborn and Fels, 2015) in order to promote **engagement** with positive activating emotions in the activity. The literature review by (Hamari et al., 2014) show that, depending on the context and types of players, gamified activities can empower players by engaging them. Diverse motivation theories are invoked to explain why and how gamification can engage players (Kapp, 2012). Using self determination theory as the reference framework (Deci and Ryan, 1985; R.M. and Deci, 2000), in order to sustain engagement in time, a gamified activity should nourish three universal needs: a sense of **progression** and competence, **control** and **social relatedness** (R.M. and Deci, 2000). In GaCoCo, social relatedness means promoting collaboration as in cooperative learning.

To satisfy such needs, GaCoCo uses gamification to organize design tasks as in games, and to present them with ad-hoc gamified probes for making tangible cooperative groups' progression, control and relatedness throughout tasks.

#### *Progression*

Specifically, co-design tasks are presented as **missions** with clear and valuable goals for children. The first mission must be easy to take up by all, creating a relaxed atmosphere for exploring the activity and material, besides mutual trust between researchers and children. Missions should then build one upon the other so as to sustain children's progression in time. According to its complexity for children, a mission can be chunked into progressive **challenges**. A progression bar, typically used in a game, shows groups their progression through the co-design activity, to remind them such progression and to share it with others, giving children a sense of control over it, without increasing competition.

#### *Control and Autonomy*

A co-design context that invites children's free exploration and choice, like an unexplored game world, can even more tangibly promote a sense of autonomy and control over their co-design work. Rewards, part of the feedback system in gamification, are gamified objects designed with special care in GaCoCo. According to cooperative learning, if rewards are seen as a mean for controlling, or not valuable to work, they can cause people to feel less competent and in less control, which decreases engagement and also interferes with creativity (Deci

and Ryan, 1985). Therefore GaCoCo considers only rewards that are symbolic and contingent to the design work. They are controlled by children, customizable, surprising, and achievable on completion of a mission or challenge, in line with cooperative learning recommendations in (Graves, 1991).

### *Relatedness*

Gamification of the learning contexts should be done fostering cooperation, so as to be faithful to the co-design partnership principle, e.g., without increasing competition within groups. Such a constraint can be met by providing rewards that only mildly favor inter-group competition so as to promote “intra-group positive interdependence” and cooperation, and still satisfy relatedness needs. Gamified probes can be designed so as to make it tangible cooperative learning rules and roles for connecting with others. Examples of such objects are scepters for sharing with others, presented in Chapter 4. A scepter is used for sharing and organizing the cooperative learning rule of taking turns in speaking in a group discussion. Progression maps can also be used to connect with others and satisfy relatedness needs. Shared maps can show other learners that a group or an individual could overcome a mission, and are available for sharing their experience and acquired expertise.

## 3.3 VALUES

Challenges and values of participatory design are **collaboration** and **empowerment** of all participants.

In GaCoCo, collaboration means cooperation in the sense of cooperative learning as explained above, and the heterogeneity in groups of children is taken from cooperative learning as an additional value for GaCoCo co-design, e.g., for creating alternative ideas. In GaCoCo, positive interdependence and individual accountability in group work, as well as promoting face-to-face interaction, are further important cooperative learning values for promoting collaboration. They are supported through cooperative learning strategies, rules and roles.

Empowering children means engaging them in a design activity, eliciting positive activating emotions. Empowering children also means promoting children’s own expression of ideas and creativity.

Not only children are empowered; empowerment is achieved for adults involved in GaCoCo as well. Empowering adults means promoting their learning by doing: through dialogues with children dur-

ing a GaCoCo activity, and through the GaCoCo outcomes. Specifically, game design products should transmit adults, acting as game developers, children's game design ideas.

Assigning stakeholders specific roles helps in supporting collaboration and empowering all, as explained in the following.

### 3.4 PARTICIPANT STAKEHOLDERS AND THEIR ROLES

In GaCoCo, while children mainly work on early design in cooperative groups, with gamified tasks and material, researchers support children's empowerment in designing, possibly with the help of teachers.

In GaCoCo studies, presented in details in Chapters 4 and 6, at least two researchers are present in class together with children, with different expertise and roles.

One researcher, experienced of child development studies, acts as observer during the design activity, and is referred to as observer henceforth. She or he gathers data according to the activity goals, and maintains a constant dialogue with teachers and the other researcher concerning the class behavior and children's well-being.

The other researcher is the design expert, collaborating with children in the following ways. During a design activity, possibly assisted by teachers, this expert follows each group and conducts a formative evaluation of their work, asking clarifications and giving rapid feedback about specific design choices through dialogue. Moreover, at the end of a design session or at the end of the entire activity, this expert, and at least another, not presented at school, should conduct a summative evaluation of groups' products. Results of such evaluation must be returned to children, possibly across design sessions, so as to allow children to further self-reflect on their design products and promote their learning.

### 3.5 OUTCOMES

Generally in a participatory design experience, the outcome is the actual artifact or design delivered at the end of the experience; then the outcome embodies decisions and considerations and, as such, it brings researchers epistemology insights as design knowledge, e.g., what genre of games 8–10 years old children prefer. GaCoCo as well

considers tangible outcomes, that is, children’s early game design products. Then epistemology is design knowledge concerning such products, which empowers adult designers. The challenge that GaCoCo picks up is whether such design products can be delivered (as-is) to game developers and brought by developers into design maturity. This thesis considers this challenge, and turns it into a research question.

However, GaCoCo goes beyond that: it values knowledge coming from GaCoCo products and related to the empowerment of children participating in the GaCoCo activity. Examples of such knowledge are: what specific game elements children could design at the end of their design experience, as in (Dodero et al., 2014a); quality of children’s game products assessed and discussed with children throughout the experience, and regarded as a measure of whether children are learning about design, by doing it together.

Last but not least, GaCoCo considers in tangible outcomes in addition to design products by children, still related to their empowerment: their engagement in a GaCoCo activity, and their learning an attitude on social inclusion. By treating them as outcomes, GaCoCo has to devise a way to assess them. In particular, engagement in an activity can be assessed considering children’s concentration, interest and enjoyment, e.g., see (Shernoff et al., 2003; Hamari et al., 2016). It can also be assessed considering achievement emotions, being positively correlated to enjoyment and negatively to anxiety and boredom, e.g., (Kahu et al., 2015). Given that knowledge in participatory design is often co-created and context bound, GaCoCo tends to use a mixed-method research to assess them: quantitative data are collected and analyzed; qualitative data are then used to explain quantitative findings. This is the approach followed in the studies reported in Chapter 4 and in Chapter 6 of this thesis.

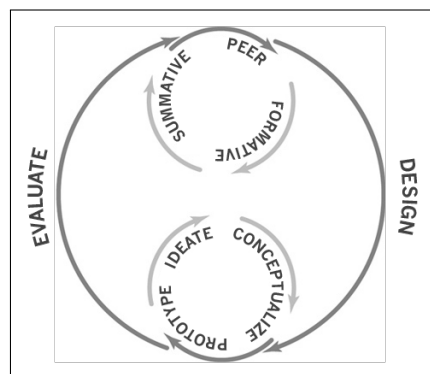


Figure 3: Product GaCoCo lifecycle stages

## 3.6 LIFECYCLE

In line with a lean approach to UCD (Gothelf, 2013), GaCoCo design sessions alternate and intertwine with evaluation sessions. Evaluation can be with experts of the domain under consideration, e.g., by using discount inspection methods, or with the end users of product. In this thesis, the domain experts are game designers, whereas the end users are primary-school children. See Figure 3.

Specifically, all GaCoCo studies reported in this thesis start with the preliminary definition of the design goal and of a protocol to achieve it. This is done with experts of child development, game design and school stakeholders, specifically school teachers and deans. GaCoCo studies then move into schools, and game design sessions start. Each design session takes place at a week's distance from the previous one, and is broken into three progressive stages: **ideation**, **conceptualization** of ideas into structured documents and **prototyping** of these.

Internal evaluation, done by design participants themselves, is of three different types, delivered at different moments: peer evaluation among children during design sessions, with discussions at the pair, at group or at class level; formative evaluation by experts of children's products at specific moments during design sessions, with rapid feedback for validating or clarifying design decisions by children; summative evaluation by experts of children's products in between design sessions, giving constructive elaborate feedback on design choices by children. External evaluation is also important for GaCoCo but is not part of the method itself. In one of the GaCoCo studies, it was done with children with interactive prototypes of games designed by children with GaCoCo. See Chapter 5.

Iteration, incremental work, and the interleaving of design and (internal) evaluation are thus cornerstones of GaCoCo.



# 4

## THE GACOCO 2014 STUDY

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In this chapter we present the case study executed during the Spring 2014 in two primary schools in Italy. The chapter is organized as follows. In Section 4.1 the main goals of the study, with the related hypotheses, the participants involved, and the study design organization are presented. Section 4.2 details the material, namely generative toolkits and gamified probes, used in the study, the design protocol, with the strategies used, and the design session outcomes.

Analyses and results are detailed in Section 4.3. At the end of the chapter, in Section 4.4, we discuss results obtained during the study, considering whether the study worked or not, and what requires a re-design.

## 4.1 STUDY

The study of 2014 revolves around GaCoCo, with its learning goals and with the related product design goals. As explained in Chapter 3, collaboration and engagement are GaCoCo key values and challenges. Therefore, the GaCoCo activity aims at empowering children by engaging them and by promoting their learning of early game design.

In this GaCoCo study, prototypes of digital games were designed with 35 children in two classes of two primary schools in the area of Bolzano, north of Italy. During the game design children were split in groups, where each group worked on designing and prototyping a game. All games are based on a story, namely storyline of the game. The game design activity per se took 5 days per school. Each day was named as *mission* (as in a game) and it was executed during the time-frame of the daily school activity. At the end of the game design activity, each group of children had developed a paper-based prototype of their own game. In the remainder, we report details on the goals of the study, the participants involved and their roles, the study design and its organization.

### 4.1.1 Goals

The study aims at empowering children by engaging them and promoting their learning of early game design.

Children's learning of design can be related to their performances in the design activity and to the quality of their design products.

Children's engagement can be correlated to their achievement emotions, e.g., engagement has been positively correlated to enjoyment and negatively correlated to anxiety and boredom, and can be qualitatively assessed in terms of interest, concentration and enjoyment, in line with (Shernoff et al., 2003). Moreover, children's performances with gamified probes as measure of children's engagement during the GaCoCo game design experience can be qualitatively assessed.

The study inspects and evaluates the following goals: (Goal 1) monitoring and assessing children's performances in GaCoCo design; (Goal 2) assessing engagement by: (Goal 2.1) monitoring and assessing the intensity of children's achievement emotions along the GaCoCo design, (Goal 2.2) assessing the engagement along the GaCoCo activity and with GaCoCo gamified material; (Goal 3) assessing possible relationships between performance and emotions.

Each goal and the associated hypotheses are specified in details in the following.



### *Goal 1: Monitoring and Assessing Children's Performances*

Group performance in the GaCoCo activity was operationalized by considering the quality of the group product, for each group. The study aimed at monitoring the quality of products released by groups of children during GaCoCo, and whether the quality of products was increasing over time at the group level. Such increase would suggest that children were learning, by doing design together. A single hypothesis was formulated:

**G1.H1** *Quality of products changes in time (alternative hypothesis, H1) against the null hypothesis of no differences (null hypothesis, H0). This hypothesis was based on the organization of game design missions with GaCoCo, and it is not backed up by findings in the literature. Therefore it is of an exploratory nature only.*

### *Goal 2: Monitoring and Assessing Children's Engagement*

**GOAL 2.1: MONITORING THE INTENSITY OF CHILDREN'S ACHIEVEMENT EMOTIONS.** The study aimed at describing the intensity of children's achievement emotions during GaCoCo missions, and how intensity of emotions changed over time at the individual level. More in details, we focus on four emotions, quite frequent in learning contexts, also for Italian primary school children (Raccanello et al., 2013, 2014), and representing quadrants of Pekrun's model (Pekrun, 2006), which result from intersecting the valence and activation dimensions: **enjoyment**, an activating positive emotion; **relaxation**, a deactivating positive emotion; **anxiety**, an activating negative emotion; and **boredom**, a deactivating negative emotion.

The hypotheses we formulated were:

**G2.H1** *Positive emotions more intense than negative emotions (H1) against the null hypothesis of no differences (H0). Along the line of the data on Italian learners concerning learning activity in other domains (Raccanello and Bianchetti, 2016), we hypothesized positive emotions to be more intense than negative ones.*

**G2.H2** *Higher intensity for activating emotions than deactivating emotions (H1) against the null hypothesis of no differences (H0), given the active role of the learner involved in the GaCoCo Activity. This hypothesis is not backed up by findings in the literature. Therefore it is of an exploratory nature;*

**G2.H3** *Intensity of negative and positive emotions changes over time (H1) against the null hypothesis of no differences (H0). This hypothesis*

was based on the possibility of diminished novelty and increasing demands in complexity of game design missions, and falsification of the null hypotheses could enable to extend similar data emerged for long-term competence-relevant traditional activities in regular classes (Raccanello et al., 2013).

**GOAL 2.2: ASSESSING ENGAGEMENT ALONG THE GACOCO ACTIVITY AND WITH THE GACOCO GAMIFIED MATERIAL.** The study considered exploratory qualitative observations of students' engagement during the GaCoCo activity. In order to qualitatively assess the GaCoCo game design experience, we monitored the engagement of children's group design activities in terms of concentration, interest and enjoyment, as stated in (Shernoff et al., 2003). The authors in (Shernoff et al., 2003) refer the aforementioned variables as important components of the flow theory (Csikszentmihalyi, 1997) that can be used as a measure of learner engagement in an activity.

Moreover, we assessed engagement of the whole class with the GaCoCo gamified material: the frequency of the usage of the gamified probes, and whether the usage was or was not distracting children from their activity. In addition, we assessed preferences of children for gamified probes for designing, besides their usage of such probes.

*Goal 3: Assessing Relationship between Performances and Emotions*

We aim at exploring possible relationships between children's achievement emotions and quality of products. In light of literature findings (Pekrun and Perry, 2014), we focussed on formulating hypotheses only for the activating positive emotions of enjoyment and deactivating negative emotion of boredom, while no specific hypotheses were formulated for relaxation and anxiety, for both of which inconsistent results are frequently reported.

Correlational analyses were run both at the individual and at the group level, given that quality of products was conceptualized as a measure of group performances, while emotions were investigated individually per child.

The hypotheses we formulated were:

**G3.H1** *Quality of products are positively correlated to enjoyment (H1) against the null hypothesis of absence of relations (Ho).*

**G3.H2** *Quality of products are negatively correlated to boredom (H1) against the null hypothesis of absence of relations (Ho).*

#### 4.1.2 Participants and Roles

The study involved two classes of 35 children, two teachers and two design experts. Each participant, from children to teachers as well as researchers, had a specific role. Roles for participants were specified in detail below.

##### *Teachers*

Two teachers were involved in the study. Both were teaching Italian Language and Literacy<sup>1</sup>. At the start of a design session, teachers illustrated the work organization and material to be used, according to the GaCoCo protocol for the mission. Moreover, they were in classroom together with GaCoCo researchers during the entire design activity: teachers assisted the GaCoCo researcher in the communication with children, and in scaffolding of group work, following the GaCoCo protocol.

##### *Researchers*

Two researchers were involved in the study. As reported in Chapter 3 they had different types of expertise and roles. Below we briefly recap their roles.

The first research is the *design expert*: she has expertise in both game design and interaction design. During the design activity, she followed each group and conducted quick formative evaluation of their work (formative feedback), asking clarifications and giving feedback about design choices. For instance: “what are points for”; “you stated that characters lose lives but did not explain how”. She used the heuristics of (Desurvire et al., 2004) for informing her evaluation as well as work expertise in game and interaction design. The choice of having just one design expert per class, interacting with children at specific moments, is due to resource constraints. In addition, the expert avoids the risk that adults lead discussions among children, e.g., see (Nesset and Large, 2004). Moreover, at the end of a design session, or of the entire activity, this expert conducted a summative evaluation of groups’ products. Product evaluation is also performed by an independent design expert, who never works with children. Specifically, during the evaluation, the design experts used again the heuristics of (Desurvire et al., 2004), revised for the released game design documents and paper-based prototype. Such heuristics were used as guidelines for the expert review—experts used heuristics for informing their

<sup>1</sup> In the Italian primary school, the Italian Language and Literacy subjects employ the most of the daily school timetable, therefore teachers spend in class most hours during the school week

evaluation, but they also relied on their game and interaction design expertise. Products of children were then evaluated against emerged issues, which were thematically analysed by the experts. Results of this evaluation must be returned to children, possibly across design sessions, so as to allow children to further self-reflect on their design products, and to promote their learning.

The second researcher, experienced in child development studies, named *education expert*, acted as *observer* during the design activity, and was referred to as observer henceforth. She gathered data according to the activity goals, and maintained a constant dialogue with teachers and the design expert concerning the class behavior and children's well-being.

### *Children*

Children were 35 in total (59% females), coming from a variety of socio-economic backgrounds. Classes were of different ages and sizes. The younger class was of  $n = 15$  children, in grade 3, with mean age = 8.85 years,  $SD = .44$ . The class had two children diagnosed with an attention deficit hyperactivity disorder (ADHD). The older class was of  $n = 20$  children, in grade 4, with mean age = 9.72 years,  $SD = .47$ . The class had a child with autism and a cochlear implant who was involved in the whole activity. All children participated on a voluntary basis, and their parents authorized their participation through a written consent form.

Children were the main game designers, mainly working in groups of 3–5 members. In line with GaCoCo protocol, their work was organized into small groups, in pairs or with the entire class.

### 4.1.3 Design

This section specifies the study design organization into a pre-activity, the core GaCoCo activity for realizing early game prototypes, and a post-activity.

#### *Pre-activity.*

During the pre-activity, researchers organized a meeting with all potentially interested teachers and school deans, in order to explain and discuss the GaCoCo activity. A week after this, a six-hour open workshop was organized for teachers. During the workshop, the GaCoCo design protocol was explained by researchers, as well as the main ideas of gamification and cooperative learning. Teachers worked in group and experimented the co-design protocol for children by prototyping

games themselves. During the workshop, teachers of the participating schools gave researchers feedback on the GaCoCo activity protocol, e.g., concerning timings of feedback, and researchers revised the protocol accordingly.

Moreover, teachers were also administered a form for: collecting specific data; creating co-design groups of children, heterogeneous in terms of learning and social styles, in line with cooperative learning values acquired by GaCoCo, see Chapter 3. The education expert explained the form to teachers, who compiled it with her assistance. For instance, the education expert explained that relevant social skills were related to inter-personal relations, such as: taking decisions; resolving problems; communicating in an assertive manner; managing emotions.

For each learner, teachers annotated: (1) gender; (2) age; (3) social skills, assessed with a 3-level scale, in which 1 is the minimum and 3 the maximum; (4) work attitude, namely, whether a learner prefers working alone to working in group, or to something else; (5) learning style, namely, whether a learner is global-creative, or deductive-analytic, or something else; (6) school skills, namely, whether a learner is highly proficient, proficient or lowly proficient at school, or something else. The form is shown in Figure 4. The form also contained a field for additional observations, concerning power relations or whether a learner had special needs, and which ones. Such information was also specifically used to refine the GaCoCo activity protocol for managing group dynamics with cooperative learning, e.g., emphasizing rules for listening in silence to all group members' ideas.

*Group Formation*

#### *GaCoCo activity.*

The activity aimed at enabling groups of children to work on the early design of games, with GaCoCo. Groups started their work from a story for children, acting as game storyline. Since children are familiar with narratives, using a story as starting point, on the one hand, may increase children's confidence and engagement in the game design activity, on the other hand it allows teachers and researchers to frame game design as a continuation of a traditional school activity.

The story, chosen by teachers, was "The edgeless village" (Il paese senza punta) by Gianni Rodari. It tells the adventure of a teenager in a village, where all objects are edgeless, e.g., roses without thorns. The story was read and discussed in class before starting the GaCoCo activity.

The GaCoCo design activity was long, thus it was fragmented and conducted during regular classes. Design sessions, of progressive complexity, were presented as missions to children. Missions and their organization with GaCoCo are illustrated in details in Section 4.2.3 .

*Main Game Design  
Activity*

	Child ...	Child ...	Child ...	Child ...
<b>Age</b>				
<b>Social skill (min 1 - max 3)</b>	1 2 3	1 2 3	1 2 3	1 2 3
<b>Work attitude</b>	- in group - alone - something else ...	- in group - alone - something else ...	- in group - alone - something else ...	- in group - alone - something else ...
<b>Learning style</b>	- global ded. - ded. analytic - something else ...	- global ded. - ded. analytic - something else ...	- global ded. - ded. analytic - something else ...	- global ded. - ded. analytic - something else ...
<b>School skills</b>	- lowly proficient - proficient - highly proficient - something else ...	- lowly proficient - proficient - highly proficient - something else ...	- lowly proficient - proficient - highly proficient - something else ...	- lowly proficient - proficient - highly proficient - something else ...
Write here any additional observations, e.g., friendships, special needs and which:				

Figure 4: The form for organizing groups and collecting data concerning children

*Post-activity.*

*Debriefing and Feedback*

In the post-activity, debriefing interviews with children were run by teachers with the help of researchers to know about their experience with GaCoCo. Children were asked about their experience with the GaCoCo activity, e.g., they were asked to rank their preferred gamified probes used for co-designing at school. Moreover, children of the participating school were invited to our university, see Section 4.2.3

**4.2 GACOCO DESIGN ACTIVITY**

The activity took a total of five missions per school. Each mission was organized the same day in different weeks, and lasted circa two hours and a half.

All missions employed gamified probes for two main purposes. The first purpose was conveying a sense of progression and control, over game design work split across weeks. The second purpose was making cooperative learning rules, roles and strategies tangible. Subsection 4.2.1 details the gamified probes of the activity. Subsection 4.2.2 outlines the cooperative learning contributions used in missions.

Each mission follows the game lifecycle as introduced in Section 3.6. In each mission, by moving from one stage to another (ideation, con-

ceptualization, prototyping), each group of children released specific design outcomes: a specific game design document, organized as a form and a specific paper-based prototype. Such products were progressively building one upon the other, releasing a final game design document and prototype per group.

Section 4.2.3 explains the protocol common to all the activity's missions and details each mission with its specific outcomes, and the procedure followed for releasing each outcome.

#### 4.2.1 Gamified Environment and Gamified Material

In line with (Sanders and Stappers, 2008), GaCoCo uses specific material, namely generative toolkits and gamified probes for children so as to organize and make tangible, for them, the cooperative learning contributions to design, and the design tasks themselves, as well as the school environment. Generative toolkits were made of game design document forms and prototype frames; gamified probes acted as early design versions of gamified tangibles. The material were designed ad-hoc for the GaCoCo studies, considering several aspects, and also whether the material would distract children from their tasks. The design of such material was discussed with child development experts, and it followed general and specific design principle, e.g., by (Hutchinson et al., 2003b): a well-designed probe should be distinguished from other design prototypes or products for the following reasons: (1) design-phase: probes should be introduced in early design stages; (2) functionality: each probe should have few clear functionalities for its users; (3) flexibility: probes should be designed to be open-ended with respect to their functionalities, and users should be allowed to reinterpret and use them in unexpected ways for inspiring designers.

During the game design activity, children worked in their classrooms. At the start of a mission, each group arranged classroom tables in groups of four. On such tables, each group was given a jute basket to store the different objects of each mission, and generative toolkits needed for the game design activity. The design expert hanged two A0 format posters on the wall: one was a paper-version of a progression bar, called progression map, and the other, called tree map, showed a tree, which was growing with the growth of groups' game prototypes.

Specific generative toolkits and gamified probes with its purposes are explained in the following.

The main reference point in class for each group was the **progression map**, see Figure 5. Its main functionality is enabling wayfinding through the process: what I have done so far, where I am now, where

*Progression Map*

I can go next (Lynch and Horton, 2015). In that manner it helps make tangible children's progression through the process, and hence promote children's feeling of control over it. The progression map used in this study is designed as follows. It showed missions vertically, and groups horizontally. Each mission was divided into challenges, one per design task. For tracking their position in a mission, each group had their **badge** to move across mission's challenges. Each badge showed the group logo. On completion of each challenge children found a tangible reward, in the form of a removable wood **coin**. Those coins were completion-contingent rewards, that is, a group earned a coin only after completing a challenge. In addition, when a group grabbed their coin, they found a positive feedback behind it, e.g., good work!.

*Tree Map*

The progression map showed the end of a mission with a door, which was hiding a surprise symbolic reward: sticker for the group's tree to position in the **tree map**, showing the group's progression through missions. That is the tree would grow as the group's game design would grow through missions. Children used these rewards in the tree map, showed in Figure 5, for assembling their tree. Each group had a dedicated portion of land where to stick their stickers. Firstly each group had to plant the seed into the soil, secondly they had to water the seed and then to grow their tree, piece by piece, across missions.

Besides maps, other gamified probes was created for tangibly promoting cooperative learning rules and roles for collaborating and relating to others.

*Scepters and  
Signalling Disks*

For tangibly promoting taking-turns in speaking for cooperation in groups, each group was endowed with a scepter. When a child held the **scepter** he or she could speak and other group members should be listening without interrupting. Moreover in challenges, each group member could vote the proposal of other group members using wooden **signalling disks**: on their signalling disks, children drew smileys or wrote their feedback, positive or not, in relation to the voting task. See Figure 6.

*Shop*

At the end of each mission, groups used their coins, found in the progression bar: with coins each group could buy objects for their prototypes they were designing. Groups had to move to the shopping point, where they found the wood fabric **shop** with 20 jute pockets, containing different objects for prototyping, e.g., potion, wings. Groups could buy objects for their daily mission by inserting their coin into the shop fissure. There were 20 objects on sale, including a special card, the "help of the expert card". This card gave each group the right to ask the game designer for extra-help concerning their prototype. See Figure 6.





Figure 5: The progression map (on the left) and the tree map (on the right).



Figure 6: The signalling disk and the scepter in use (on the left); the shop (on the right).

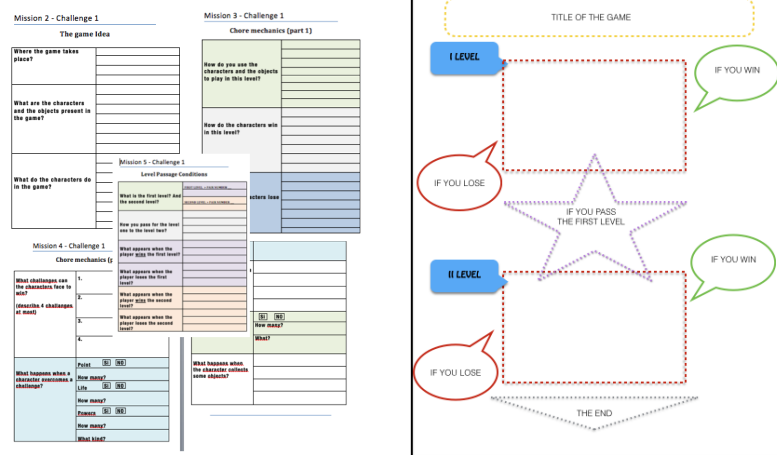


Figure 7: Forms for releasing the game design document (on the left) and the ad hoc frame for game prototype (on the right).

*Game Design Document Forms*

In order to design and prototype their game, children were provided with different forms to fill in. These forms were referred to as the **game design documents** and represented game design stage. In line with the game lifecycle explained in 3.6 and the related stages, each design session provided different forms to fill in that represented parts of the game lifecycle: from ideation and conceptualization to prototyping. These forms were A4 printed on papers. They were structured with simple questions related to the game design documents and dedicated space to answer the questions. See Figure 7. Overall each group had five forms to fill in, one per mission. They are described in Section 4.2.3. Game design forms and prototype frames are available with English translations at the following link: [GaCoCo Mission Forms 2014](#).

*Tablet Frame*

Each group had two A3 frame with a tablet shape for prototyping their game level.

*Ad Hoc Game Frame*

The last mission was centered on a presentation of the co-designed prototypes. For this, each group had an A0 **poster frame** with colored shapes where to insert pieces of information about their paper-based prototype, in a structured manner. See Figure 7. More in detail, the upper part was dedicated to the game title. Below there were two dedicated spaces for glueing the two prototyped game levels. For each level, two balloons represented the winning and losing conditions; e.g., what appears when the player loses or wins. At the center of the poster there was a star representing the passage conditions; e.g., what appears when the player pass from the first level to the second. The bottom part was dedicated to the end of the game, e.g., what appears when the game was completed.

## 4.2.2 Cooperative Learning Rules, Roles and Strategies

*Roles and rules*

Different cooperative learning roles were considered and adapted according to the game design protocol. Roles for children in group work recurred across missions. Such rotated among group members across missions, so that all children had a chance to train different skills.

The **group roles** used in each mission were the following.

- *Secretary*: she/he collected and recorded data in mission specific forms, concerning design choices.
- *Ambassador*: she/he was responsible of exchanging information with teachers and the design expert.
- *Materials Manager*: she/he was the only one who could stand up for collecting material for the activity, making sure that each members of his/her group had equal access to it.
- *Time Keeper*: she/he encouraged the group to stay on task and announced when time was halfway through and when time was nearly up.
- *Participation Checker*: she/he checked that all group members participated and gave their contribution, e.g., if some member was distracted, the participation checker would recall his or her attention

If group members were less than five, the teacher chose who would take up more than one role per mission. Alternatively, she did not assign some of the least relevant roles, e.g., the time keeper or participation checker.

Besides group roles, pair roles were assigned when group members were split in pairs for specific missions. According to the protocol of each mission, if group members were three, the group was divided into a pair and a single member. Otherwise, if necessary, the three members would work together. If a group had five members, the group was divided into a pair and a trio.

The **pair roles** were as follows.

- *Pair-Speaker*: she/he could speak for both members of the pair, describing the pair's work to others.
- *Pair-Checker*: using game design documents, she/he controlled whether the pair-speaker had given all necessary details or not. She/he could ask clarification questions to others.

In a five-member group, two members of a trio would execute the pair checker role; whereas in a three members group, two member execute the checker role.

Besides roles, and in support of them, cooperative learning considers a set of rules, necessary for working in group and for involving all members. Rules for managing group work were explained to the class by their teacher during the first mission, and were recalled at the start of each mission. More in details, rules were concerned with social skills such as reciprocal listening and respecting different views. Examples of cooperative learning rules that GaCoCo employed were: taking turns in voicing opinions, reconciling different views, e.g., concerning game concepts or prototypes, helping peers or listening in silence to the other group members ideas. GaCoCo studies made such rules clear and easy to recognize by using ad-hoc gamified probes, as introduced in Section 4.2.1. For example, each group was endowed with the scepter for organizing turns in speaking, and each child could vote on different views by drawing smileys on signaling-disks.

### *Strategies*

There are many cooperative learning strategies for organizing group work. This subsection describes the main strategies adapted to the GaCoCo activity. These strategies, adapted to the GaCoCo study and made tangible with gamified probes, recurred across missions and are related to specific mission's challenges that include group work, pairing and sharing informations.

**SHARING FOR IDEATING AND CONCEPTUALIZING.** When children had to fill in a game design document, structured as a form, they were asked to proceed in a specific manner. In case of group work, the group secretary read aloud the information required, field by field. In turn, each group member shared his or her own ideas with the group, and the secretary reported it. Group members shared ideas and gave their own opinions on others members' ideas using scepters for taking turns. Once all members had given their opinions, within the allotted time, the group had to converge on a single design choice: to do so, they voted using signalling-disks. In case of pair work, one member read the form questions, the other member filled in the form, and both shared ideas.

**THINK PAIR SHARE.** In case of pair and group work, the think-pair-share strategy of cooperative learning was employed and adapted in order to share with the group the pair's outcome, whether this was a game design document or a prototype. The strategy had three distinct

steps. In the “think step”, each member reflected or worked individually on the proposed challenge. In the “pair step”, groups were split in pairs to discuss about their work, and to listen to the other pairs’ ideas, releasing a game design document or prototype. In the “share step”, group were recomposed; in turn, pairs shared their document or prototype, using the roles of pair speaker and pair checker.

GaCoCo 2014 Study											
	Mission 1		Mission 2		Mission 3		Mission 4		Mission 5		
<b>GOAL</b>	Training and group identity		Conceptualizing the game idea and game characters		Prototyping the game levels		Prototyping the game levels		Finalisation of each group game levels, and its presentation to the entire class.		
<b>CHALLENGES</b>	Choosing the group name and prototyping the group badge.	Game Idea	Game character	Sharing and revising	Core mechanics (part 1)	Sharing and revising	Core mechanics (part 2)	Sharing and revising	Progression through levels + Winning and losing Effects	Game Title	Presentation
<b>COOPERATIVE LEARNING STRATEGIES</b>	Group work	Group work	Group work	Think Pair Share	Pair work	Think Pair Share	Pair work	Think Pair Share	Pair work	Group work	Group work
<b>GENERATIVE TOOLKITS</b>	The group name form with the sticker badge	Game Idea Form	Game Character Form		Level frames Core mechanics form (part 1)	Level frames Core mechanics form (part 2)	Level frames Core mechanics form (part 2)	Level frames Core mechanics form (part 2)	Game frame Progression form	Game Frame	Game Frame
<b>GAMIFIED PROBES</b>	Per class: Progression Map; Tree Map Per group: Scepters, Per child: Roles badge, Signaling disks Per class: shop										

Figure 8: Steps and material mission by mission of the 2014 study

## 4.2.3 Protocol Mission by Mission

This subsection details the protocol mission by mission. Firstly it details the common protocol to all the activity's missions in the *Across Missions* paragraph. Secondly, it outlines each mission in the *Mission by Mission* paragraph, detailing the outcomes and the procedure for tackling the related outcomes.

Figure 8 summarizes the main steps for each mission, detailing the goal of each mission, its specific challenges and the cooperative learning strategies and material (generative toolkits and gamified probes) to use.

*Across Missions*

Missions followed a recurring pattern.

AT THE START OF A MISSION. The teacher and the researcher re-capped what children had produced at the end of the previous mission (if any), and outlined the goal of the daily mission. Teachers explained or reminded rules, assigned and explained roles of cooperative learning to each child. Then the design expert explained the organization of the mission into challenges, using the progression map and the relevant gamified probes.

*Recap and Mission Goal*

DURING THE MISSION. Each group worked at their tables, arranged so as to promote face-to-face interaction. The time-keeper tracked time and the progression of groups in the map. In all missions, the secretary was responsible for his or her group's game design documents. At the end of each mission challenge, the group ambassador asked the expert to validate their challenge's outcomes. During this formative evaluation, the expert gave rapid feedbacks, for validating the challenge or for clarifying design decisions. Only when the challenge resulted tackled and hence validated by the expert, the group could move their badge on the progression map, awarding the coin related to the challenge.

*Formative Evaluation*

*Rewards System*

AT THE END OF THE MISSION. The material manager earned the group's sticker to place in the tree map on behalf of his or her group. Subsequently, groups could use their coins for buying prototyping objects at the shop. Teachers and researchers gathered feedback from children, administering a questionnaire concerning their emotions.

AFTER A MISSION. A summative evaluation is an expert evaluation used as a discount inspection method conducted by experts, against

*Summative Evaluation*

given heuristics or principles (Macefield, 2014). Starting from the second mission until the fifth mission, two game design experts evaluated game products, released at the end of a mission; one of them was the expert present at school. They used heuristics by Desurvire et al. (Desurvire et al., 2004) concerning the game storyline, game play and game mechanics. Evaluation results were tracked in a structured format (Albert and Tullis, 2013). The expert that went back to school used the evaluation results as summative feedback for children during the next mission.

**OUTCOMES.** The first mission aimed at: (1) training all children to cooperative learning rules and group roles as well as to the use of gamified probes; (2) creating the identity of each group; (3) introducing the game design activity with its design goal. Its *outcome products* were the group badges and brand names, specified in the related forms. The Figure 9 shows the first mission outcomes for a group.

**PROCEDURE PER CHALLENGE.** The mission started with the teacher explaining the design activity goal, rules and group roles. Then the design expert explained children how game design would work using metaphors related to the tree map in Figure 5: each game would be rooted into a game idea (seeds), would build on game mechanics (trunk) and would flourish with aesthetics (leaves and fruit). Gamified probes were unveiled on a need-to-use basis. After the explanation, the teacher assembled groups who started working together.

The *first mission* had one challenge, namely choosing the group name and prototyping the group badge. This was done in two steps.

In the first step, each group was provided with a form for choosing the group name, see Figure 9. Each group filled in their form by using the sharing strategy and the related gamified probes. Each group started to practice their roles and rules, as explained before in Subsection 4.2.2.

In the second step, each group developed their own badge. The badge served to track their progression on the map in Figure 5. The design expert validated badge completion, and the material manager then placed the group badge on the mission challenge in the progression map.

**REWARDS.** At the end of the mission each group gained one coin and a (paper) seed, to be planted on their group soil on the tree map (see Figure 5).



Mission 1 - Form: Group Name

Scheda 1

Nome del gruppo	Num. Faccine felici ☺	Num. Faccine tristi ☹
I MITICI	4	0
I BABINI FANTASTICI	2	2
INVENTATORI DELLE STORIE	2	2
CILI	4	0

Mission 1 - Badge



Figure 9: Form for choosing the group name (on the left) and the group badge prototyped (on the right)

### *Second Mission. Group Game Idea and Characters*

**OUTCOMES.** The second mission aimed at conceptualizing the game idea. The game idea is related to the game world; e.g., setting, characters.

The *outcome products* of the second mission were the high-level concept document with the game idea of each group, and a prototype game character per child. See Figure 10

**PROCEDURE PER CHALLENGE.** Before starting the mission, the class re-read the story chosen by the teacher. Next, the expert researcher, helped by teachers, explained that each group had to create a game to continue the story; games would have to include story characters, or other elements related to the story.

The second mission had three challenges.

In the *first challenge*, starting from the story read in class, each group had to create their game idea for continuing the story and to report it by filling in the high-concept document form. In order to fill in the high-level concept document, each group used the sharing strategy (see Subsection 4.2.2). This was structured as a form with simple questions, e.g., where does the game take place?

In the second and third challenges, groups were split into pairs and the think-pair-share strategy was used as follows.

In the *second challenge*, each member was given a form (see Figure 10) for prototyping his or her own game character. The character form required to specify physical characteristic, specific powers and character

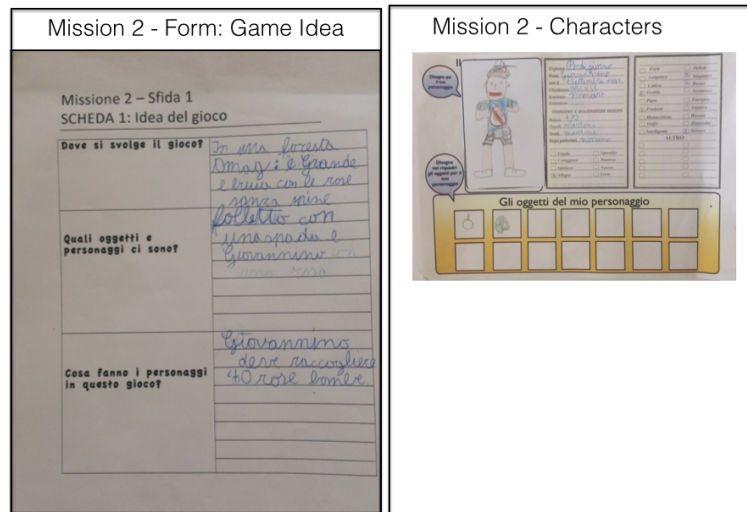


Figure 10: The form for the Game Idea (on the left); a character prototyped by a group (on the right).

traits e.g., courageous, funny, and the character’s objects. At the end of the challenge each member had their character prototyped.

In the *third challenge*, each group was again split into pairs. Each pair shared each member’s character prototype, and enriched their characters together, orally or graphically, according to their skills. Then groups were reunited to share the pairs’ prototypes and refine them again; each pair speaker described the prototyped characters, whereas the pair checker reported if the pair-speaker had forgotten something.

**REWARDS.** At the end of the mission, each group gained three coins, one per challenge, and a watering to water the seed and to make it grow. On the tree map there was a dedicated space for glueing the watering, see Figure 5.

*Third and Fourth Missions. Group Levels.*

**OUTCOMES.** The third and fourth missions aimed at prototyping the game levels, completing the core game mechanics documents. Starting from the high-concept document, the outcome products of the third and fourth missions were prototypes of two game levels per group, and their core mechanics documents. See Figure 32.

**PROCEDURE PER CHALLENGE.** In the third and fourth missions, groups worked in pairs, and the think-pair-share strategy was used in order to prototype two levels of the group game, one per pair.

The third mission had two challenges. In the *first challenge*, after revising their high-level concept document in group, each pair worked

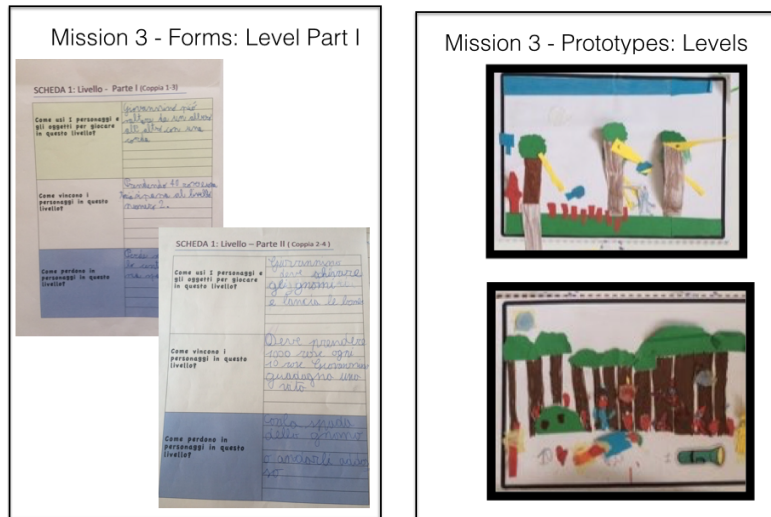


Figure 11: The filled form for the core mechanics document (on the left); two game levels prototyped by a group (on the right).

on the core mechanics document for their level. In the *second challenge*, each pair used this document for prototyping their level using the second mission's characters. Results were then shared in group.

The fourth mission had three challenges. In the *first and second challenge* the same pairs of the third mission worked on continuing the core mechanics document and prototype of their level. The form contained questions concerning the core mechanics, e.g., rules. In the *third challenge* pairs shared results with their group.

**REWARDS.** At the end of the mission each group gained a coin per challenge, and parts of a tree (tree roots, trunk and frond) like stickers to glue on the dedicated space on the tree map, see Figure 5.

#### *Fifth Mission. Passage Conditions and Game Finalisation*

**OUTCOMES.** The fifth mission aimed at the finalisation of each group game levels, and its presentation to the entire class. The outcome products of the fifth mission per group were: the conceptualization of (1) passage conditions from one level to the other, as in the accompanying progression document, (2) the assembled game prototype and (3) the presentation, namely play , for showing player's interaction using the prototype. See Figure 12.

**PROCEDURE PER CHALLENGE.** The fifth mission had four challenges. In the *first challenge*, each group used the sharing strategy for revising their levels together and for filling in the progression document

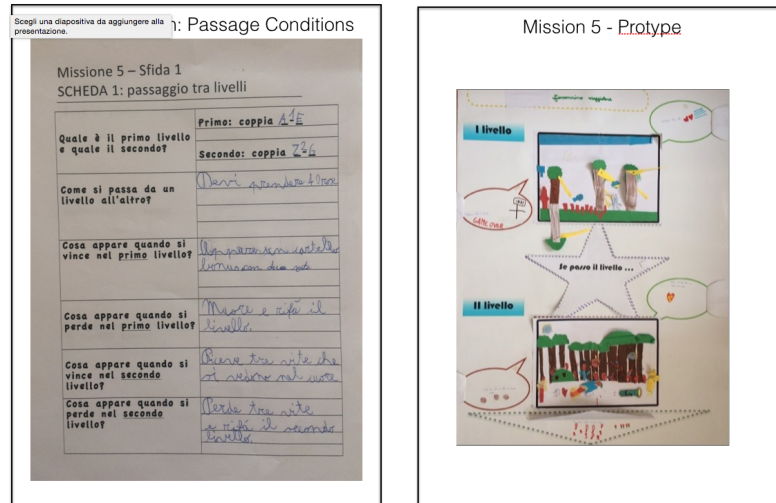


Figure 12: Passage conditions form (on the left); the final prototyped game with the winning and losing conditions and passage conditions (on the right)

concerning the passage between levels, e.g., “what happens when the player wins at the first level?”.

In the *second and third challenges*, using an ad-hoc frame, groups assembled their level prototypes into a single game and chose the game title. Firstly, each pair inserted their level in the frame. Secondly, all group members worked on prototyping passage between levels, in a dedicated area of the frame, following the progression document. See Figure 12. Thirdly, the group had to choose the winning and losing effects that appeared when the player won or lost.

In the *fourth challenge*, each group presented their game prototype to the entire class, simulating a game activity (*play testing*) and showing the player’s interaction with it, so as to gather feedback from peers. In line with cooperative learning, each group member was responsible for presenting a specific part of the group’s game.

**REWARDS.** At the end of the mission, each group gained four coins and won a wooden star that allowed each group to receive a special prize. The special prize was a certificate, signed by the game designer responsible for the project. Each group would receive this prize during a dedicated mission at the university, as explained in section 4.2.3.

*Mission at University.*

The mission at the Free University of Bozen-Bolzano was organized at the end of the GaCoCo design activity. The mission lasted circa 4

hours. The two classes with their teachers were invited to present their prototyped game.

**OUTCOMES.** The mission at the University aimed at (1) presenting the prototyped games by each group to the other class, (2) receiving feedback from all children about the games. Moreover, each child was asked to vote the preferred game. The *product outcomes* of the mission at the university were the feedback given by children to each game, and the preferred game chosen by voting.

*Game presentations*

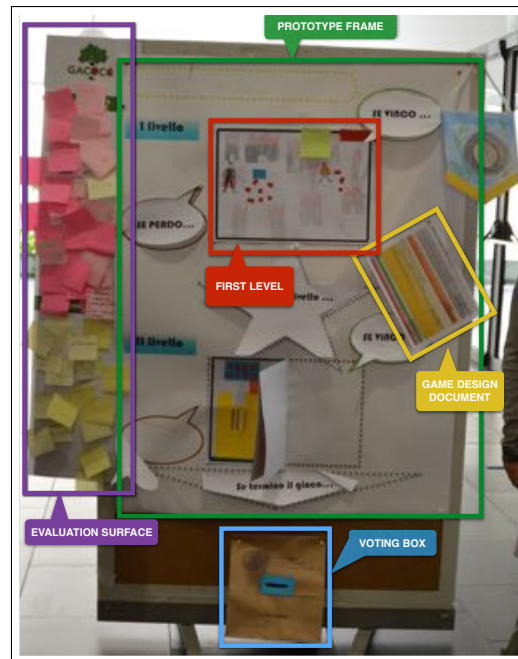


Figure 13: The panel with the assembled game on the poster frame. On the right, each game had a space for comments and feedback; at the bottom the panel had the voting box for voting the preferred game.

**PROCEDURE PER CHALLENGE.** Since each group had to show and present their game, the gallery tour strategy (Barnes and O'Farrell, 1990) of cooperative learning was used. The premise of the strategy is that classes are divided into groups, each one delivering own products. Groups' products are then displayed as in a gallery. Each product comes with an allocated space for other groups to ask questions or write comments using colored post-it, see Figure 13. Each group presented their game, and then answered any questions and comments with other teams concerning their product. After the presentation, each child was asked to vote on of the group's prototypes, expressing their preferences. In order to vote, each child was provided with gamified

probes to the purpose, e.g., banknotes and voting boxes for voting the preferred game. See Figure 13

**REWARDS.** At the end of the vote, each group delivered the reward (wooden star) gained at the end of the five mission, and each child received a certificate of game designer.

### 4.3 ANALYSIS AND RESULTS

This GaCoCo study collected three main types of data, respectively concerning: (1) quality of game products, released at the end of every GaCoCo mission, and assessed via heuristics by two game design experts; (2) children's achievement emotions, gathered with the GRAED questionnaire, and engagement in the activity and with gamified probes, assessed via observations during the activity.

This section presents and analyses all such data along several perspectives using descriptive and inferential statistics. Section 4.3.1 details the collected data and the used instruments. Section 4.3.2 presents results from executed data analyses.

#### 4.3.1 Data Collection and Instruments

Data concerning quality of products, emotions and engagement were gathered with different instruments, at specific moments, as explained in details below.

#### EXPERT EVALUATION OF CHILDREN'S PRODUCTS

##### *Quality of Products*

**Theoretical underpinnings.** As reported in Chapter 2, learning can be assessed as "authentic" and children's progress through tasks should be evaluated as an authentic assessment using adults' criteria as far as possible (Grisham-Brown et al., 2006). An heuristic evaluation is an inspection method conducted by experts against given sets of heuristics or principles (Nielsen and Molich, 1990). Specifically, the Heuristic Evaluation for Playability (HEP) aims at assessing how playable a game (prototype) is (Desurvire et al., 2004). Playability evaluators perform a heuristic evaluation, while focusing on how each heuristic was supported or violated, and then define the playability issue.

**Format and Coding** Starting from the second mission until the fifth mission, two game design experts evaluated the game product of each group as released at the end of a mission. One of them was present

at school and the other was not involved with school activities. The quality of product was operationalized in terms of playability following the heuristics by (Desurvire et al., 2004) as guidelines (see Section 4.1.2). The used heuristics related to the gameplay and game mechanics, the game storyline and the coherence between the documents released each mission.

At the end of the GaCoCo activity, the game design expert had been at school, created categories of issues found in products, briefly, issues, by analyzing products by children and summative evaluation results delivered at the end of missions, from Mission 2 to Mission 5 (M2–M5). Issues were then discussed and refined with another game-design expert, not working with schools. The distinct issues detected in products across missions are explained as follows.

#### ISSUES

- **Gameplay and mechanics inconsistencies and unclear functionalities.** Game products presented issues concerning inconsistencies or unclear functionalities in gameplay or mechanics. Specifically, children reported a number of elements or challenges in documents, without specifying their functionality in the gameplay or mechanics of their game products.
- **Goals.** The goal of the game idea or players' objectives in game levels are unclear or not consistently aligned in the final game product.
- **Storyline.** Children started creating their game idea from a given story, acting as the game storyline, and could use story elements in their game. The interplay between the gameplay and the story was not always maintained, in particular, consistency between the game and the story was not always maintained.
- **Player.** In children's work, it was often unclear the player's role and how the player interacts with the game, e.g., if the player is pretending to be one of the characters and, in case so, which.
- **Gameplay and mechanics incompleteness.** Gameplay or mechanics information was missing in game products, which was requested explicitly, e.g., in game design documents. Specifically, children often did not specify how characters tackled challenges for winning or losing, or how characters passed between levels.
- **Documentation.** Children delivered game design documents, one extending the other. It happened that design choices were not consistently reported across documents.



All the above issues are applicable to products of missions starting with the second, except for documentation and game play and mechanics, which are applicable from the third mission onwards. The udder of two experts providef inter-judge reliability. The design expert working with schools classified all products against issues, while the expert not working with schools classified 33,33% of them, that is, 12 out of 36 products. The mean agreement percentage between the two experts was 87,50%. The lowest agreement between experts was scored for “elements” (66,67%). However, debate arose between experts concerning Documentation: the expert not working with children at school was not convinced that Documentation was a severe issue if the design process is incremental and iterative. Experts resolved disagreements through discussions to revise the products’ classification.

Starting from the aforementioned issues, the quality score of a group for an issue in a mission is defined as follows: at the end of the mission, if the product of the group does not present the issue, then the quality score of the group is equal to 1 for that issue and that mission (a positive result); else the score is equal to 0 (a negative result). This scoring was used later to calculate descriptive statistics and intercorrelations, using STATA 12.1 for Windows (Stata Corp., 2013).

#### ACHIEVEMENT EMOTION QUESTIONNAIRE

##### *Emotions*

**Theoretical underpinnings.** At the end of each mission, researchers administered the Graduated Achievement Emotion Set (GR-AES) (Raccanello and Bianchetti, 2016, 2014), in order to investigate children’s achievement emotions during the GaCoCo activity. The GR-AES is a preliminary version of a verbal-pictorial instrument enabling to assess the intensity of achievement emotions, based on Pekrun’s control-value theory (Pekrun, 2006; Pekrun and Perry, 2014). The study adapted GR-AES instructions so as to guide children to refer specifically to the emotions emerged during the daily design activity. The emotions we focused on enjoyment, relaxation, anxiety, and boredom.

**Format.** GR-AES is presented on booklets, with a page per emotion. A question is at the top of each page, concerning the intensity of the emotion in the activity, e.g., How much did you enjoy it?. For answering, the page displays five faces in a row, corresponding to five increasing levels of emotion intensity; each face is also labeled by a verbal caption, i.e., “not at all”, “slightly”, “moderately”, “very much”, and “extremely”. Such a dual-code representation, verbal and pictorial, favors a more direct access to the semantic network in which emotional information is stored (Paivio, 1971; Goeleven et al., 2008). There are two



versions of GR-AES, differentiated by gender, so as to support children's identification (Lichtenfeld et al., 2012). Boys filled in GR-AES with boy faces, girls filled it in with girl faces. The page for enjoyment, for males, is presented in Figure 14.

**Administrating and Coding.** In the first mission the presentation order of emotions in GR-AES was randomized; subsequently, each child was administered GR-AES with emotions in the same order as in the first mission. The administration of GR-AES was preceded by a familiarization phase, aiming at exemplifying how to answer. Then each child had to indicate how much she or he had felt, in relation to each emotion, during a mission (e.g., "Think about how you felt during today's mission...for each emotion, displayed as follows, indicate how you felt"). A score ranging from 1 to 5 was used for coding the intensity of each emotion, using a 5-point Likert-type scale: 1 = not at all; 5 = extremely.

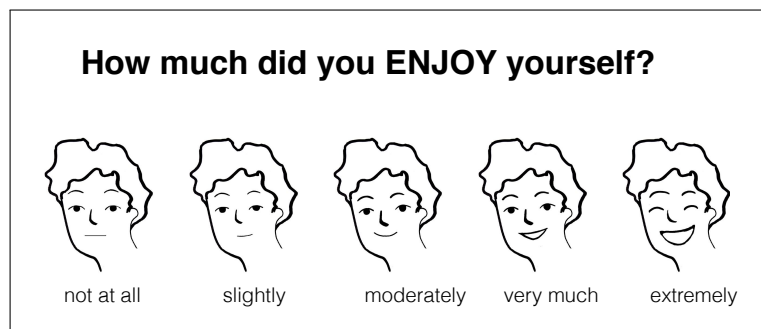


Figure 14: A page of GR-AES concerning enjoyment for males

For achievement emotions analyses we used SPSS version 21.0 for Windows, to calculate descriptive and inferential statistics. The level of significance was set at  $p < .05$ . We used Mplus version 5.2 (Muthén and Copyright, 2007) to run path analyses to test some mediational models. A maximum-likelihood (ML) estimation was performed, and a bootstrapping method with a confidence interval was used to test indirect effects. No missing data were present in the dataset.

Moreover, in order to calculate correlation between the quality of products and emotions, we used again SPSS version 21.0 for Windows to calculate descriptive statistics and intercorrelations.

#### OBSERVATIONS AND VIDEO RECORDING.

**Theoretical underpinnings.** In line with (Shernoff et al., 2003; Biklen and Bogdan, 2007; Hamari et al., 2016), engagement is evidenced by behaviors in mission challenges that denote: (1) positive emotions, such as enjoyment, amusement or negative emotions, such as an increase

*Engagement*

in anxiety or boredom, shown with facial expressions or body postures; (2) interest, or its absence, such as frequently asking questions or not, engaging in conversations with teachers, experts or peers; (3) concentration, or its absence, such as showing attention in listening to instructions, remaining in one's group and on task.

**Format.** The education expert acting as passive observer was present in each mission at schools. She observed the class without interfering. In the first mission she identified herself as a researcher and explained the overall purpose of her observations. While in the classroom, she tracked class behavior, reporting in a daily diary all those situations which potentially indicated engagement or disengagement. A diary allows an observer to collect data as events unfold and to leave room for the emergence of unforeseen categories. In addition, a video camera was positioned in a corner of the classroom; at the end of the mission, the observer integrated her diary by analyzing visible behaviors in videos.

**Coding.** At the end of the GaCoCO activity, diaries were analyzed thematically against the considered categories of behaviors: enjoyment, interest and concentration. To provide inter-judge reliability, the observer classified behaviors in diaries against the three categories, while another education researcher, not present in class, classified 40% of diaries, that is, 4 diaries out of 10. In line with the typical coding scheme of qualitative data by (Ocumpaugh et al., 2012), namely observations on behaviour (e.g., on and off task conversation) and affect (e.g., engaged concentration, boredom) of students in field setting, they proceeded as follows: they agreed on colors for categories; each of them, separately, colored segments of texts in diaries, according to the related category; then they reported segments per category in electronic format, marking whether a segment of text was related to engagement or disengagement; at the end of their coding, they compared results. The mean agreement percentage between researchers was 85,67%, distributed as follows per category: 95,16% for enjoyment behaviors; 85,12% for interest behaviors; 76,73% for concentration behaviors. Disagreements were solved through discussion between researchers and were used to revise the observer's classification of behaviors in diaries, as well as to refine the list of behavior categories to observe. As refinement, another category was added: engagement behaviour with gamified probes (Dodero et al., 2015). More in detail, we analysed the usage of gamified probes: whether probes were used with functionalities different than the planned ones, and whether the usage was (or was not) distracting children from their activity.

## PREFERENCES FOR GAMIFIED PROBES—SELF-REPORT SURVEY

**Theoretical underpinnings.** Children’s preferences for gamified probes recurring in every mission were investigated via self report survey. There is a large body of literature regarding tools for measuring fun that children have when using technology (Read, 2008), e.g., the Fun Sorter in which children are asked to rank the relative fun of a variety of activities. We adapted the Fun Sorter tool and created a survey for ranking the preferred gamified probes of the study.

*Engagement*

**Format.** The survey is on A4 page, see Figure 15. A question is at the top of the page, e.g., what objects did you like more? and there are five spaces representing the preference positions from 1 (the preferred gamified probes) to 5 (the less preferred gamified probes). Each child had some “stickers” with pictures and captions of the gamified probes used during the GaCoCo activity, e.g., progression map, and had to rank pictures by sticking them in the related space position, see figure 15.

**Administration and Coding** The teacher administered the survey during the post-activity. A score ranging from 1 to 5 was used for coding the preference of each gamified probes, using a 5-point Liker-type scale: 5 = the first place and 1= the last place among the preferred gamified probes.

Figure 15: A ranking survey for engagement with gamified probes used in the activity

### 4.3.2 Study Results

This section reports on results concerning the main data collected, concerning quality of products, emotions and engagement.

Firstly, it analyses the evolution of the quality of products in time in relation to Goal 1. Secondly, it presents results concerning the emotion in time (Goal 2.1) and it presents qualitative results reported in narrative form concerning the mission engagement of children with design work and material, as well as their preferences on gamified probes (Goal 2.2). Finally, the section inspects relationships between emotions and quality of products (Goal 4).

#### *Quality of Products*

This section focuses on the first research goal, G1, concerning children's performances in GaCoCo design. At the end of missions M2–M5, groups released products consisting of game design documents and prototypes, as specified in Section 4.2.3.

Table 1 shows, for each issue and mission, groups with quality score 1 for the issue and in the mission.

In order to assess the evolution in time of children's products, quality scores of a group in a mission were added across issues, and then divided by the number of issues applicable in the mission (4 issues in M2; 6 issues in all other missions). The result for a group product is referred to as the *quality of the product* of the group or of group members. Table 2 reports the quality of product per group and per mission, mean (M) and standard deviation (SD) across groups.

*G1.H1 Quality of product change in time. Partially supported.*

A non-parametric Friedman's test of differences among repeated measures was then conducted on the quality of products, and it was significant,  $\chi^2(3) = 16.737$ ,  $p = .001$ . A post-hoc comparison with Wilcoxon indicated that quality of products were significantly different in all cases except between M4 and M5:  $z = -2.084$ ,  $p = .037$ , comparing M2 (M = 0.25, SD = 0.35) and M3 (M = 0.54, SD = 0.28);  $z = -2.375$ ,  $p = .018$ , comparing M2 and M4 (M = 0.59, SD = 0.34);  $z = -2.388$ ,  $p = .017$ , comparing M3 and M5 (M = 0.81, SD = 0.19); most importantly,  $z = -2.565$ ,  $p = .010$ , comparing M2 and M5, starting and concluding the design of game products. These results partially support the rejection of the null hypothesis on the effect of time (G1.H1).

#### *Children's Achievement Emotions*

This section focuses on Goal 2.1, and it analyses the four emotions gathered with GR-AES. It analyzes them at an individual level, in order to verify the hypotheses concerning possible intensity differences related to valence (G2.H1), activation (G2.H2) and time (G2.H3).

Category	Mission 2	Mission 3	Mission 4	Mission 5
Gameplay and mechanics inconsistencies and unclear functionalities.	3, 4	1, 2, 3,	2, 3, 4, 7	1, 2, 3, 4, 7, 8
Goals	1, 4	1, 2, 4, 7, 8,	2, 4, 7, 8	1, 2, 4, 5, 6, 7, 8
Storyline	2, 4,	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8	1, 2, 3, 4, 5, 6, 7, 8
Player	1, 2, 4,	1, 2, 4, 5, 7, 8,	1, 2, 3, 4, 7, 8	1, 2, 4, 5, 6, 7, 8
Gameplay and mechanics incompleteness	-	2	2, 3, 4, 7	1, 2, 4, 5, 9
Documentation	-	1, 2,3, 4, 7	1, 2, 4, 5, 7	1, 2, 3, 4, 5, 7, 8, 9

Table 1: Groups with quality score equal to 1 (positive result) for an issue in a mission

Groups	Mission 2	Mission 3	Mission 4	Mission 5
Group 1	0.50	0.83	0.50	1.00
Group 2	0.50	1.00	1.00	1.00
Group 3	0.25	0.50	0.67	0.50
Group 4	1.00	0.67	1.00	1.00
Group 5	0.00	0.33	0.33	0.83
Group 6	0.00	0.17	0.17	0.50
Group 7	0.00	0.67	1.00	0.83
Group 8	0.00	0.50	0.50	0.83
Group 9	0.00	0.17	0.17	0.83
M	0.25	0.54	0.59	0.81
SD	0.35	0.29	0.34	0.19

Table 2: Quality of product for each group and mission (M2-M5); means (M) and standard deviations (SD) across groups

To check for normality of variables, we verified that mean values of skewness ( $M = .74$ ,  $SE = .78$ ) and kurtosis ( $M = .85$ ,  $SE = .40$ ) did not exceed  $|2.0|$  and  $|7.0|$ , respectively, supporting normality assumptions (Curran et al., 1996). We carried out a  $2 \times 2 \times 5$  (Valence [positive emotions, negative emotions]  $\times$  Activation [activating emotions, deactivating emotions]  $\times$  Mission [first, second, third, fourth, fifth mission]) repeated-measure ANOVA on the intensity of the four emotions, with Valence, Activation, and Mission as within-subjects factors.

A graffiti main effect of Valence was found,  $F(1,34) = 38.07$ ,  $p < .001$ ,  $\eta_p^2 = .53$ , indicating higher intensity for positive emotions ( $M = 2.97$ ,  $SE = .12$ ) compared to negative emotions ( $M = 1.88$ ,  $SE = .09$ ), falsifying the null hypothesis on the effect of valence (G2.H1).

*G2.H1: positive emotions more intense than negative ones. Supported.*

*G2.H2: higher intensity for activating emotions. Partially supported.*

In addition, a significant two-way interaction Valence x Activation emerged,  $F(1,34) = 9.81, p = .004, \eta_p^2 = .22$ . Specifically, the activating emotion was more intense than the deactivating emotion only for positive emotions (enjoyment:  $M = 3.23, SE = .17$ ; relaxation:  $M = 2.70, SE = .12$ ) but not for negative emotions (anxiety:  $M = 1.83, SD = .13$ ; boredom:  $M = 1.93, SD = .12$ ), partially falsifying the null hypothesis on the effect of activation (G2.H2).

*G2.H3: intensity of negative and positive emotions change in time. Supported.*

Concerning hypothesis G2.H3, Mission  $F(4,136) = 2.55, p = .042, \eta_p^2 = .07$ , Mission X Valence,  $F(4,136) = 5.62, p < .001, \eta_p^2 = .14$ , and Mission X Activation,  $F(4,136) = 4.23, p = .003, \eta_p^2 = .11$ , resulted as significant. To further explore these findings, we carried out four repeated-measure ANOVA, with Mission as the within-subjects factor, on the intensity of emotions, separately for the four emotions. For each emotion, a significant effect of Mission emerged (enjoyment:  $F(4,136) = 3.87, p = .005, \eta_p^2 = .10$ ; relaxation:  $F(4,136) = 6.45, p < .001, \eta_p^2 = .16$ ; anxiety:  $F(4,136) = 3.12, p = .017, \eta_p^2 = .08$ ; boredom:  $F(4,136) = 3.59, p = .008, \eta_p^2 = .10$ ). Pair comparisons revealed that intensity was higher for the third mission compared to the fifth mission for enjoyment, and for the first and the second missions, compared to the fourth mission for relaxation; in addition, it was lower for the third mission compared to the fourth mission for anxiety, and for the third mission compared to the fifth mission for boredom. Figure 16 reports descriptive statistics of the intensity of four emotions, across missions. These results enabled to falsify the null hypothesis on the effect of time (G2.H3).

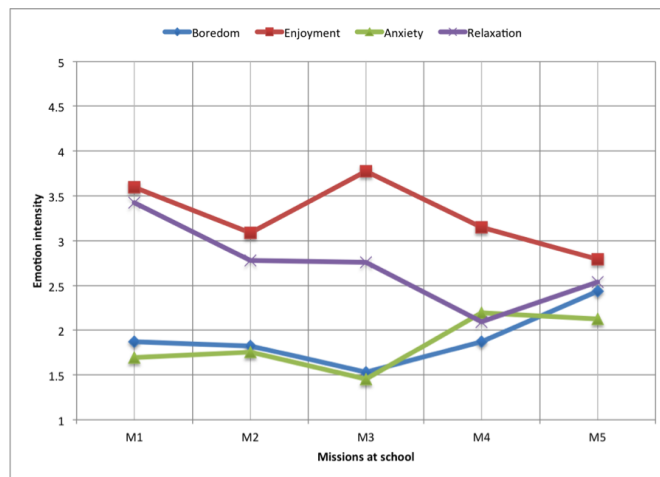


Figure 16: Mean intensity of emotions per mission (M1–M5)

### *Children's Engagement*

This section focuses on Goal 2.2. Relevant results due to engagement observations are reported in narrative form, in a manner that facilitates comparisons with statistical analysis results, that is mission per mission, emphasizing whether differences were observed among groups or not.

Firstly we present the mission per mission engagement in terms of interest, concentration and enjoyment. Secondly, the section presents the engagement of children with the gamified probes used during the activity. The section ends with results of the survey about the preferences of each child of gamified probes.

ENGAGEMENT IN MISSIONS The engagement in terms of interest, concentration and enjoyment during the missions was analysed mission per mission. The results were as follows.

M1. All groups, in younger and older classes alike, listened with attention to the game design overview and to the explanation of rules and roles. A child cheerfully exclaimed "Wow" when teacher assigned him the role. During the first challenge (creating badges), groups of the younger class generally worked in an orderly manner, respecting rules and roles and showing interest for the activity. In the older class, two groups were concentrated and enjoying their tasks. Younger children showed more excitement for the activity. For instance, in the younger class, when a group completed the challenge, one member stood up for showing proudly their work (badge) to the other groups. A group had two members working together concentrated on the task, whereas the other two were isolated. Two groups were noticed for the behaviour of one member: one group had a dominant member, creating confusion; another had an isolated member with lack of concentration: she sat with her arms folded, often yawned and did not interact with the other members. In general the younger class was engaged in the first mission whereas only half of the older class was engaged.

M2. During the recap time, children answered teacher's questions, interacting with her positively, and showing interest in the activity. All children played "guess who gets that role in this mission". All listened to the story intensely and worked on their group challenge (first), individual challenge (second), pair and group challenge (third), except for the group with the dominant member, who was creating confusion. During the first challenge, a group member scolded her (dominant) peer to be distracted, e.g. "Stop playing with your pencil and work". The majority of groups showed difficulties in conceptualizing the game

idea. They asked several time help to teachers and expert, especially for compiling the related forms of the game idea. In particular, younger class was more neatly and groups showed enjoyment in listening their group members' ideas. In general both classes were engaged in the second mission.

M3. During the recap time, children positively behaved as in the other missions. During pair-work (second challenge), all children, including those least involved in group work in previous missions, tended to work and stay on task. Younger groups worked neatly, calmly and with the smiling faces.

In general engagement shown in the second mission was maintained in the third mission.

M4. In the younger class, children showed interest, interacting during the recap time. During challenges, some younger groups alternated distraction and concentration moments. When a group member draw their character, a child said aloud "Yes, we've drawn a 3d character", and all the other groups came near the child to see the 3D character. In the older class, across the entire mission, there was more evident confusion and signs of anxiety or boredom, e.g., children frequently raised their hands asking for the expert's feedback on their game design challenge, showing nervousness while waiting. In some cases, children played with prototyping material, e.g., a member used the post-it as accordion. One group of the older class tried to remain concentrated, but its members were distracted by the general confusion. In particular, during the mission the teacher was very distracted and did not notice and stop some "wrong" behaviours. However, all groups managed to conclude their challenges and, as in the third mission, pair work tended to activate both members.

In this mission, with respect to the previous mission, engagement decreased. The younger class was more engaged of the older class.

M5. During challenges, in both classes, there was some confusion but children showed to enjoy their game design, and to see the finally assembled game. When the expert explained the final challenge (present their game) children showed fear and anxiety. Moreover, they asked several questions about their roles during the presentation and their work distribution. In both classes, when a group presented their work, and played testing it, all others listened and asked many appropriate questions, e.g., about game elements functionality (how does your player gain life?, how does the player get the coins, and what I can buy



with coins? Both younger and older classes were engaged during the mission, especially during games' presentations.

#### *Engagement with material*

Engagement with material was analysed mission per mission. The results were as follows.

**M1.** Children showed curiosity, interest and enthusiasm towards all material. For instance, all material checker queued up before fetching material was called. Signalling disks got soon very popular and were also creatively used for tasks designers had not planned, e.g., for showing an example logo to other groups.

**M2.** In the first challenge, when creating the game idea, several children played with signalling disks when not expected to be used in the protocol. The usage of scepters for the taking-turn rule of cooperative learning was not immediate, and it required some training. In the second challenge when creating characters, all children were concentrated on the individual task. All children showed enthusiasm for the shop for acquiring prototyping objects. In this mission, objects tended to be chosen for their aesthetic appeal and not so much for their functionality in the game. Maps were also a great source of curiosity for finding out rewards. At the end of the mission children showed enjoyment for the gained coins, e.g., two children exclaimed "Yuuuuh, we gained 3 gold coins!".

**M3 and M4.** At the start of both missions, children asked for their signalling disk. In the challenge for prototyping levels they showed enthusiasm for generative toolkits, e.g., tablet frames and transparencies. Once more the shop was source of strong interest, however objects were chosen according to their game functionality; discussions were observed in front of the shop concerning the usage of objects in games. Moreover, every time children finished a challenge, they were very solicit in asking the expert's feedback on their work in order to be allowed to go to the progression bar, move their place card, and hence collect their coin. An extreme case happened when a fire alarm sounded for training purposes. Knowing that it was for training, a child asked to be allowed to progress on the bar and get his coin, because the group was approaching the end of the challenge and the training would take too long a time, so the child wished to have his coin as soon as possible.

M5. Albeit the A0 frame for assembling levels created curiosity and enthusiasm, matching it against the passage document required effort on the side of younger learners.

#### *Preferences for Gamified Probes*

Preferences for gamified probes are as follows. As for younger learners, 12 out of 15 completed the survey. At the first place of the survey, 50% of them chose the shop, and 34% chose the signalling disk. Moreover, 33% of them chose the signalling disk as second. The progression map for challenges was the third object for 42% of younger learners.

As for the older learners, 19 out of 21 completed the survey. At the first place of the survey, 37% chose the shop, and circa 32% chose the progression map for missions. Moreover, 32% of them chose the progression map for challenges as second, 50% chose the signalling disk as second or third, and 21% chose the scepter as third.

#### *Emotions and Quality of Products*

This section focuses on the third goal, G3: the relationships between performance and the four emotions of enjoyment, boredom, anxiety, relaxation. Tables 17 and 18 show descriptive statistics (mean, M; standard deviation, SD) computed at the individual level (before the slash) and at the group level (after the slash) for the following variables: intensity of positive emotions in each mission (M1–M5); intensity of negative emotions in each mission (M1–M5); quality of group products in each mission (M2–M5). Correlations among intensity of emotions per mission and quality of product per mission were again computed separately for the individual level (for which parametric Pearson correlations were run) and the group level (for which non-parametric Spearman correlations were run). Correlation coefficients are thus  $r$  for the individual level, and  $\rho$  for the group level. Both coefficients range from  $-1$  to  $1$ : the greater the absolute value of the coefficient, the stronger the correlation. A positive correlation means that if one variable increase, the other variable tends to increase. A negative correlation means that, if one variable gets bigger, the other variable tends to decrease. Table 17 displays the correlation coefficients among intensity of positive emotions per mission and quality of product per mission:  $r$  is displayed before the slash;  $\rho$  is displayed after the slash. Table 18 does the same with negative emotions.

Concerning hypotheses 3a and 3b, there are significant correlations between intensity of emotions and quality of product, for the same mission, for enjoyment and boredom, similarly at the individual level and at the group level. For enjoyment, the mentioned correlation was

positive for M2 (individual level:  $r = .42$ ,  $p = .012$ ; group level:  $\rho = .77$ ,  $p = .015$ ), while for boredom it was negative for both M2 ( $r = .41$ ,  $p = .013$ ;  $\rho = -.76$ ,  $p = .017$ , respectively) and M3 ( $r = .35$ ,  $p = .037$ ;  $\rho = -.72$ ,  $p = .029$ ). These findings enabled to partially falsify the null hypothesis on the relationship between the two emotions and quality of product. Always considering the same mission, no significant correlations emerged between relaxation and anxiety, on the one hand, and quality of product, on the other hand.

Frequently, the quality of product of a mission correlated significantly and positively with those of subsequent missions, indicating a certain level of coherence in children's quality of product over time, again at the individual and group levels (Tables 6 and 7), with only a few exceptions. Specifically, the quality of product of M2 correlated positively with those of M3 ( $r = .62$ ,  $p < .001$ ;  $\rho = .72$ ,  $p = .027$ ), M4 ( $r = .60$ ,  $p < .001$ ), and M5 ( $r = .55$ ,  $p = .001$ ;  $\rho = .68$ ,  $p = .045$ ). The quality of product of M3 correlated positively with those of M4 ( $r = .81$ ,  $p < .001$ ;  $\rho = .83$ ,  $p = .006$ ) and M5 ( $r = .65$ ,  $p < .001$ ;  $\rho = .75$ ,  $p = .019$ ). The quality of product of M4 correlated positively with the quality of M5 ( $r = .47$ ,  $p = .005$ ).

In addition, intensity of emotions in a mission was frequently correlated, and significantly so, with the quality of products of subsequent missions, suggesting a sort of delayed effect of emotions creating expectations for later performance, with slight differences between the individual and the group level (Tables 17 and 18). Specifically, enjoyment in M2 correlated positively with quality of product of M3 ( $r = .59$ ,  $p < .001$ ;  $\rho = .84$ ,  $p = .005$ ) and M4 ( $r = .52$ ,  $p = .001$ ;  $\rho = .76$ ,  $p = .017$ ), and enjoyment measured in M3 correlated positively with quality of M4 ( $r = .36$ ,  $p = .036$ ). Anxiety measured in M1 correlated positively with quality of product of M4 ( $r = .40$ ,  $p = .018$ ;  $\rho = .77$ ,  $p = .016$ ). Boredom measured in M1 correlated negatively with quality of product of M2 ( $r = .61$ ,  $p < .001$ ;  $\rho = -.78$ ,  $p = .012$ ) and M3 ( $r = .47$ ,  $p = .005$ ). Boredom measured in M2 correlated negatively with quality of product of M3 ( $r = .47$ ,  $p = .004$ ;  $\rho = -.72$ ,  $p = .027$ ) and M4 ( $r = .52$ ,  $p = .001$ ;  $\rho = -.89$ ,  $p = .001$ ). Boredom measured in M3 correlated negatively with quality of product of M4 ( $r = .45$ ,  $p = .007$ ;  $\rho = -.90$ ,  $p = .001$ ).

*G3.H1.2: quality of products is positively-negatively correlated to enjoyment. Partially supported.*

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
<b>1. Employment M1</b>														
2. Employment M2	-.32/.62	--												
3. Employment M3	.08/.01	.50**/.60	--											
4. Employment M4	.36**/.91**	.12/.53	.12/.17	--										
5. Employment M5	.40**/.63	.44**/.84**	.27/.57	.41**/.59	--									
6. Relaxation M1	.49**/.72*	.06/.35	-.07/-.29	.26/.70*.20	-.08/	--								
7. Relaxation M2	.14/-.15	.43**/.52	.18/.25	.20/-.09	.06/.33	.37**/.03	--							
8. Relaxation M3	-.07/-.44	.19/.13	.21/.22	-.25/-.35	-.06/-.08	.32/.03	.40**/.63	--						
9. Relaxation M4	.41**/.64	.04/.29	-.16/-.10	.63***/.76*	.28/.40	.32/.73*	.17/-.21	-.05/-.04	--					
10. Relaxation M5	-.18/-.42	-.01/.20	.02/.37	-.07/-.33	.34**/.08	-.11/-.03	-.11/.62	.28/.97**	-.04/-.02	--				
11. Quality of product M2	.27/.64	.42**/.77*	.13/.22	.40**/.61	.29/.64	.24/.52	.11/.41	.13/.19	.25/.53	.05/.14	--			
12. Quality of product M3	.26/.34	.59***/.84**	.32/.44	.33/.34	.45**/.70*	.17/.39	.30/.80**	.24/.52	.09/.30	.21/.57	.62***/.72*	--		
13. Quality of product M4	.03/.17	.52**/.76*	.36**/.58	.24/.30	.35**/.66	.02/.12	.26/.63	.31/.54	.12/.35	.24/.62	.60***/.61	.81***/.83**	--	
14. Quality of product M5	.05/.18	.29/.49	.13/-.05	.16/.21	.06/.15	.18/.54	.23/.73*	.30/.57	.12/.22	.13/.45	.55***/.68*	.65***/.75*	.47**/.49	--
M	3.52/3.59	3.07/3.08	3.79/3.78	3.07/3.15	2.73/2.79	3.38/3.43	2.80/2.78	2.79/2.76	2.00/2.10	2.33/2.54	.25/.25	.53/.54	.59/.59	.82/.81
SD	1.37/1.04	1.43/1.08	1.47/1.04	1.55/1.02	1.63/0.98	1.46/0.74	1.12/0.47	1.45/0.93	1.11/0.98	1.19/0.46	0.34/0.35	0.28/0.28	0.34/0.34	0.18/0.19

Figure 17: Correlations for intensity of negative emotions per mission (M1–M5), and quality of product per mission (M2–M5), at the individual (n = 35) and group level (n = 9). Pearson *r* (individual) is before the slash, Spearman *r*/*ho* (group) is after the slash. \**p* < .05, \*\**p* < .01, \*\*\**p* < .001

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Anxiety M1	—													
2. Anxiety M2	.41**/26	—												
3. Anxiety M3	.14/-19	.60***/53	—											
4. Anxiety M4	.45**/21	.10/-44	.20/-11	—										
5. Anxiety M5	.08/-86**	.24/-10	.33/-20	.33/-20	—									
6. Boredom M1	.15/-14	-.16/-20	.03/-15	.20/-10	-.02/-05	—								
7. Boredom M2	-.14/-73*	.16/-18	.28/-30	.12/-11	.07/.64	.28/.37	—							
8. Boredom M3	-.05/-35	.06/-35	.36**/-10	.07/-04	.33/.47	.11/.16	.44**/.79*	—						
9. Boredom M4	-.04/-27	-.07/-47	-.14/-03	-.17/-12	-.08/-11	.26/.65	.10/.54	.31/.42	—					
10. Boredom M5	-.28/-72*	-.08/-10	-.07/-09	.02/-36	.46**/.58	.28/.38	.14/.56	.18/.23	.28/.16	—				
11. Quality of product M2	.06/.39	.17/.21	-.02/.01	-.02/.03	-.01/-05	-.61***/-78*	-.41**/-76*	-.22/-50	-.41**/-69*	-.42**/-52	—			
12. Quality of product M3	.17/.49	.18/.28	.17/.37	.02/.16	-.15/-34	-.47***/-46	-.47***/-72*	-.35**/-72*	-.29/-39	-.54***/-69*	.62***/.72*	—		
13. Quality of product M4	.40**/.77*	.28/.44	.03/.05	-.02/.13	-.23/-58	-.27/-24	-.52***/-89***	-.45***/-90**	-.31/-52	-.52***/-57	.60***/.61	.81***/.83**	—	
14. Quality of product M5	-.04/.15	.23/.43	.25/.56	.06/-01	-.02/.06	-.25/-39	-.16/-41	-.22/-53	-.12/-23	-.28/-34	.55**/.68*	.65***/.75*	.47**/.49	—
M	1.73/1.69	1.44/1.76	2.21/1.45	2.09/2.20	3.38/2.13	2.80/1.88	2.79/1.82	2.00/1.53	2.53/1.87	1.73/2.44	.25/.25	.53/.54	.59/.59	.82/.81
SD	1.14/0.79	0.84/0.58	1.34/0.45	1.52/0.63	1.46/0.77	1.12/0.82	1.45/0.70	1.11/0.44	1.19/0.65	1.14/1.17	0.34/0.35	0.28/0.28	0.34/0.34	0.18/0.19

Figure 18: Correlations for intensity of negative emotions per mission (M1–M5), and quality of product per mission (M2–M5), at the individual (n = 35) and group level (n = 9). Pearson *r* (individual) is before the slash, Spearman *r*<sub>ho</sub> (group) is after the slash. \*p < .05, \*\*p < .01, \*\*\*p < .001

## 4.4 DISCUSSION

This study statistically analyzed different aspects of GaCoCo: evolution of quality of products in time; evolution of emotions in time; relationships between emotions and quality of products. This section discusses each of them in relation to the Goals of Section 4.1.1, and it uses engagement observations to complement and reflect on statistics results.

Moreover, this section discusses what aspects of the study worked smoothly, and what require a re-design of the protocol or material for engaging all children in game design at school. In particular, the reader can find some aspects of the study that should be taken into account. In order to replicate the study, these aspects are named, and they are identified as MH with a brief description (e.g., MH: use of signalling disks for voting).

### 4.4.1 Quality of Products for Learning

Quality of products tended to increase across missions, with significant differences between M2, when the first game products were created, and M5, when the final game design document and prototypes were released in time. This result suggests that children were learning about game design through the activity itself. The organization of the GaCoCo design activity, split into progressive missions for cooperative learning groups assisted by an expert, seems work in term of learning for children, as indicated by the increase in quality of products. An explanation lies in the presence of multiple types of feedback, that could have helped children to reflect on their products. There was the expert feedback resulting from the expert evaluation of their products, during missions and across missions; but also, peer feedback, promoted through pair or group discussions with cooperative learning strategies, rules and roles. Such considerations are partially supported by engagement observations during missions. Specifically the engagement observations highlight that all group could complete their challenges and in time using their roles and rules. In addition, pair work activate also those members that during the group work were more isolated.

The process of conducting, with experts, a formative evaluation of children's products, mission per mission, seems promising for improving their quality, and should be maintained in future game design experience at school.

During the evaluation, issues concerning the usage of game elements, as well as game play and mechanics occurred with the highest relative frequency across group products and missions. In general,

*MH: splitting the (game) design activity into progressive missions with progressive challenges, with its own clear valuable goal.*

*MH: providing multiple feedback opportunities mission per missions: from domain experts and from peers.*

*MH: providing summative feedback across missions and in each mission.*

children tended to insert many elements, without considering their overall coherence or functionality in the game. This is especially evident in M4 when, according to engagement observations, children asked frequently for the expert's feedback when filling in the related core mechanics document. Therefore the design expert should take specific care of such an issue (game elements and its functionality in the gameplay) when working in classroom. More formative feedback during specific stage, e.g., choosing characters and elements, could positively influence on the quality of products. The evaluation could even be more severe in the third mission, when levels are for the first time conceived, in view of the criticality of the fourth mission in terms of emotions.

*MH: providing more formative design feedback in critical design stage.*

#### 4.4.2 Children's Achievement Emotions for Engagement

Results concerning emotions, indicate that, on average, missions engaged children: they triggered positive emotions more than negative emotions, in line with results concerning traditional Italian Language and Mathematics activities in Italian primary schools, reported by (Raccanello et al., 2013). Concerning the dimension of activation, activating emotions were more intense than deactivating emotions, and this happened only for positive emotions.

It is interesting to observe that intensity of relaxation was significantly higher for missions M1 and M2, compared to M4, confirming the role that GaCoCo envisions for the first mission, that is, creating a relaxed atmosphere for building mutual trust. In addition, M4 shows a change in the growing trend of emotions, e.g., anxiety was lower for the third mission compared to the fourth mission. According to the engagement observations, children globally showed engagement with the game design activity. Lack of concentration and a peak of feedback and help requests was observed during the fourth mission only. Mission 4 consisted on a completion of the previous mission's work, concerning game levels, and more often than the other missions it required the expert's feedback for evaluating children's work. This happened in particular with older children. Such a situation suggests for the future a redesign of the fourth mission for avoiding a bottleneck of requests for the single game design expert in classroom.

*MH: avoiding a bottleneck of request inserting more formative feedback during a mission.*

Moreover, our interpretation of the increased children's anxiety is that the each group had to finalize, and hence complete, their game levels. For completing the game, each group needs the expert's and teachers' help, more than in other missions. An explanation for the growth in anxiety, self-reported by children, is related to the increase in complexity of design demands across missions, as asserted in (Sh-

ernoff et al., 2003). During the mission 4, children may have perceived design tasks to be more challenging for their skills, and yet they had better game design performances, releasing products showing increasingly higher quality over time.

*MH: differentiating as much as possible the missions for improving children's engagement over time.*

Finally, a similar trend characterized emotions across missions, stimulating reflections on how the GaCoCo game design method should take into account the effect of time on children's engagement. More in details, children could benefit on acquiring familiarity with routines typical of the missions as the game design activity at school proceeds.

*MH: assigning a role for each member with rotation system.*

Results from observations, showed another important aspect, that is the engagement within the group using specific cooperative learning roles. Roles within a group provided a right distribution of work in group and an equal participation of all member. In addition, the roles rotated among members for each mission and each member of a group with its specific roles had a chance to train different skills. It was observed that children who were not involved in group work got instead engaged after being paired with an engaged child. Strategies such as think-pair-share and three-step-interview should then be used in situations where engagement of all in design work is critical so as to involve all group members.

*MH: Using cooperative learning strategies within a group—subgroups with specific roles, e.g. pairs.*

*MH: using cooperative learning strategies at class level.*

In this study each group interacted with others only in the last mission that was the group work presentation. In according to the engagement observation, the sharing of ideas and feedbacks among groups during the last mission allows children to express interest and curiosity about others group products. In light of the many questions concerning the functionality of elements reported in the last mission though observations, GaCoCo could also foster the exchange of ideas at the class level to promote peer discussions concerning games and their elements. Moreover, children working with the class felt as part of a big common task and can be more engaged.

#### *Engagement with Material*

*MH: using gamified probes for making tangible rules and roles.*

Material was generally received with curiosity. Specific gamified probes, e.g., scepters and signalling disks, was properly used, taking into account cooperative learning rules or roles that the probes embodies. In particular, scepters for taking turns in speaking and frames for prototyping passage conditions, required more explanations than other material. This issues can be interpreted as follows: the cooperative learning rule of taking turns in speaking requires per se more training; maintaining consistency across game design documents and prototypes was cognitively demanding, above all for younger learners, and requires more guidance of the expert in class. Signalling disks were often creatively used, albeit they became source of distraction at

*MH: training by expert about the usage of gamified probes and generative toolkits.*



points, showing on the other hand the desire of children of expressing and sharing their perceptions. All children showed a marked preference for buying objects in the shop for customizing their games. Specifically, the objects in the shop served for prototyping games, so that children perceive that coins, earned at the end of each challenge, could have a tangible effect on their design work and they were in control of choosing parts of this. These refers to a sense of control and autonomy that the gamification should nourish (Deci and Ryan, 1985). As second or third choices, children tended to prefer signalling disks or progression maps: younger learners tended to prefer signalling disks, whereas older learners tended to prefer maps. Moreover, referring to the use of maps, it was observed that the progression map was properly used and it was quite functional for its purpose: groups often turned their attention to the map to figure out their progression within the whole activity. In addition, the metaphor of the tree to show progress in game design stages was properly interpreted, yet the tree map per se was less successful: the tree map was used only at the end of a mission, when there was not enough time to enhance it in a right way. We noticed that the use of two maps was demanding in terms of cost and time. Additionally, it decomposed artificially missions progression, while progression was naturally considered as unique.

*MH: providing a sense of autonomy and control in missions and challenges.*

*MH: using rewards systems or gamified probes for a customization of the game.*

*MH: providing a sense of progression to missions and challenges.*

#### 4.4.3 Children's Achievement Emotions and Quality of Products

The study also inspected the nature of the relationships between emotions and quality of products as a measure of group performance, in a context only rarely investigated in the literature. Our hypotheses G2.H1 and G2.H1 were mainly confirmed for enjoyment and boredom, which correlated, respectively, positively and negatively with performance. In other terms, as assumed by the control-value theory (Pekrun and Perry, 2014; Pekrun, 2006), the more children enjoyed the GaCoCo mission, the better the quality of the released product was; the more children were bored, the worse the quality of their product was. It is interesting to note that such links emerged both between emotions and quality of products related to the same mission, and frequently between emotions of a mission and the quality of products of the subsequent missions, indicating a sort of expectation effect created by emotions on future performances.

Such results could inform professionals aiming at projecting and monitoring participatory design game experiences with children, working in group, with indications for conducting such type of study in relation to the key emotions and quality of products, by tracing their evolution across design sessions.

*MH: tracking and taking into account children's emotions in relation to a better quality of product over time.*

## 4.5 CONCLUSION

This chapter reported the 2014 GaCoCo study, its organization and results. The study focused on a GaCoCo experience for designing low-fidelity game prototypes with and for children. Children's empowerment is a key of GaCoCo and the analyses reported in this chapter focused on it, and precisely on: (G1) children's performance in the GaCoCo experience, via an evaluation of the quality of children's products across the experience; (G2) assessing engagement by (G2.1) by assessing achievement emotions (enjoyment, boredom, relaxation and anxiety) relevant for children's performance, across the GaCoCo experience, and by (G2.2) assessing engagement via observations; (G3) the relationships between emotions and performance across the experience.

**G1: QUALITY OF PRODUCT FOR LEARNING.** In relation to G1, the study results show that the quality of products tended to improve in time, suggesting that children were learning by doing design together. In line with GaCoCo, empowerment was supported by progressive design challenges, and through multiple feedback opportunities for children: from peers and by expert through formative and summative feedback.

Specific issues emerged across missions and game design products. Thereby the design expert should take specific care of them when providing feedback to children. For instance, future GaCoCo activities could extend the time of feedback moments during the activity, and the design expert should ask children explicitly about their game elements; in light of the many questions concerning the functionality of elements reported in the last mission through observations, future GaCoCo activities could also foster the exchange of ideas at the class level to promote peer discussions concerning games and their elements. Alternatively, as suggested by an anonymous reviewer, such issues may well be due to the cognitive maturity of children in the considered age range.

**G2.1 AND G2.2: ENGAGEMENT THROUGH ACHIEVEMENT EMOTIONS AND OBSERVATIONS.** With respect to these goal, the study results confirmed the higher salience of the positive emotions of enjoyment and relaxation compared to the negative emotions of anxiety and boredom, highlighting changes during the GaCoCo activity as time progresses. However, it is worth nothing that mission M4, with a peak of feedback requests, had an increase of anxiety intensity. Also in light of engagement observations, such a result suggests that a single design expert

for delivering formative feedback may not be sufficient in such a mission, contrary to what suggested by GaCoCo. If GaCoCo is used as-is, then a re-design of M4 is necessary for avoiding a bottleneck of requests for the design expert. For instance, the core mechanics forms of M4 could be simplified.

**G3: ACHIEVEMENT EMOTIONS AND QUALITY OF PRODUCTS.** In relation to G3, the quality of products, as assessed by experts, was also positively related to enjoyment and negatively related to boredom, with a sort of expectation effect created by emotions on future performances.

#### GaCoCo 2014 Study: Success and Failures

In order to point out what worked during the main game design activity, and what is a Must-Have in future studies, all missions were analysed in details. In the remainder, we list for each mission success and failures.

**ACROSS MISSIONS.** The recap phase was an important stage for each mission because, considering the age of the involved children, it was difficult for them to maintain a thread across missions. Moreover, the summarization of rules, roles and of the main phase of the activity helped the children during the game design activity. It was also noted that children needed the link across missions, in terms both of the activity in general and of game design stages.

*MH: recapping phase and link across missions.*

**FIRST MISSION** The first mission, with its easy goal and structured as a training, was an important means for creating the identity of each group, for fostering teamwork and for introducing children with the proper usage of materials.

*MH: providing an easy mission for training working in group.*

**SECOND MISSION** In the second mission the concept of game design was introduced. The objective, that is, to continue a narrative story that teachers read before in class, was clear. However issues emerged in relation to the usage of the story during game design—few groups used story elements in their game. That was interpreted as a sign of lack of interest in the story, assigned by adults. Although that story may have not been sufficiently appealing to children, as claimed in (Tan et al., 2011), the integration of narrative elements may increase children's engagement in an activity: elaborating a storytelling component for a game is stimulating and is often a topic of fascination for children. Moreover using a game storyline ensured that games were related with the class topic into which the activity was inserted. All this suggests

*MH: basing game design on a storyline that children are interested in, possibly related to a school subject.*

that stories can be used in game design but children need to develop a sense of affection for them. Moreover, in relation to the story of the game, children should had a precise player interaction perspective for choosing among the characters of the storyline who acted as player in their game.

*MH: setting a player interaction model for the game (e.g., third person perspective, with the main character of the storyline that acts as the player of the game).*

*MH: using stimulus card or sentences for a better expression of children creativity.*

*MH: making generative toolkits, e.g., paper-based forms, captivating and functional for group work.*

*MH: Using simple and clear forms, which should be as different as possible between missions.*

*MH: considering a design of a single game level per group.*

Another important aspect was the idea of the game. This part was the most demanding and it was observed that the form for expressing the game idea limited the creativity of the children. Indeed, children filled in the form, question by question without thinking of a general idea of the game. We thus realized that stimulus sentences or less structured forms could be better for children, in order to express their ideas and to encourage them better on sharing their opinions. In addition, too specific questions are limiting, because questions could be misinterpreted.

**THIRD AND FOURTH MISSION** The third and the fourth missions were similar. For children, activities in these missions were repetitive and had the effect of decreasing group engagement. In addition, forms related to these missions, were too repetitive and created confusion within groups and the whole class.

Moreover, the study comprised the design of two game levels per group. This often resulted in the design of two similar levels, or on the opposite, in totally disconnected levels which provided no progression. As reported in the discussion, the division of work into subgroups, like pairs, improved the collaboration and the engagement but did not improve the quality of products and the overall consistency of game design. For this purpose, the creation of a unique game level per group could be a good alternative, able to favor the quality of products and their coherence.

**FIFTH MISSION** As introduced before, designing two levels per group resulted in two levels either not properly linked, or too similar. The level passage conditions was a challenging task; the group found by difficulties in designing a unique passage level for levels designed by pairs.

The last challenge was presentation of each game by the groups. It was important in terms of engagement of the entire class and of sharing opinions by feedbacks. Moreover, having a structured ad-hoc frame (see Figure 12) was important for allowing children to better present their game, and for showing the interaction among game elements they designed.

*MH: creating an ad-hoc structured frames for the prototyped games so as to better allow children to present their products and interact with them.*

# 5 | IN-BETWEEN 2014 AND 2015: THE DEVELOPMENT STAGE

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This chapter reports on the follow-up session of the 2014 game design experience with children. After this experience we posited the following question: can the resulting game design be taken as-is in the hands of game developers? Specifically, in the study reported in this chapter, university students were challenged to develop children’s ideas into high-fidelity interactive game prototypes, starting from game design documents with low-fidelity prototypes, released at the end of the 2014 study, see Section 4.2.3, and assessed by design experts, see Section 4.3.

The chapter explains how children’s products were picked up and developed by computer-science university students. Firstly it outlines the goal of the study and the participants involved, in Section 5.1. Then it details the study design organization, in Section 5.2, focusing on the development approach followed by university students and on the development activity itself. Finally, the analyses and results are discussed in Section 5.3.2.

## 5.1 STUDY

Students from the software engineering course of the second year of the Bachelor programme in Applied Computer Science were asked to develop high-fidelity interactive prototypes of games conceived by children, starting from the game design documents and the accompanying low-fidelity prototypes released in the last mission of the 2014 study (reported in Section 4.2.3)—children’s game products. Since the course enrolled five groups of students, the design expert of the 2014 study and the course teacher chose five products to develop, selecting those which minimized the number of issues and satisfied technical constraints of the course, e.g., the need to develop 2D games in C<sup>++</sup>.

### 5.1.1 Goals

The study aimed at developing interactive games starting from children’s products, released at the end of the 2014 study and reported in Chapter 4.

At the end of the 2014 study we posed ourselves different questions concerning the development of children’s products. Specifically, questions that this chapter tackles are concerned with children’s products, released after receiving the experts’ feedback: were such products sufficient specifications for computer science students to develop games? More generally, what issues did students find in developing games from children’s products? Were they different from those found by design experts?

Therefore, the **goal** of the study was answering those questions by investigating what issues would emerge during development.

### 5.1.2 Participant and Roles

Students involved were 15. The development team was formed by five groups, each one with three students. All participating students had already passed courses on advanced programming, data structures and algorithms. Even though they were not seasoned programmers, they were judged to have sufficient expertise to understand, analyze, design and develop a working software solution. As the groups had three members each one, students were requested to take a role (coordinator, recorder, checker), and to take care of the tasks and responsibilities associated for each role.

In class, besides instructors, the design expert, working with children in 2014, was also present every two week. This acted as the me-

diator between the game products by children and their development by university students, collecting questions and remarks by these, answering questions in case children's specifications were unclear.

## 5.2 STUDY DESIGN ACTIVITY

This section specifies the principles of the approach followed in organizing the course at university, and then the development activity itself.

### 5.2.1 Development Approach with Students

Following the guidelines by Oakley et al. (Oakley et al., 2004) and in line with cooperative learning principles used in designing games with children, the course instructors formed heterogeneous groups with members who were diverse in programming skills but had common blocks of time to meet outside class. Each group had three different roles: coordinator, recorder and checker. As with children, also roles rotated among students of a group. Instructors assigned a (game) development task to each group.

Each group decided their own name, thereby creating their identity, and wrote a sort-of expectations agreement, which was then signed by each member of the group and delivered to the instructors. The expectations agreement had two purposes: it joined the team with a common set of realistic expectations, and it served as a "quasi-legal document" to prevent students from making invalid claims about what they were supposed to do, binding them to a common shared goal.

### 5.2.2 Development Activity with Students

Groups had about three months of time to deliver their implementation. In such time frame, an iterative approach was adopted. Groups submitted a weekly brief report, which described the state of the project and future plans. The report was used as a basis for twelve meetings with instructors. In the kick-off meeting, groups were formed and the structure of the activity was explained by one of the instructors. Then each group decided their own name, read the so-called policies statement provided by instructors, and wrote their expectations agreement.

In six of such meetings with instructors, students also met the (game) design expert working at school with children. The first time students got to know the game-design project with children. In the second and

third meetings students read documents and inspect low-fidelity prototypes by children, as shown in Figure 19. In the fourth and fifth meeting, students commented on children's products and, in case needed, asked the design expert clarification questions. During all such meetings questions by students were added in their reports. In the sixth meeting, held towards the middle of the course, students delivered a presentation in front of the other development groups, instructors and the design expert. Goals of this presentation were: (1) to share relevant information with other groups, for sharing similar game design or development issues; (2) to share the progress of their work with the design expert, and getting feedback on their development before presenting their work to children in a final conclusive meeting, where student products get evaluated by children.

Student groups concentrated on the implementation of the game. High-level requirements of the game progressively evolved into low-level requirements and implementation constraints. Rules of the game evolved into business logic, whereas the storyline, game core mechanics and gameplay evolved into an execution flow. For the product development, the resources at hand were a programming Integrated Development Environment (IDE), and a collection of pre-furnished graphic elements (e.g., sprites and backgrounds).

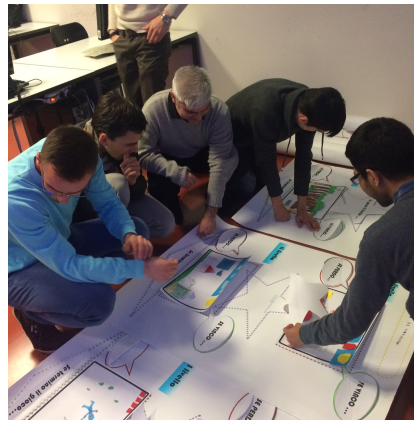


Figure 19: Students inspecting children's prototypes

Figure 20 shows the starting point for university students, namely a game design document and the low-fidelity prototype released by a group at the end of the 2014 study. The related game developed is shown in Figure 21.

The game developed, with the related game design documents and prototype are available at [GaCoCo 2014 Game Developed](#).



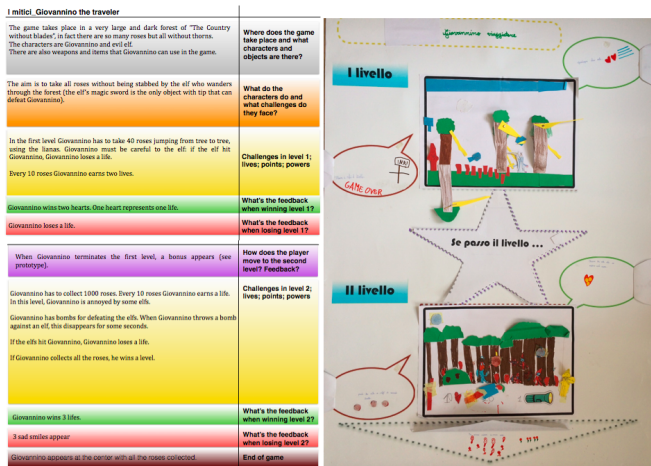


Figure 20: A game design document (at the left) and the related low-fidelity prototype (at the right).

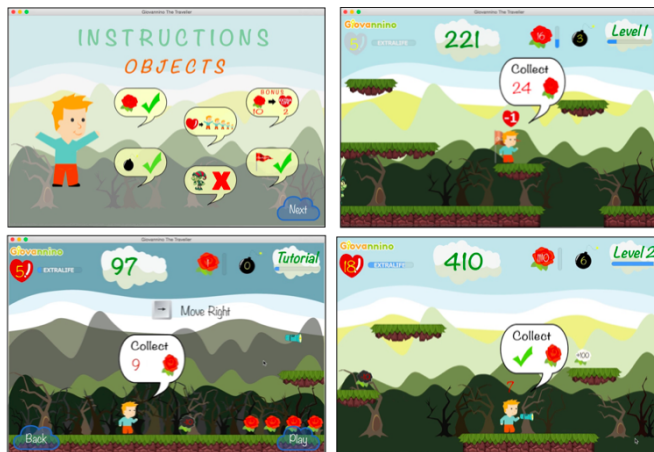


Figure 21: Screenshots of a game developed by university students.

## 5.3 ANALYSIS AND RESULTS

Students reported issues in their game development. A thematic analysis was conducted on the issues reported by students by the course instructors and the two design experts who had evaluated children's products. Evaluators first worked separately and then together. Issues for the game development by students were finally categorized as explained in Section 5.3.1. Results of students were also presented and qualitatively compared with those by design experts, in Section 5.3.2

### 5.3.1 Game Development Issues

Issues that students found in developing games were clustered into five main categories: gameplay and mechanics inconsistencies or unclear functionalities; gameplay and mechanics incompleteness; development; audience; game design understanding. The first two categories were the same used by design experts to classify issues found in children products, see Chapter 4. The other categories were novel. All are explained in details in the following.

#### *Gameplay and mechanics inconsistencies or unclear functionalities*

Students noticed issues concerning inconsistencies or unclear functionalities in gameplay or mechanics. Students remarked them or advanced proposals. Issues in this category include what follows: What are powers for? What is the function of objects?—They are only mentioned without giving further details.

#### *Gameplay and mechanics incompleteness*

Students advanced solutions concerning gameplay and mechanics, missing in children's game design. Issues in this category include: How long is the game expected to last? Should we also create an introduction video to the game?

#### *Development*

Students sometimes asked instructors questions concerning implementation details. Issues in this category include what follows: Where do we get graphics elements and sound? For which platform should we implement the game?

#### *Audience*

Students sometimes wondered about specific requirements of the intended players with respect to games. Issues in this category include what follows: Our idea was to provide children a very nice, easy to understand game; by considering also the current trend, is it possible to implement a 2D game? Which should be the official language of our game? English? Or the native language of children?

#### *Game Design understanding*

Students also asked the design expert questions concerning design choices already specified in documents or in prototypes. Issues in this category include what follows: Is it ok if we interpret slaps to guards

as scored questions that have to be answered by the player? (This is inconsistent with the game design document). How do you complete the first level? (This was specified in the game design document).

### 5.3.2 Results

A total of 39 issues were tracked, distributed among the 5 categories in Figure 22. One third of issues (33%) were concerned with game design understanding questions, whereas 23% were concerned with development issues. A qualitative analysis of issues concerning game design understanding revealed that they were mainly related to animatable objects or interaction elements which were present in prototypes and were not fully specified in game design documents.

Let us consider issues pertaining to inconsistency, incompleteness and unclear functionalities of gameplay and mechanics in the children's game products. Issues found by design experts in the last mission of the design activity were found by students, who also found other issues in the same categories, see Figure 22. This plot shows if there is an issue in a category. A qualitative analysis and comparison of these issues, across students and across experts, revealed what follows:

- unclear functionalities concerning the role of characters were found in a game product (by the children of Group 9) by experts and students alike;
- the incompleteness reported by students and experts in a game product (by the children of Group 7) was concerned with the termination of the game, which was not specified;
- issues concerning unclear functionalities of objects, e.g., powers, were found by students in products by children (in Groups 1 and 2), which were not classified as issues by the design experts; these issues were solved by talking with the game designer working with children;
- issues concerning incompleteness, e.g., a tutorial video for showing the gameplay, were found by students in a product (by the children in Group 4), but were not classified as issues by the design expert design experts.

## 5.4 DISCUSSION

According to the above analyses, issues concerning gameplay and mechanics, left by design experts as requirements of children, were

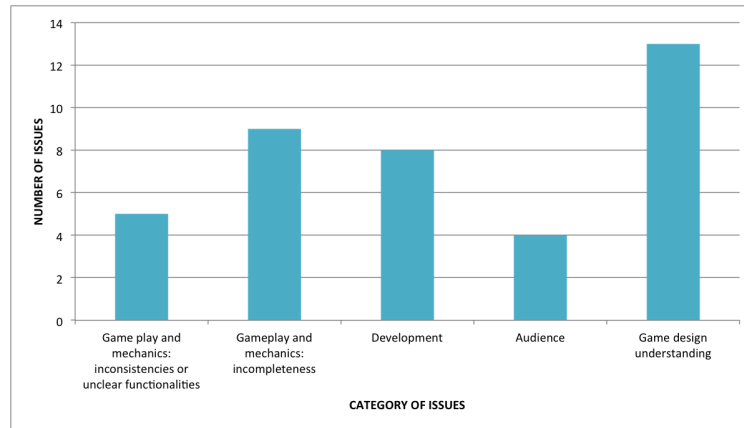


Figure 22: Number of issues found by students per category, in total.

also detected as issues by students. The incompleteness of gameplay and mechanics in children's products was also detected, and students proposed design solutions, e.g., tutorial video for the gameplay.

Other issues concerning unclear functionalities of elements for gameplay and mechanics were found by students. These issues were generally related to powers and roles of characters, but were not classified as issues by design experts. According to the explanation given to students by the design expert working with children, children had specific functionalities in mind for powers and roles of characters, but were unable to realize them properly in paper-based prototypes or to specify their functionalities in documents.

Game design understanding issues were also high in number. According to their qualitative analysis, these issues were related to the interaction and animation, which were not rendered in low-fidelity prototypes nor always fully explained in game design documents.

## 5.5 CONCLUSIONS

This chapter reported how the game design experience evolved into a game development experience with university students.

During this study, university students from computer science were challenged to develop children's products into high-fidelity prototypes of games, starting from products released by children in their last design day, in 2014. Issues that students found in developing games were also tracked and categorized. According to the conducted analyses, children's products were in general clear but not sufficient as specifications for university students, in particular due to incompleteness or unclear functionalities of gameplay and mechanics elements.

Such results give feedback to game designers. Most importantly, design issues in children's products reported in this work could be due also to the choice of design material: for instance, paper-based prototypes should be well structured and re-elaborated for convey interaction, and game design documents by children, alone, were not sufficient in that respect as specifications for university students.

Another important lesson is that, if the game design experience with children continues, their game design documents could require a completion with adult game designers, so as to fix remaining issues concerning unclear functionalities and incompleteness of gameplay and mechanics elements. The design expert, sitting in class with children, seems a promising candidate for completing game design documents before passing them on to developers, in an act of collaboration across design experience participants.



# 6

## THE GACOCO 2015 STUDY

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In this chapter, we present the case study carried out during Spring 2015 in two classes of a primary school in Italy. The structure of the chapter follows the organization of the 2014 study.

Section 6.1 presents the main goals of the study with the related hypotheses, the participants involved and the study design organization. Section 6.2 details the material, namely generative toolkits and gamified probes, used in the study and the design protocol, with the strategies used and the design session outcomes. Analyses and results are detailed in Section 6.3. Finally, in Section 6.4, we discuss results.

## 6.1 STUDY

This GaCoCo study was run during Spring 2015 in two fourth grade classes in a primary school.

During the GaCoCo game design activity, each class prototyped a single game per class (class game). In line with the GaCoCo approach, a class was divided into small groups and each group worked on a game level. The outcome of the GaCoCo game design activity was a game per class.

In the remainder of this section, we report details on the goals of the study, the participants involved, the study design and its organization.

### 6.1.1 Goals

The goals of the 2015 study are identical to those of the 2014 study. They are related to the empowerment of children: engaging them and promoting their learning of early game design.

In short, the 2015 study inspects and evaluates the following goals: (Goal 1) monitoring and assessing children's performances in GaCoCo design; (Goal 2) assessing engagement by: (Goal 2.1) monitoring and assessing the intensity of children's achievement emotions, (Goal 2.2) assessing the engagement along the GaCoCo activity and with GaCoCo gamified probes; (Goal 3) assessing possible relationships between performances and emotions.

Table 3 outlines each goal with the related hypotheses. Given the similarities with the 2014 study, further details can be found in Section 4.1.1.

### 6.1.2 Participants and Roles

The study involved two classes, two teachers and two expert designers.

**TEACHERS.** The two teachers involved in the study were present in the two classes. They were teaching in both classes the same subjects, that is, Science and History<sup>1</sup>. Teachers had the same roles as in the 2014 study: in brief, during the game design activity they assisted in scaffolding group work, following the given GaCoCo protocol.

<sup>1</sup> In some Italian primary schools, more than one teacher can be present in class. In this case study, the two teachers were teaching together an interdisciplinary topic, namely, eating habits in ancient cultures.



Goals	Hypotheses
<b>Goal 1.</b> Assessing children performances	<b>G1.H1.</b> Quality of products changes over time.
<b>Goal 2.1</b> Assessing the Intensity of children's achievement emotions	<b>G2.H1.</b> Positive emotions more intense than negative emotions.
	<b>G2.H2.</b> Higher intensity for activating emotions than for deactivating emotions.
	<b>G2.H3.</b> Intensity of negative and positive emotions changes over time.
<b>Goal 2.2.</b> Assessing children's engagement along GaCoCo and with its material	<b>G2.H4.</b> Children's engagement changes over time.
<b>Goal 3</b> Assessing relationships between performances and emotions	<b>G3.H1.</b> Quality of products is positively correlated to enjoyment.
	<b>G3.H2.</b> Quality of products is negatively correlated to boredom.

Table 3: Goals of the study with the related hypotheses. See Section 4.1.1 for more details.

**RESEARCHERS.** The GaCoCo activity involved the same researchers of the 2014 study: a *design expert* and an *education expert* (called also observer). The researchers' roles are detailed in Section 4.1.2.

**CHILDREN.** The game design experience of 2015 involved two classes from a primary school in the North-East of Italy, different from the school involved in the 2014 study. Children were, in total, 42 (45% girls), coming from a variety of socio-economic backgrounds. Classes were in grade 4: one class was composed of 19 children; among them there was one child diagnosed with an attention deficit hyperactivity disorder (ADHD) and one with autism. The other class was composed of 23 children; among them there were three children diagnosed with ADHD, and one child with a mental retardation or intellectual disability, (MR/ID)<sup>2</sup>. The mean age at the start of the activity was 9.75 years, with a standard deviation  $SD=0.35$ . As in the 2014 study, children were the main game designers, mainly working in groups of 3–5 members.

<sup>2</sup> Italian schools by law must include children with special needs within regular classes, until 10th grade.

### 6.1.3 Design

The 2015 study design organization followed that of the 2014 study: a pre, core and a post GaCoCo game design activity.

#### *Pre-GaCoCo activity.*

During the pre-activity, a workshop for training teachers on the GaCoCo game design activity was organized. During this workshop, teachers tested the GaCoCo approach acting as game designers, and gave feedback and suggestions to the researchers about complexity of the tasks, times of execution and the usage of materials. After the workshop, teachers were asked to create balanced and heterogenous work groups, filling in the form which is detailed in Section 4.1.3.

#### *Core-GaCoCo activity*

During the core GaCoCo activity (GaCoCo game design activity), each class released one class game. Within a class, each group worked on a game level of the class game. The class game was based on a storyline created directly by the class, in one of the missions, and not assigned by teachers as in 2014. However, the starting topic was assigned by the teachers and researchers, that is, the subject taught by teachers: eating habits in ancient cultures.

The core GaCoCo activity was fragmented into missions as in 2014, and conducted during regular classes. Missions and its organization are illustrated in detail in Section 6.2.3.

#### *Post-activity*

As in the 2014 study, during the post-GaCoCo activity, debriefing interviews with children were run by the teachers to gather more information on children's experience with GaCoCo. Children were also asked to rank their preferred gamified probes used during the GaCoCo activity. Moreover, children were invited to the Free University of Bozen-Bolzano for a final mission, see Section 6.2.3 for details.

## 6.2 GACOCO DESIGN ACTIVITY

The 2015 GaCoCo activity was improved by considering the lessons learned in the 2014 study. In particular, this latter study allowed us to identify a set of must-have with a label. At the beginning of this section and for the subsequent sections, we report the must have of 2014 with the related label in a box. Later in the text we refer to them to

explain the design choices of the 2015 study.

**Must-Have 2014—Game Design Activity with Children**

- MH-D1** Splitting the game design activity into progressive missions with progressive challenges, with its own clear valuable goal.
- MH-D2** Tracking and taking into account children's emotions in relation to the quality of product over time.
- MH-D3** Differentiating as much as possible missions for improving children's engagement over time.
- MH-D4** Providing multiple feedback opportunities mission per mission: from domain experts and from peers.
- MH-D5** Providing summative feedback across missions and in each mission.
- MH-D6** Providing more formative design feedback in critical design stages, so as to avoid a bottleneck of requests (by children to expert).

**Must-Have 2014—Group Formation and Cooperative learning contributions**

- MH-G1** Having groups formed by teachers respecting relationship between peers.
- MH-G2** Forming heterogeneous small groups (3–5 members).
- MH-G3** Assigning a role to each member with a rotation system.
- MH-G4** Using cooperative learning strategies within a group—subgroups with specific roles, e.g. pairs.
- MH-G5** Using cooperative learning strategies at the class level.

The overall aim of the core GaCoCo activity in 2015 was a class game composed by game levels designed by group within a class. Game design work was organized in line with the GaCoCo protocol. Based on the results of 2014, in order to empower children and sustain children's engagement, the GaCoCo activity took into account children's emotion trend of 2014 for organizing groups work in different missions and for improving the quality of products (**according to must-have MH-D2**). Moreover, cooperative learning strategies for small heterogeneous groups were used in the GaCoCo protocol for children. As suggested by the results of 2014, empowerment was also supported through mul-

tiple feedback opportunities for children: from peers, with cooperative learning for sharing ideas and for sustaining discussions at the pair, at group or at class level; from domain experts, with dedicated evaluative moments: rapid *formative evaluation feedback* for validating or clarifying design decisions by children during a mission, and *summative evaluation* of children's products after and across missions for a more constructive elaborate feedback on design choices (**MH-D4**; **MH-G4,G5**).

*GaCoCo  
Organization*

The design work took five missions (M1–M5) per class at school and lasted circa two hours per mission. Taking into account the results of the 2014 study results, each mission was organized as a gamified mission with its own design goal and each mission were split into progressive challenges (**MH-D3**). In light of the results of 2014, the first mission (M1), the easiest one, served as training for children and for creating group identities (**MH-P2**). Then, from the second (M2) to the fifth mission (M5), each mission was built in progression one upon the other (**MH-D1**). Firstly, each group created the storyline at the class level (M2) (**MH-P3**). Secondly, each group conceptualized the game idea for their game level and released the main character prototype (the player for their game) (M3). Thirdly, each group conceptualized their game level by prototyping it in a paper based format (M4). Finally, (M5) each group completed the game level with the winning and losing effects and presented their game level to the class (**MH-D3**).

*Gamified Probes and  
Strategies*

Also in this study, the core GaCoCo activity used tangible gamified probes for conveying a sense of progression, control and relatedness to children. Section 6.2.1 details the gamified probes used in the study. Moreover, the gamified probes made tangible for children cooperative learning strategies, rules and roles. These are detailed in Section 6.2.2. The protocol of each mission (M1–M5) is widely detailed in Section 6.2.3.

## 6.2.1 Gamified Environment and Material

**Must-Have 2014**

- MH-T1** Training by expert about the usage of gamified probes and generative toolkits.
- MH-T2** Providing a sense of progression across missions and challenges.
- MH-T3** Using gamified probes for making tangibles roles, rules or strategies.
- MH-T4** Using rewards systems or gamified probes for a customization of the game.
- MH-T5** Providing a sense of autonomy and control in missions and challenges

According to results on children's engagement with material from the 2014 study, see Section 4.3.2, children were generally engaged, showing curiosity and enthusiasm towards all generative toolkits and gamified probes. In particular, the survey for the preferred gamified probes showed a marked preference for the shop and the signaling disks. Moreover, the progression map was properly used, and it resulted a necessary tool for giving a sense of progression during a mission (**MH-T2**).

As in 2014 study, the ad-hoc designed gamified probes followed general and specific design principles, e.g., by (Hutchinson et al., 2003b), specifically those concerning with the technology probes, which differ from design probes and, more generally, from low-fidelity prototypes in that technology probes collect data about users according to their functionalities (logging).

In light of the 2014 results, some gamified probes of the 2014 study was reused in the 2015 study namely, the **Signaling disk** and the **Shop**. The remaining was changed or enhanced, possibly enhanced with Arduino controllers and sensors or it was new. Specifically, the progression map and the tree map were unified into a unique and clearer **progression map**. New gamified probes were: **control box** connected with the progression map, **cards** for each member for the speaking turn, and a **speaking cup** to manage the speaking turn during a brainstorming at class level.

As in 2014, children worked in their classrooms, and at the start of each mission, groups arranged classroom tables in groups. During the core GaCoCo activity, researchers gave materials needed for design-



Figure 23: The progression map with Arduino sensor and controllers.

ing and prototyping their game, e.g., generative toolkits, and gamified probes.

New and modified gamified probes used in this study are the following ones.

**PROGRESSION MAP.** The progression map in Figure 23 was a gamified technology probe. It showed children that the design learning process was progressively structured; its main functionality was enabling wayfinding through the process—what I have done so far, where I am now, where I can go next (Lynch and Horton, 2015). In that manner it helped make tangible children’s progression through the process, and hence promote children’s feeling of control over it.

The expert, at the start of each mission, positioned the progression map in front of the class as a reference point for each group. See Figure 23. The progression map used in the study is designed as follows. It showed five fruits corresponded to one of groups. Each fruit was contained five rows, one for each mission. Each mission (row) was divided into challenges, each challenge represented as an icon and a led. For tracking their position, each group had to move across all challenges a group icon, represented by a wooden farmer. When a challenge was tackled by a group, the corresponding led lit up.

As in 2014, we inserted completion-contingent rewards represented by removable wooden coins that children collected at each challenge. Coins acted as symbolic rewards for sustaining children’s sense of progression and control. Moreover, coins could be spent at the wooden shop for acquiring objects, e.g., paper based drawings, in order to customize their prototypes (MH-T3, T4, T5). They could be acquired during mission relaxing game prototypes. Children could also personalize prototyping objects and hence reinforce their perception of being in control of their design work.

On top of each fruit, there was a big led indicating that such group asked the expert feedback (group led).

Within each fruit, at the end of each mission, a wooden small box was placed, to indicate the end of the corresponding mission. The small box was hiding a mission reward, that is a set of stickers. Each mission had a different reward: a seed (M1), five different tools for gardening (M2), five pieces of a tree (M3), a scarecrow (M4), a star (M5). Rewards earned after each mission could be used by each group for growing their tree, and for conveying to children the idea of growth through accomplishment of game design tasks.

The back of the progression map had Arduino micro-electronics sensors and controllers, which are open-source rapid prototyping solutions. In addition, Arduino components enabled connection between the map and the control box, and the management of led switching on and off.

**GROUP CONTROL BOX AND CARD.** For tangibly promoting cooperative learning rules and roles for collaboration, each group was given a wooden **control box**, positioned at the centre of their tables. The control box, shown in Figure 24, was shaped as a pentagon (since the largest allowed membership for a group was 5 children). It showed on its top (up to) 5 children names with a led, corresponding to group members. The control box was completed by one slot for a **NFC card**, one **big button**, and a **money slot** to keep the gained coins.

Inside the box there was a NFC card reader, whose purpose was recording the speaking turn, and an Arduino board that connected the control box to the progression map. Each group member had **NFC card**, showing his or her name, and the fruit on the progression map that represented the group. This card organized turns in speaking. In order to speak, the child had to put his or her card on the dedicated slot (the card reader) of the control box. As a result, the led near the name of the child who was using the card, lit up, indicating that the child was speaking. Moreover, control boxes served also to enable the connection between groups and the design experts supervising their design work. By pressing the **big button** on the box, a group requested the expert's feedback. The corresponding group led on the progression map lit up. For instance, the button was pressed when a group completed a challenge, for getting a rapid feedback and challenge validation from the expert.

**SPEAKING CUP.** The speaking cup, shown in Figure 25, was used in the brainstorming sessions, and when the design expert required feedback at the class level. The speaking cup contained an Arduino board



Figure 24: The control box of a group and the NFC card in action.

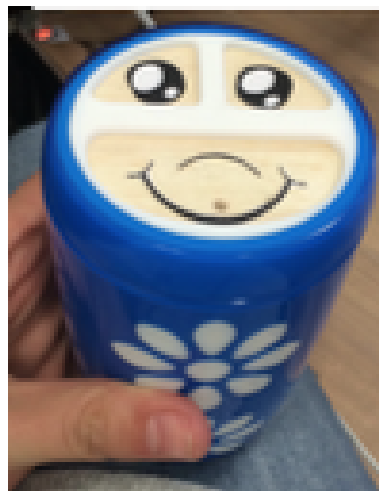


Figure 25: The speaking cup used during the brainstorming session.

with a touch sensor inside. This board connected the speaking cup to the progression bar. When a child held the cup in his or her hands, a led strip on the map lit up, indicating that someone was speaking, and hence others should have been listening without interrupting.

**AD HOC GAME FRAME.** Following the 2014 study organization, in the last mission (M5) children had to present their game. Each group had an A1 poster with colored shapes where to add pieces of information about their game prototypes: a dedicated space for the prototyped level, two balloons for describing what appears when the player loses or wins, a dedicated space for sticking the group logo.

**GAME DESIGN DOCUMENT FORMS.** As in 2014, for each mission children were provided with different forms to fill in, namely game design documents. More details on game design documents are in Sec-



tion 2.4.3. The forms followed the same structure as in the 2014 study: they were A4 papers with simple questions related to game design, and dedicated spaces for answering. However, with respect to the 2014 study, some forms were modified, and new forms were added, e.g., a storyline form.

### 6.2.2 Cooperative Learning Rules, Roles and Strategies

<b>Must-Have 2014</b>	
<b>MH-G1</b>	Having groups work formed by teachers respecting relationship between peers.
<b>MH-G2</b>	Forming heterogeneous small groups (3–5 members) by teachers.
<b>MH-G3</b>	Assigning a role for each members with rotation system.
<b>MH-G4</b>	Using cooperative learning strategies within a group—subgroups with specific roles.
<b>MH-G5</b>	Using cooperative learning strategies at class level.

During the pre-GaCoCo activity teachers, using the specific form (see Section 4.1.3), formed heterogeneous work groups of 3–5 member (**MH-G1, G2**). The cooperative learning strategies for organizing work in group, as well as rules and roles for children, were all important means that GaCoCo adopted throughout the game design activity. According to the GaCoCo approach, such means are made tangible via the gamified probes described above.

**ROLES AND RULES.** Different cooperative learning roles were considered and adapted according to the GaCoCo protocol. As in 2014, children rotated their roles among group members, across missions, so that all children had a chance to train different skills (**MH-G3**).

**Group roles** used in each mission were the same as in the 2014, namely (1) Secretary, (2) Ambassador, (3) Materials Manager, (4) Time Keeper and (5) Participation Checker. To support group roles, cooperative learning considers a set of rules, necessary for working in a group, and for involving all members. More details about rules and roles have been given in Section 4.2.2.

**STRATEGIES.** As in 2014, the *sharing for ideating and conceptualizing* strategy, detailed in 4.2.2, recurred across missions and was related to

specific mission challenges, that included group work and information sharing.

Additionally, we introduced new strategies to be used in specific missions, for working at class level (MH-G5). These strategies are the following ones.

**JIGSAW.** *Jigsaw* (Barnes and O'Farrell, 1990) is a group strategy where learners are responsible for teaching to one another. In the first phase of the strategy, each group is assigned some subject material, this way becoming the group expert of a subject. In the second phase, experts from different groups meet together to discuss their areas, and learn about the other materials. This new group composed by all experts of each area. Then experts return to their respective groups, to share their learning. In this way, the work of the expert group is quickly disseminated throughout the class, with each person taking responsibility for sharing a piece of the "puzzle". We adapted the JIGSAW strategy for creating the main character of the class game (M3).

**One stay other stray.** The *one stay, other stray strategy* (Barnes and O'Farrell, 1990) is used as a means for sharing information and gathering feedback about a task, such as the description of the game level, designed and prototyped by each group (M4). During this strategy, all members of a group take a break from their work: members who leave the group visit other groups to share their results and collect information about their tasks (visitors). The group member that stays in his or her group (at home member), receives members from other groups (visitors) to share the result and information from the mission task. Then visitors return to their own group and report on their results. This way, each group compares and discusses its result. We adapted the one stay other stray strategy for sharing the game levels prototyped in M4.

## 6.2.3 Protocol Mission by Mission

**Must-Have 2014**

- MH-P1** Recapping phases and links across missions.
- MH-P2** Providing an easy mission for training work in group.
- MH-P3** Basing game design on a storyline that children are interested in, possibly related to a school subject.
- MH-P4** Using stimulus cards or sentences to better express of children's creativity.
- MH-P5** Making generative toolkits, e.g., paper-based forms, captivating and functional for group work.
- MH-P6** Using simple and clear forms, which should be as different as possible between missions.
- MH-P7** Creating ad-hoc structured frames for prototyped games, so as to better allow children to present their products and to interact with them.
- MH-P8** Setting a player interaction model for the game (e.g., third person perspective, with the main character of the storyline that acts as the player of the game).
- MH-P9** Considering a design of a single game level per group.

GaCoCo 2015 Study										
	Mission 1	Mission 2		Mission 3		Mission 4	Mission 5			
<b>GOAL</b>	Training and group identity	Conceptualizing the storyline of the class game		Conceptualizing (1) the game level idea, and (2) the main character related to the storyline		Prototyping the game level	Finalisation of each group level			
<b>CHALLENGES</b>	Choosing the group name and prototyping the group badge.	Group storyline	Class storyline	Storyline Character (player)	Game Idea	Core mechanics	Sharing and revising	Winning and losing Effects	Assembling final game level	Presentation
<b>COOPERATIVE LEARNING STRATEGIES</b>	Group work	Group work - Stimulus cards	Class work (Focus Group)	JIGSAW	Group Work - Stimulus Sentences	Group Work	One Stay Other Stray	Group work	Group work	Group work
<b>GENERATIVE TOOLKITS</b>	Group name form with the sticker badge	Group storyline form	Class Storyline form	Character Form	Game Idea Form	Level frames	Core mechanics form	Game Level frame	Game Frame	Feedback form
<b>GAMIFIED PROBES</b>	Per class: Progression Map, Coins Per group: Control Box Per child: Role Cards, Signaling disks					+ Per class: shop				

Figure 26: Steps and material mission by mission of the 2015 study

In this section, *Across Missions* paragraph details those parts of protocol that are common among all missions. Then, each mission is outlined in the *Mission by Mission* paragraph, detailing the outcomes and the procedure for tackling these outcomes.

In addition, Figure 26 summarizes the main steps for each mission, detailing the goal of each mission, its specific challenges and the cooperative learning strategies and material (generative toolkits and gamified probes) a practitioners could use in each mission.

### *Across Missions*

AT THE START OF A MISSION. Teachers, together with the design expert, recapped what children had produced at the end of the previous mission (if any), and outlined the goal of the daily mission. Teachers explained or reminded rules, and assigned and explained roles of cooperative learning to each child (MH-P1). Then, the design expert explained the organization of the mission in challenges, using the progression map and the relevant gamified probes (MH-P5, MH-P7). Moreover, with the aim of sustaining links across missions in term of game design stages, a training to game design was organized at the start of every mission (MH-P1). This training was executed by the design expert, and it consisted of presentations of about 10 minutes. In these presentations, the design expert showed the mission game design stage, and the related game design goal, showing existing games as an example, such as “The frozen game” by Disney (Disney, 2015). Specifically the five training topics were: the storyline creation (M2), the character (player) design with its prototype, the game idea and player conceptualization (M3), gameplay and mechanics setting (M4), game finalization with aesthetics (M5).

DURING THE MISSION. Following the organization of the 2014 study, each group worked at their table, respecting rules and roles. At the end of each challenge, the group ambassador, by pressing the button, asked the design expert to validate their challenge outcomes. The design expert gave rapid feedback for validating the challenge, or else for clarifying design decisions (*formative evaluation*). After a positive validation by the design expert, the group moved their farmer on the progression map, awarding the coin related to the challenge.

AT THE END OF THE MISSION. The material manager collected the group’s rewards to be placed on the map, on behalf of his or her group. Subsequently, groups could use coins for buying prototyping objects at the shop. Teachers and researchers administered children with the questionnaire concerning their emotions.

**AFTER A MISSION.** From the second mission until the fifth mission, following the 2014 GaCoCo organization, two experts (the one at school and another one not present at school), evaluated game products, using heuristics (Desurvire et al., 2004) as in the 2014 study, see Chapter 4. Back to school, the first expert used the evaluation results as summative feedback to children in the next mission (*summative evaluation*).

#### *First Mission. Group Identity and Logo*

**OUTCOMES.** As in the 2014 study, first mission (M1) aimed at: (1) training all children into cooperative learning rules and group roles as well as to the use of gamified material; (2) creating the identity of each group; (3) introducing the game design activity with its design goal (MH-P2). Moreover, M1 ended with a brainstorming session, aiming at (4) eliciting ideas, about the chosen subject, i.e., eating habits in ancient cultures. Its *outcome products* were group logo with the group names, specified in the related forms. Figure 27 shows M1 outcomes for a group.

**PROCEDURE PER CHALLENGE.** The mission followed the same procedure as in 2014. The single challenge of the mission allowed choosing the group name, this was done by filling in the related form, and prototyping the group logo. For this purpose, groups used the *sharing for ideating and conceptualizing* strategy.

Differently than in 2014, after the challenge, the entire class was engaged into a brainstorming session. This concerned the topic chosen by teachers: eating habits in ancient cultures. It aimed at eliciting a large variety of ideas at the class level. These ideas acted as starting point for the subsequent mission, when children had to create the storyline of the class game. The speaking turn during the brainstorming session was regulated by the speaking cup shown in Figure 25. Each child held it when he/she was talking and handed it to another child for giving him or her the speaking turn.

During the brainstorming session, teachers were responsible for guiding and moderating the class in the brainstorming process; the design expert collected and showed children's ideas on the blackboard. To make sure all ideas were duly collected, also the observer too notes about ideas, and later compared them with the design expert's list. After the mission, the expert and the observer categorized children's ideas, e.g., places (desert, pyramids), foods (junk food, healthy food), characters (pharaoh, greek gods). As a result, the expert produced several stimulus cards (MH-P4) as A6-sized pictures with labels. These cards acted as stimuli encouraging children to write simple captions,

Mission 1 - Form Group Name

Mission 1:  
NOME DEL GRUPPO

NOME DEL GRUPPO	M. PUNTI	M. PUNTI
	PUNTI	PUNTI
14 geni	1	2
1 ballanti	2	1
1 geni della frutta	3	0

NOME SCELTO PER IL GRUPPO:  
1 geni della frutta

Mission 1 - Badge

Figure 27: Form for choosing the group name and the group logo prototyped.

and stimulating their creativity in the follow-up mission (MH-P4). See Figure 28 for details.

**REWARDS.** At the end of the mission, each group collected one coin and a seed to plant in their group soil on the progression map (see Figure 23).

#### *Second Mission. Class Game Storyline*

**OUTCOMES.** The second mission aimed at conceptualizing the storyline of the class game (MH-P3). The *outcome product* was a storyline form. See Figure 30

**PROCEDURE PER CHALLENGE.** The second mission had two challenges.

In the *first challenge*, each group selected some cards from the stimulus cards released at the end of the first mission. The selected cards were used for creating a *group storyline* form (MH-P3). This was structured as an A3-sized form with five removable cards. Each card had a label and a space in which children could write (MH-P4). The card labels were as follows: (1) All started in... (Setting), (2) where there is... (Main character)... that... (What does the character), (3) suddenly it happens... (main event or problem) (4) for... so as to... (action of the character for solving the problem), (6) Finally... (resolution of the story). (MH-P4) See Figure 30 for details. The five cards of the form corresponded to the main structures of narratives (Stein and Glenn, 1979): *setting* and *main character*; a *problem*, leading the story forward and making the character act; *resolution*, when the problem in the story it resolved; *conclusion*. The group filled in the form as in 2014, using the *sharing for ideating and conceptualizing* strategy.



Figure 28: The brainstorming panel (on the upper part) and the stimulus cards (on the bottom part).



In the *second challenge*, starting from the group storylines, the class worked under the direction of the design expert, as in a focus group, in order to create a single storyline for the class game. See Figure 30. Firstly, the expert pinned (or drew) the storyline labels on the blackboard. In turn, the ambassador of each group read aloud the five cards of his or her group storyline form. Meanwhile, the material checker of the group pinned each card in the appropriate field on the blackboard. If appropriate, the teacher asked the group for clarifications. When all ambassadors ended their presentations, the blackboard showed each group storyline (five boxes per group).

Then the design expert took the lead: she asked the class to “break all stories apart and recreate a single storyline”. The design expert changed the positions of the boxes on the blackboard and mixed the group storyline. The design expert moderates the flow of ideas and rapidly evaluates them according to the specific game heuristics for storylines. In particular, as main aspect the expert focused on game design elements consistency (Desurvire et al., 2004).

In the end, the design expert assembled the result in a single storyline form, which determined the storyline that each group in the class should use to create their game level idea.

A class storyline form filled in by a group is shown in Figure 29

**REWARDS.** At the end of the mission, each group earned two coins, one per challenge, and five wooden pieces representing gardening tools. These were kept in their dedicated box on the progression map. See Figure 23. The gardening tools were the following: shears, gloves, weakened, fertilizers and shovels.

#### *Third Mission. Game Idea and Character*

**OUTCOMES.** The third mission aimed at conceptualizing (1) the game level idea, and (2) the main character related to the storyline. The main character of the storyline acts as player in the class game.

The *outcome products* of the third mission were prototypes of the class game character, shown in Figure 32, and the high-level concept document, with the game level idea of each group.

**PROCEDURE PER CHALLENGE.** The third mission had three challenges.

In the *first and second challenges*, each group worked on ideating and prototyping the character of the class game. The character acted as the player for the class game. Each group was given a form for prototyping the class game character. The form had 5 removable cards to fill in, representing different aspects of the character: demographic information; physical characteristics; specific powers; character traits;

Gruppo 5

### STORYLINE

**1 Tutto ebbe inizio ...**

*Nelle Antiche Egitto.*

In the ancient Egypt

**2 dove c'è ... che fa ...**

*(ISHTAR)*  
Una bella ragazza egiziana che riceve semi magici da una vecchia saggia contadina. Per aiutare i suoi genitori malati.

A beautiful girl named **Ishtar** receives magic seeds from an old wise lady to help her sick parents

An old arrogant **witch** steals her magic seed, so as to look younger and gain more powers. The witch runs away in other epoch through portals.

**3 ed ecco che accade ...**

*Una vecchia arrogante strega ruba i semi e tutti gli animali magici x ringiovanere e avere più potere. La strega fugge in altre epoche attraverso i portali.*

To **get back the seed**, Ishtar asks help to Hamut the slaves and his magic animals. Riding on animal, she can pass through the portal to **find the witch**.

In this way, Ishtar **retrieves** all magic seed and can **finally** plant them. The seeds convert into magic fruits that once dated allow to recover.

**4 per... bisogna ...**

*Per recuperare i semi chiede aiuto allo schiavo Hamut ed i suoi animali magici salendo su un animale, Ishtar passa attraverso i portali x trovare la strega.*

**5 ed è così che ...**

*Ed è così che Ishtar recupera tutti i semi e li pianta. I semi si trasformano in frutti magici che una volta mangiati permettono di guarire.*



Figure 29: The class storyline form filled in by a group.

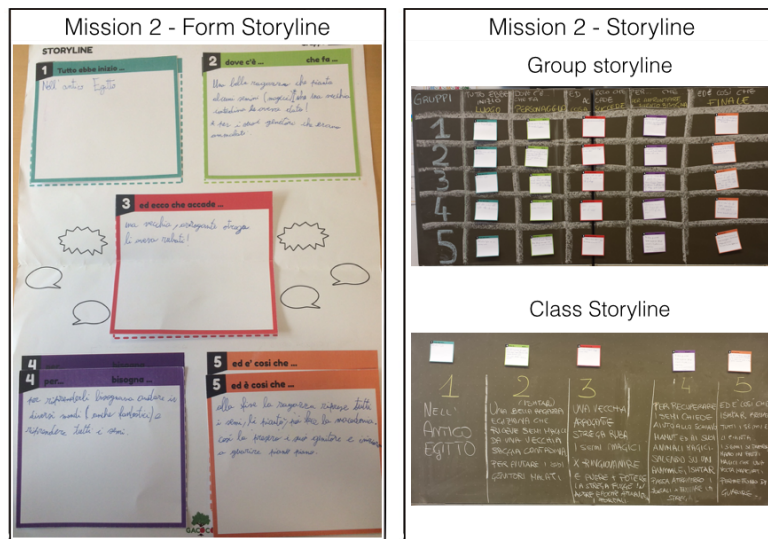


Figure 30: A form for the Game Idea (on the left); the character prototyped by a group (on the right).

personal objects and tools. Using the JIGSAW strategy, each group had their character cards filled in, and could complete the character form by drawing the character, to be used as a player in their game level. See Figure 32.

In the *third challenge*, each group, using the sharing strategy as in 2014, had to create their game idea filling in the high-level concept document form. In order to stimulate the creativity of children and to tackle a demanding task, such as the conceptualization of a game idea, stimulus sentences were given to children (MH-P4). The stimulus sentences were simple sentences printed on a sheet of paper that recalled the main elements of a game. The sentences were the following: (1) I would like to have a game; (2) the character of the story is in... (choose the setting and location); (3) and the character had to... (actions of the player); (4) for...so as to... (objective); (6) during the game the character encountered... (other characters or objects).

**REWARDS.** At the end of the mission each group collected a coin per challenge and parts of a tree (tree roots, trunk and frond) to stick on the appropriate space on the progression map, see Figure 5.

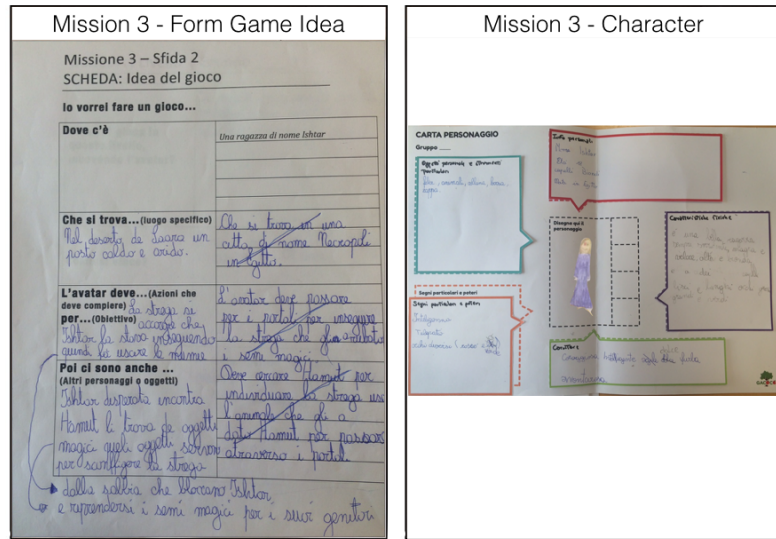


Figure 31: A form for a Game Idea (on the left); a prototyped character by a group (on the right).

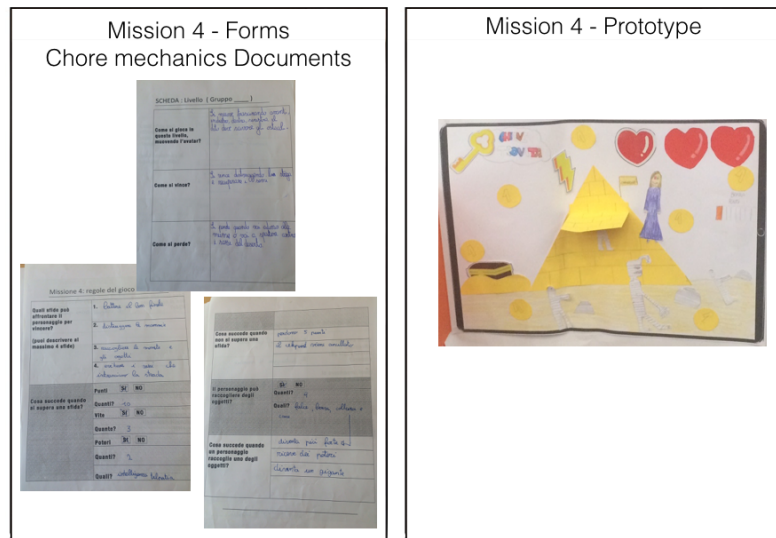


Figure 32: A filled form for the core mechanics documents (on the left); a prototyped game level (on the right).

*Fourth Mission. Group Game Levels.*

**OUTCOMES.** The fourth mission aimed at prototyping the game levels, completing the core mechanics documents. Starting from the high-concept document, the *outcome products* were prototypes of a game level per group, and the related core mechanics documents. See Figure 32.

**PROCEDURE PER CHALLENGE.** The fourth mission had 4 challenges.

In the *first and second challenges*, after revising their high-level concept document, each group worked on the core mechanics documents for their level. Groups filled in the documents, and started to prototype their level using the paper-based material. In the *third challenge*, group had to share their game level with the class. The strategy *One stay Other stray* was used: each group knew and learnt about the work of the other groups. In the *fourth challenge*, each reunited group worked on completing their game level based on the received feedback from the other groups.

**REWARDS.** At the end of the mission each group earned four coins and a scarecrow for protecting their tree, to be used on the progression map.

*Fifth Mission. Game Finalization*

**OUTCOMES.** The fifth mission aimed at finalizing each group game levels and presenting it to the entire class. The *outcome product* of the fifth mission per group was made of the completed game levels with the losing and winning effects.

**PROCEDURE PER CHALLENGE.** The fifth mission had four challenges. In the *first challenge*, each group used the sharing strategy for revising their levels together, and filling in the forms for the winning and losing effects, e.g., "what happens when the player wins or loses this level?".

In the *second and third challenges*, using the ad-hoc frame, groups assembled their game level prototypes. Firstly, groups inserted their level in a part of the frame. Secondly, each group had to choose the winning and losing effect that appeared when the player wins or loses.

In the *fourth challenge*, each group presented their game prototype to the entire class, so as to gather feedback from peers.

**REWARDS.** At the end of the mission, each group collected four coins, and won a wooden star that allowed each group to receive a special prize. The special prize was a certificate, signed by the game designer

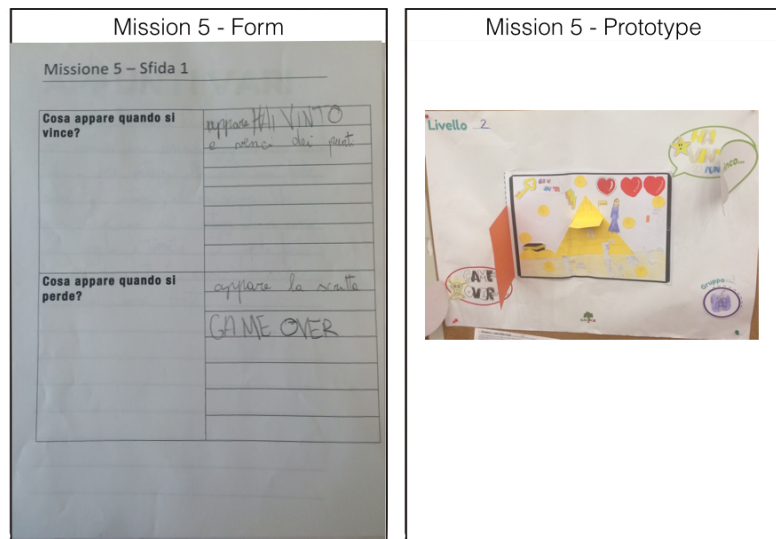


Figure 33: A passage conditions form (on the left); a final prototyped game with the winning and losing effects (on the right).

in charge of the project. As in 2014, each group received this prize during a dedicated mission at the university, as explained in Section 4.2.3.

#### *Mission at University.*

The mission at the Free University of Bozen-Bolzano was organized after the core GaCoCo design activity. The mission lasted circa 4 hours. The two classes with their teachers were invited to present their prototyped games.

**OUTCOMES.** The mission aimed at (1) presenting the prototyped games by each group to the other class, (2) receiving feedback from all children about the games and voting the preferred game. In addition, children was asked to (3) complete each class game inserting the passage conditions between levels, as in 2014 study (M5). Besides the feedback given by children and the preferred game chosen by voting, the *products outcomes* of this mission were the passage conditions forms for the class games.

**PROCEDURE PER CHALLENGE.** Since each group had to show and present their game, the *gallery tour strategy* (Barnes and O'Farrell, 1990) of cooperative learning was used. Presentations were organized as in





Figure 34: The gallery tour during the Mission at university.

2014, see Section 4.2.3. Each group presented their game, and then answered any questions and comments by other teams concerning their product. After the presentation, groups worked on the passage conditions forms for the class game. They filled in the related form for conceptualising the passage conditions and prototype the passage levels. See Figure 33

At the end of the mission, each child was asked to vote one of the group's prototypes, expressing their preferences.

**REWARDS.** At the end of the vote, all children received a certificate of game designer.

## 6.3 ANALYSIS AND RESULTS

As in 2014 study, two main types of data were collected and analyzed: the quality of game products, assessed via expert evaluation, and the children's engagement, assessed via GR-AED emotion questionnaires and via observations.

Section 6.3.1 summarized the data collected and the instruments used in 2014, focusing on the differences about 2015 data collection and instruments. Section 6.3.2 presents the results of the data analyses executed.

### 6.3.1 Data Collection and Instruments

Data concerning quality of products and engagement were gathered with different instruments, at specific moments. For the sake of readability, the data collected, its description and the instrument used for gathering it, are summarized in Table 4. Further details have been given in Section 4.3.1.

Data		
<b>Quality of product</b>	<b>Description</b>	The quality of product is defined as the quality scores of a group in a mission summed across issues, and then divided by the number of issues applicable in the mission.
	<b>Instrument</b>	Expert evaluation of products against issues, defined starting from playability heuristics of (Desurvire et al., 2004).
	<b>Analysis</b>	Descriptive statistic and intercorrelations, using SPSS version 21.0 for Windows.
<b>Children's Achievement Emotions</b>	<b>Description</b>	Children's achievement emotions and their intensity is investigated at the end of the GaCoCo activity. The emotions we focussed are: enjoyment, relaxation, anxiety and boredom.
	<b>Instrument</b>	The Graduated Achievement Emotion Set (GRA-ES): verbal-pictorial questionnaire administered at the end of the GaCoCo activity. It enables to assess the intensity of ten achievement emotions (Raccanello and Bianchetti, 2016).
	<b>Analysis</b>	Descriptive and inferential statistic, using SPSS version 21.0 for Windows.
<b>Children's engagement in mission</b>	<b>Description</b>	Children's engagement is evidenced by those behaviours in mission challenges that denote enjoyment, interest and concentration.
	<b>Instrument</b>	Observations. The observer used diaries to collect observations during the missions, moreover observations were integrated with video recorded by video-cameras set in class.
	<b>Analysis</b>	Relevant results on engagement observations are reported in narrative form, in a manner that facilitates comparisons with statistical analysis results.
<b>Children's engagement with material</b>	<b>Description</b>	Engagement with material is evinced by the observer by tracking the children's behavior with gamified probes (e.g., frequency of usage of the material).
	<b>Instrument</b>	Observations and video recordings. In addition, at the end of the GaCoCo activity, children were given a survey for rating the preferred gamified probes.
	<b>Analysis</b>	Narrative form for the observations of the engagement with gamified probes and quantitative results from the data gathered from the survey.

Table 4: The first column contains the type of data collected during the study. For each data we provide a description, the instrument used so as to gather such data, and the analyses executed with the gathered data. Further details have been given in Section 4.3.1.



Issues	Mission 3	Mission 4	Mission 5
Gameplay and mechanics inconsistencies or unclear functionalities	A	A	A
Goals	A	N/A	N/A
Gameplay and mechanics incompleteness	N/A	A	A
Documentation	N/A	A	A

Table 5: Issues applicable (A) or not applicable (N/A) across Mission (M3–M5)

### 6.3.2 Study Results

This section reports on results concerning the main data collected, that is the quality of products, children’s achievement emotions and their relationships with the quality of products, and finally children’s engagement. We quickly recap our goals, which are listed in Table 3. Goal 1, refers to the evolution of the quality of products over time. Goal 2 deals with children’s emotions over time (Goal 2.1) and with qualitative results concerning the engagement of children with design work, as well as their preferences on materials (Goal 2.2). Finally, Goal 3 relates the relationships between emotions and quality of products.

#### *Quality of Products*

This section focuses on the first research goal, **G.1**, concerning children’s performances in GaCoCo design. At the end of missions M3–M5, groups released products consisting of game design documents and prototypes, as specified in Section 6.2.3.

Issues applicable from the third mission onwards are those related to *gameplay and mechanics inconsistencies or unclear functionalities*. The *goal* issues are applicable only in the third mission; whereas, issues of *gameplay and mechanics incompleteness* and *documentation* are applicable from the fourth mission onwards. See Section 4.3.1 for details on product issues.

To provide inter-judge reliability, the design expert working with schools classified all products against issues, while the other expert classified just 33,33% of them. The mean agreement percentage between experts was 87,50%. The lowest agreement between experts was for “gameplay and mechanics Inconsistencies or unclear functionalities” (75,00%). Experts resolved disagreements through discussions to revise the products’ classification.

Issues	Mission 3	Mission 4	Mission 5
Gameplay and mechanics inconsistencies or unclear functionalities	2, 4, 6, 7	2, 4, 7	1, 2, 3, 4, 6, 7, 8, 9,10
Goals	2, 4, 6	N/A	N/A
Gameplay and mechanics incompleteness	N/A	1, 2, 4, 6, 7, 8, 9, 10	1, 2, 3, 4, 5, 6, 7, 8, 9,10
Documentation	N/A	2, 4, 6, 8	1, 2, 4, 5, 6, 7, 8, 9,10

Table 6: Groups with quality score equal to 1 (positive result) for an issue in a mission.

Groups	Mission 3	Mission 4	Mission 5
Group 1	0.00	0,33	1.00
Group 2	1.00	1.00	1.00
Group 3	0.00	0.00	0.67
Group 4	1.00	1.00	1.00
Group 5	0.00	0.00	0.67
Group 6	1.00	0.67	1.00
Group 7	1.00	0.67	1.00
Group 8	0.00	0.67	1.00
Group 9	0.00	0,33	1.00
Group 10	0.00	0,33	1.00
M	0.40	0.50	0.93
SD	0.52	0.36	0.14

Table 7: Quality of product for each group and mission (M3–M5); mean (M) and standard deviation (SD) across groups.

Table 6 shows, for each issue and mission, groups with quality score 1 for the issue and in the mission.

Quality scores of a group in a mission were added across issues, and then divided by the number of issues applicable in the mission (two in M3; three in M4, M5). See Table 5 for details.

Table 7 reports the quality of product per group and per mission, mean (M) and standard deviation (SD) across groups.

A non-parametric Friedman test of differences among repeated measures was then conducted on the quality of products, and it was statistically significant,  $\chi^2(2) = 42.471, p < 0.001$ . A post-hoc comparison with Wilcoxon test indicated that quality of products was significantly different in all cases:  $z = -1.796, p = 0.073$ , comparing M3 (M =0.40, SD =0.52) and M4 (M =0.50, SD =0.36);  $z = -5.261, p < 0.001$ , comparing M4 and M5 (M =0.93, SD =0.14); most importantly,  $z = -4.490, p < 0.001$ , comparing M3 and M5, the mission that started and concluded the de-

*G1.H1 Quality of products changes over time. Supported.*

	Enjoyment	Relaxation	Anxiety	Boredom
Means (M)				
M1	4,76	3,58	1,33	1,25
M2	4,08	3,03	1,54	1,68
M3	3,87	2,90	1,90	2,05
M4	4,20	2,79	1,74	1,71
M5	4,51	3,17	1,84	1,62
Standard errors (SE)				
M1	0,11	0,20	0,08	0,10
M2	0,20	0,22	0,14	0,13
M3	0,22	0,23	0,20	0,19
M4	0,21	0,21	0,16	0,20
M5	0,16	0,23	0,20	0,17

Table 8: Descriptive statistics for intensity of emotions per mission: M1–M5

sign of game products. These results support the rejection of the null hypothesis on the effect of time (G1.H1).

#### *Children's Achievement Emotions*

This section focuses on **Goal 2.1**, and it analyses the four emotions gathered with GR-AES. It analyses them at individual level, in order to verify the hypotheses concerning possible intensity differences related to valence (G2.H1), activation (G2.H2) and time (G2.H3).

Specifically, we carried out a 2x2x5 (Valence [positive emotions, negative emotions] x Activation [activating emotions, deactivating emotions] x Mission [first, second, third, fourth, fifth mission]) repeated-measure ANOVA on the intensity of the four emotions, with Valence, Activation, and Mission as within-subjects factors. Table 8 reports descriptive statistics for intensity of emotions per missions: M1–M5.

In, relation to G2.H1, a main effect of Valence was found,  $F(1, 39) = 158.09$ ,  $p < .001$ ,  $\eta_p^2 = .80$ , indicating higher intensity for positive emotions ( $M = 3.69$ ,  $SE = .10$ ) compared to negative emotions ( $M = 1.67$ ,  $SE = .09$ ).

*G2.H1: positive emotions more intense than negative ones. Supported.*

In relation to G2.H2, a main effect of Activation emerged,  $F(1, 39) = 30.37$ ,  $p < .001$ , with higher intensity for activating emotions ( $M = 2.98$ ,  $SE = .06$ ) compared to deactivating emotions ( $M = 2.38$ ,  $SE = .08$ ).

In addition, a significant two-way interaction Valence x Activation emerged,  $F(1, 39) = 48.26$ ,  $p < .001$ ,  $\eta_p^2 = .55$ . Specifically, the activating emotion was more intense than the deactivating emotion (enjoyment:  $M = 4.28$ ,  $SE = .11$ ; relaxation:  $M = 3.09$ ,  $SE = .15$ ) for positive emotions, and not more intense for negative emotions (anxiety:  $M = 1.67$ ,  $SE = .11$ ; boredom:  $M = 1.66$ ,  $SE = .09$ ). On the whole, these data supported the falsification of the null hypothesis on

*G2.H2: higher intensity for activating emotions than deactivating emotions. Partially supported.*

the effect of valence (G2.H1), with positive emotions more intense than negative emotions, and the partial falsification of the null hypothesis on the effect of activation (G2.H2), with activating emotions more intense than deactivating emotions true only for positive emotions.

*G2.H3: intensity of negative and positive emotions changes over time. Partially supported.*

Concerning hypothesis G2.H3, a significant two-way interaction Mission X Activation,  $F(4, 156) = 5.60, p = .001, \eta_p^2 = .13$ , emerged. To further explore these findings, we carried out four repeated-measure ANOVAs with Mission as the within-subjects factors. They revealed a significant effect of Mission for enjoyment,  $F(4, 156) = 4.04, p = .002, \eta_p^2 = .10$ , and boredom,  $F(4, 156) = 3.73, p = .006, \eta_p^2 = .09$ .

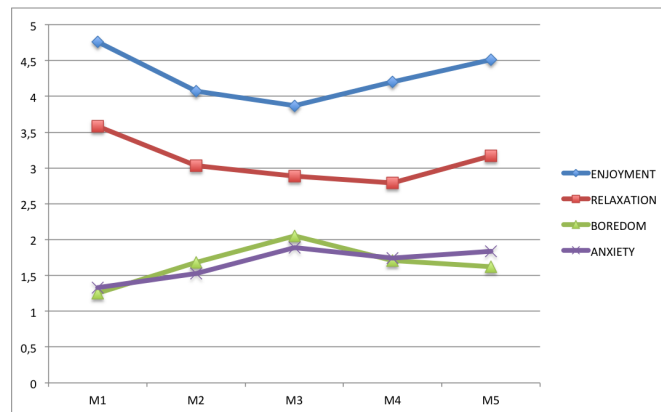


Figure 35: Mean intensity of emotions per mission (M1–M5)

Pair-wise comparison revealed that intensity of enjoyment was higher for M1 compared to M2 and M3, while boredom was higher for M3 compared to M1. However, even if the other comparisons were not statistically significant, on the whole positive emotions tended to decrease from M1 to M3, and then to increase again, and vice versa for negative emotions. Such results enabled to partially falsify the null hypothesis on the effect of time (G2.H3).

Figure 35 and Table 8 report descriptive statistics of the intensity of four emotions, across missions.

### *Children's Engagement*

This section focuses on **Goal 2.2.** and aims at reporting results concerning children's engagement in their overall activity, via observations. Relevant results are reported in narrative form.

Firstly we present children's engagement in missions, in terms of interest, concentration and enjoyment. Secondly, we report on the engagement of children with the gamified probes used during the activity. In addition, this section ends with results from the survey about each child preferences of gamified probes.

ENGAGEMENT IN MISSIONS. In this section, children's engagement, evidenced by those behaviours in mission that denote enjoyment, interest and concentration, was analyzed.

In order to provide inter-judge reliability, diaries were analyzed thematically against the considered categories of behaviors (interest, concentration and enjoyment), while another education researcher not in class, classified 40% of diaries, that is, 4 diaries out of 10. The mean agreement percentage between researchers was 90,37%, distributed as follows per category: 96,25% for enjoyment behaviors; 88,40% for interest behaviors; 86,47% for concentration behaviors. Disagreements were solved through discussion between researchers and used to revise the observer's classification of behaviors in diaries.

We report the observations, mission by mission, in a narrative form in the following.

M1. Children were interested and showed concentration during the explanation of the activity by the design expert. When the expert started the training showing examples of video games, children showed curiosity and interest interacting more with the expert, asking questions about the games. Moreover, children showed enjoyment and excitement when the expert presented the training showing example of games by Frozen (e.g., when a child recognized some characters, she (he) shouted the name and drew attention of his peers.). During the challenge for choosing the group name, all groups seemed to be amused, and worked with concentration. During the brainstorming, both classes were concentrated and showed interest. Children respected the speaking turn and worked neatly. Moreover, after the initial embarrassment, all children showed engagement in listening and proposing new ideas.

In general both classes were engaged, and showed interest and enjoyment for the activity.

M2. During the recap and the training by the design expert, children answered questions, interacting with the expert, and showed interest for the activity, e.g., on the goal of the mission, and showed interest for the proposed mission and for their roles. During the creation of the storyline, all groups were concentrated and showed interest in using the stimulus cards. Children in just one class were noisy and teachers often recalled their attention. The problem was not so frequent in the other class; but, at the end of the first challenge, all groups were noisy. All children were happy for the earned coin and soon asked the expert how to use it.

During the second challenge, when groups worked together for creating the class storyline, all groups were very interested, interacting

with the design expert and with their peers. They were keen to participate to the storyline reconstruction starting from group storylines, and were amused and satisfied for the obtained result, e.g., a child proudly exclaimed that the chosen main character was the character she created with their group. Once more, all were enthusiastic to receive the reward on the map at the end of the mission.

In general, during the training and the recap, both classes were concentrated showing interest and interacting with the design expert. During the first part of the mission both classes were noisy and often showed lack of concentration. During the challenge at the class level, each group was again interested, concentrated and enjoyed the task.

M3. During the recap and the training by the design expert, children behaved as in the other missions. They showed interest and enjoyment when listening for the expert and watching the video games demonstration.

During character creation, with the JIGSAW strategy (at class level), most groups worked with concentration and enjoyment. Several groups asked questions about the procedure showing interest for the task. Several children showed enthusiasm to work with other group of children. In a class, two groups showed lack of concentration, and within these groups some members were isolated and did not work with the others. At the end of the challenge, both classes were noisy and were often recalled by teachers. Several children stood up from their table and reached other groups showing their character. Although with low concentration, in the end, children gave their contribution showing fun and interest.

During the third challenge, when children started to conceptualize their game idea, several groups were distracted and only one group per class worked with attention on its task. A member was isolated and did not cooperate with his group. In particular, he was lying down on his chair without keeping attention to his group members. When the expert asked him what he had done until now, he replied "I didn't understand the task". The expert drew children's attention several times and, during the execution of the challenge, often repeated the procedure for conceptualizing the game idea. In particular, the expert pointed out to several groups as they were replicating (and re-writing) the storyline in the game design idea form, instead of creating a game (idea) inspired by the storyline.

In general, there were many gaps in concentration and children often left their group tables. More engagement was showed by children during the challenge at the class level, when the player was designed and prototyped.

M4. During game level design, all children worked concentrated showing interest and enjoyment. Groups seemed to be relaxed, and also those members that were less engaged during the third mission showed more interest and concentration.

All children were engaged in personalizing their game, with objects bought from the shop, and showed satisfaction for their work. Besides the typical noise that occurs when groups of children work together, all children worked concentrated in order to finish their prototype. Within a group, a member recalled his group attention exclaiming “stop joking, our time is running out”. During the challenges at the class level, when children had to share their game level, all children showed interest and curiosity in listening their peers work.

In general, children were globally engaged showing interest, concentration and enjoyment during M4.

M5. During challenges of M5, in both classes, all children worked tidily showing concentration and interest. When time for the first challenge was over, several groups were noisy and showed less concentration. In both classes, when a group presented their work, their peers listened and asked many appropriate questions (e.g., about the functionality of game elements).

In general, both classes were engaged during the mission, especially during the game presentations.

ENGAGEMENT WITH MATERIAL. The children’s engagement with material was analysed mission per mission. The results are described narratively in the following.

M1. Children showed curiosity, interest and enthusiasm towards all material. Initially, one class showed some difficulties in using the *cards* for taking turn before speaking, but, at the end of the mission, each member used the cards in a proper way. The *progression map* was a great source of curiosity for finding out rewards at the end of the mission. Signaling disks got soon very popular, all children were enthusiastic and amused of using them for communicating their opinions.

During the brainstorming, all children were initially embarrassed and had difficulty in using the *speaking cup*; whereas, at the end, all children used the *speaking cup* in a proper way.

M2. During the second mission, children created the storyline for their game. At mission start, all children were enthusiastic to receive materials for starting a new mission. Children also used gamified probes, such as signalling disks and the control box, in a creative way, still func-

tional for the purpose of the work. However, a group created confusion using cards, e.g., children laughed and played with cards and their control box. For instance, the *big button* of the control box was thought to be used for asking the expert the challenge validation. Children began to use it also for calling the expert and for asking questions, explanations or help. In one class, children often forgot to use the cards for the speaking turn. In the other class, the use of cards for speaking was more constant. It emerged also that shy children were using the cards for gaining the possibility to speak: they were holding the card on the box and then patiently wait for someone to notice it and to let them talk.

During the second challenge, when children worked at the class level, several children played with the signalling disks, even in way not included in the protocol, e.g., children were drawing on the signalling disk while the expert were working on the class storyline creation. At the end of the challenges and of the mission, children were enthusiastic and amused to collect their rewards (coins and mission completion rewards).

**M3.** At the start of the mission children showed enthusiasm for the received materials, as in the other missions. The signalling disks were used in the proper way only and when required by the protocol. The use of cards was more regular and functional, but someone tended to forget it. For instance, a group started using their cards and control boxes without waiting for the design expert to tell children that the discussion session had started. Children continued to show curiosity and interest for the *progression map*, e.g., often children left their table to see what was the new mission reward.

**M4.** Children showed enthusiasm for new generative toolkits introduced in this mission, used for prototyping the level (such as tablet frames, transparencies and colors, and objects in the shop). The *shop*, with its objects, was source of strong interest and curiosity. Groups were discussing in front of the shop, the possible usage of the objects in their game. However objects were not always chosen taking into account their functionality for the game. Some children complained that they would like the shop to have more probes of a certain type, e/g/ a child said "The hearts are finished, but we need two of them for our games!". At the end of the mission children said "it was good to buy objects at the shop". Material functional for the mission such as cards and signalling disks were used in a naturally and properly way.



M5. The A1 frame for assembling levels rose curiosity and all children showed interest when listening to the related instructions. Several children asked whether they were allowed to buy objects from the shop. During the presentation of their game, all children showed enthusiasm and satisfaction in showing their game and how to interact with it. At the end of M5, the fifth and final mission, many children asked the design expert whether they were allowed to keep for themselves coins earned in the map as tokens for remembering the experience of game design.

PREFERENCES FOR GAMIFIED PROBES. In both classes, all children completed the survey for assessing gamified probes preferences. Results are as follows. The most preferred gamified probes was the shop: 40.47% of the children put it at the first place. As for the second preferences, the control box, the progression map and the shop all scored identical preferences (21,42%)

#### *Children's Achievement Emotions and Quality of Products*

This section focuses on the third goal, G3, i.e., the relationships between performance and the four emotions of enjoyment, boredom, anxiety, relaxation.

Tables 36 and 37 show descriptive statistics computed at the individual level (before the slash) and at the group level (after the slash) for the following variables: intensity of positive emotions in each mission (M1–M5); intensity of negative emotions in each mission (M1–M5); quality of group products in each mission, starting from the third (M3–M5).

Correlations among intensity of emotions per mission and quality of product per mission were again computed separately for the individual level (for which parametric Pearson correlations were run) and the group level (for which non-parametric Spearman correlations were run). Correlation coefficients are thus  $r$  for the individual level, and  $\rho$  for the group level.

Table 36 displays the correlation coefficients among intensity of positive emotions per mission and quality of product per mission ( $r$  and  $\rho$ ). Table 37 does the same with negative emotions.

Correlations		Perf M3	Perf M4	Perf M5	Enjoyment 1	Relaxation 1	Enjoyment 2	Relaxation 2	Enjoyment 3	Relaxation 3	Enjoyment 4	Relaxation 4	Enjoyment 5	Relaxation 5
Pearson (r)	M3	1	.794**	.387*	.206	-.013	-.009	-.015	.045	.347*	.291	.482**	.067	.081
	M4	.794**	1	.703**	.056	-.155	-.050	-.102	.068	.217	.334*	.405**	.122	.076
	M5	.387*	.703**	1	-.113	.078	-.076	.058	.192	.335*	.359*	.391*	.278	.181
	M3	1.000	.779**	.573*	-.087	.288	-.025	-.025	.304	.109	.404**	.286	.080	.086
	M4	.779**	1.000	.672**	-.188	.198	-.091	-.063	.214	.106	.370*	.363*	.081	.079
Spearman (rho)	M5	.373*	.672**	1.000	.059	-.018	.067	-.035	.334*	.164	.391*	.351*	.186	.282
	M	0.4286	0.516	0.945	4.76	3.58	4.077	3.03	3.87	2.89	4.20	2.79	4.51	3.17
SD	.5008	.3320	.1244	.717	1.289	1.289	12.887	1.368	1.417	1.446	1.336	1.316	.977	1.476

Figure 36: Correlations for intensity of positive emotions per mission (M1–M5), and quality of product per mission (M2–M5), at the individual (n = 35) and group level (n = 9). Pearson *r* (individual) and Spearman *rho* (group) are shown in table. \**p* < .05, \*\**p* < .01, \*\*\**p* < .001

Correlations		Perf M3	Perf M4	Perf M5	Boredom 1	Anxiety 1	Boredom 2	Anxiety 2	Boredom 3	Anxiety 3	Boredom 4	Anxiety 4	Boredom 5	Anxiety 5
Pearson (r)	M3	1	.794**	.387*	.000	.070	-.266	-.149	.088	-.009	-.214	-.082	-.116	.030
	M4	.794**	1	.703**	.063	.120	-.125	-.246	.060	.006	-.242	-.133	.079	.031
	M5	.387*	.703**	1	.054	-.045	.064	-.461**	-.144	-.094	-.309	-.166	-.204	-.153
Spearman (rho)	Boredom1	1.000	.779**	.373*	-.047	-.040	-.252	-.111	.081	.091	-.268	-.010	.091	-.047
	Anxiety 1	.779**	1.000	.672**	-.052	-.024	-.153	-.085	.086	.085	-.265	-.063	.129	.059
	Boredom 2	.373*	.672**	1.000	-.023	-.106	.065	-.288	-.006	-.040	-.233	-.098	-.085	-.041

Figure 37: Correlations for intensity of negative emotions per mission (M1–M5), and quality of product per mission (M2–M5), at the individual (n = 35) and group level (n = 9). Pearson  $r$  (individual) and Spearman  $\rho$  (group) are shown in table.. \* $p < .05$ , \*\* $p < .01$ , \*\*\* $p < .001$

Concerning hypotheses G<sub>3</sub>.H<sub>1</sub> and G<sub>3</sub>.H<sub>2</sub>, there are significant correlations between intensity of emotions and quality of product, for the same mission, for enjoyment and relaxation. The correlation holds both at individual and at group level (Table 36 and Table 37). For relaxation, the mentioned correlation was positive for M<sub>3</sub> (individual level:  $r = .347$ ,  $p = .028$ ; group level:  $\rho = .344$ ,  $p = .030$ ) and M<sub>4</sub> (individual level:  $r = .405$ ,  $p = .010$ ; group level:  $\rho = .370$ ,  $p = .019$ ), while for enjoyment it was significantly positive only for M<sub>4</sub> (individual level:  $r = .334$ ,  $p = .035$ ; group level:  $\rho = .363$ ,  $p = .021$ ). Always considering the same mission, no significant correlations emerged between negative emotions (relaxation and anxiety) and quality of product. These findings enabled to partially falsify the null hypothesis on the relationship between the two emotions and quality of product.

*G<sub>3</sub>.H<sub>1,2</sub>: quality of products is positively correlated-negatively correlated to enjoyment. Partially supported.*

Moreover, the quality of products of each mission correlates significantly and positively with quality of products of subsequent missions. These results indicate a certain level of coherence in children's quality of products over time, both at the individual and at group levels (Table 36 and Table 37). Specifically, the quality of product of M<sub>3</sub> correlated positively with those of M<sub>4</sub> ( $r = .794$ ,  $p < .001$ ;  $\rho = .810$ ,  $p < .001$ ) and M<sub>5</sub> ( $r = .387$ ,  $p = 0.011$ ;  $\rho = .432$ ,  $p = .11$ ). The quality of product of M<sub>4</sub> correlated positively with those of M<sub>5</sub> ( $r = .703$ ,  $p < .001$ ;  $\rho = .672$ ,  $p < .001$ ).

The 2015 study results show a significant correlations between intensity of positive emotions in a mission and the quality of products of subsequent missions, with slight differences with the individual and the group level. Therefore, the delayed effect estimated in the 2014 study is again present in the 2015 study. Specifically, enjoyment in M<sub>4</sub> correlated positively with quality of product of M<sub>5</sub> ( $r = .359$ ,  $p < .023$ ;  $\rho = .351$ ,  $p = .026$ ), and relaxation measured in M<sub>3</sub> correlated positively with quality of M<sub>5</sub> ( $r = .335$ ,  $p = .036$  and  $r = .335$ ,  $p = .036$ ).

## 6.4 DISCUSSION

We again recap that the novel 2015 study had the following goals, presented in Section 6.1.1:

- G.1** assessing children's design performance, as in the 2014 study, considering issues affecting the quality of children's game design products over time;
- G.2.1** assessing children's engagement through their achievement emotions via a questionnaire,
- G.2.2** assessing children's engagement via observations;

### G.3 assessing correlations between quality of children’s products and intensity of their achievement emotions.

This section discusses results related to such goals: Subsection 6.4.1 in relation to G.1; Subsection 6.4.2 in relation to G.2.1; Subsection 6.4.3 in relation to G.2.1; Subsection 6.4.4 in relation to G.3.

#### 6.4.1 Quality of Products for Learning

In order to compare results across the two studies, quality of products was assessed in the 2014 study as in the 2015 study. Quality of products tended to increase in time in both studies; specifically, in the newer study, there are significant differences between M3, when the first game products were created, and M5, when the final game design document and prototypes were released. Such results suggest that both studies were empowering children: they were learning about early game design “by doing” game design together.

The newer study products presented a subset of issues with respect to the older study products: as reported in Section 4.4, only four issues were found across game design products in the 2015 study, with respect to six as in the 2014 study. Such differences can be due to the novel organization of the 2015 study. In order to improve on the quality of products, the 2015 study reserved longer time to formative feedback on game products (MH-D5, D6), and it divided the training to game design across missions (MH-P2). Moreover, only in the 2015 study, each class created together their game storyline, and all groups had to use the same character, acting as player, in their game levels, which was the storyline main character (MH-P3). Such organizational choices may have contributed to removing issues concerning storyline and player in the 2015 study.

The organization of both studies considered cognitive skill of participants<sup>3</sup>, and created gamified probes and tasks for designing accordingly to their maturity. However children’s products in 2015 still presented some issues affecting their quality, which had also emerged in the 2014 study: in both studies, issues pertaining to gameplay and mechanics inconsistencies or unclear functionalities were the most problematic, affecting the highest number of products. Such a result seems to suggest that maintaining coherence among design choices over time is a cognitively demanding task for 8–10 year old children.

<sup>3</sup> Children 7–11 years old are in the concrete operational stage, have no mature formal operational skills, but they can solve logical problems with concrete objects, e.g., game elements

## 6.4.2 Children's Achievement Emotions for Engagement

According to the 2015 study results, intensity of relaxation was significantly higher for missions M1 and M5, compared to the others. The same trend was observed for enjoyment. In line with 2014 findings, the 2015 study results confirms that the first mission created a relaxed atmosphere, which enables building mutual trust along the GaCoCo activity.

In the 2015 study, M3 shows a change in the growing trend of intensity of emotions. Specifically, compared with the other missions, during M3, the intensity of enjoyment was lowest and the intensity of anxiety was highest. According to engagement observations, lack of concentration and lack of interaction among group peers were observed in M3 when groups had to conceptualize their game idea. In particular, the observer reported that the game design expert had to draw children's attention several times, and, upon request by several groups, the expert had to explain how to carry on the game idea conceptualization, to the entire class. Conceptualization of the game idea from the game storyline is a challenge that resulted complex also in the 2014 study. That may be due to the cognitive skills of 8–10 year old children, who are in the concrete operational stage (Piaget, 1952).

From M3 onwards, intensity of enjoyment increased and intensity of anxiety and boredom decreased, differently than in the 2014 study. According to engagement observations, all children were concentrated and showed interest and enjoyment in prototyping their game level in M4, and in presenting it to the entire class in M5. The novel organization of the 2015 study, done in line with MH-D6 and MH-D3, allowed children to finalize their game without anxiety and with relaxation so to finish their work.

Albeit the decrease of positive emotions and decrease of anxiety in M3, the intensity of positive emotions was higher for M1 and M5 compared to the other missions, and the intensity of enjoyment was, on average across missions, above the middle intensity value ( $M=3.688$ ,  $SE=0.19$  where 1 is the lowest value and 5 the highest value for intensity, the middle value being 3). As in the 2014 study, the 2015 study results concerning children's achievement emotions confirmed the higher salience of positive emotions of enjoyment and relaxation compared to negative emotions of anxiety and boredom, highlighting changes during the GaCoCo activity as time progresses. Moreover, according to engagement observations, all children always showed enjoyment and interest when involved in class activities, as opposed to group activities. Specifically, children were concentrated and interested, and showed curiosity in listening and knowing about work of

their peers. All children made an effort on explaining their work to others, showing satisfaction for their work. Therefore also engagement observations indicate that children enjoyed the 2015 activity, speaking positively of its organization—the strictly necessary training for a mission was given at its start (MH-P2); each mission delivered a specific product and had its own design goal (MH-D3); lengthy feedback was given by the game design expert on complex game design challenges, requiring more abstract thinking, e.g., game idea conceptualization (MH-D6); the storyline had a main character acting as the player of the game (avatar based interaction mode) (MH-P3) and it was created by children using specific strategies for working at class level, e.g. cooperative learning strategy (MH-G4, G5).

#### 6.4.3 Engagement with Material

Differently than in the 2014 study, the 2015 study enhanced gamified probes with interaction technology.

In general (MH-T4), materials were received with enthusiasm and curiosity. However, technical problems often caused at certain moments lack of concentration, especially in the initial missions. From M<sub>3</sub> onwards, all children showed concentration and interest, and they worked without considering technical problems (sometimes a connection between the control box and the map did not work (the led di not light up when a children pressed a button, due to the distance between group tables and the map), or sometimes the progression map ringed albeit nobody ones pressed a big button).

Control box with cards and signalling disks, after the training and instructions given at the first mission, were properly used, taking into account the related cooperative learning rules and roles. Specifically, **cards** for taking turns in speaking by placing them on the control box were rarely used in M<sub>1</sub> and M<sub>2</sub>. From M<sub>3</sub> onwards, children started using cards more frequently, after the expert recalled the importance of the associated rule: all members within a group had to participate by giving their contribution, and to listen others' opinions with respect (social skill training). Our interpretation of the initial modest use of cards is that the rule of turn-speaking is per se difficult to internalize, which confirms observations of 2014. Moreover, cards presented other negative and positive aspects: the dominant member tended to remove forcefully other members' cards, and to place his/her own cards for speaking up; whereas, shy members used their cards for gaining space for speaking within their group. Such observations indicate that cards were used for the functionality they were designed for: an affordable

*MH:providing an affordable object or tool for allowing children to ask help to the expert when they needed.*

tool for allowing members to claim their right to speak and take turn in speaking.

The **control box** was received with enthusiasm and generally was used as designed for: for taking turn in speaking with the help of cards and for calling the expert with the big button, which triggered a sound and a LED turning to on the progression map. In particular, the **big button** was frequently creatively used: besides using it for asking for the expert validation, several groups started using the button for calling the expert and asking clarification questions on their work. This behaviour was especially observed in M3. Such a result suggests that children felt reassured and related to the expert if they could call the expert when they needed.

**Signalling disks** were often source of distraction albeit to a lesser extent than in the 2014 study.

Again, as in the 2014 study, all children showed a marked preference for the **shop**. Children showed enthusiasm and curiosity when the shop was presented, in M4, albeit the shop was also source of distraction for children. All children were excited at the idea of buying objects for prototyping, paying at the shop with coins. In such a manner, coins, earned at the end of each challenge, had a tangible effect on children's design work, which gave given them a sense of control in choosing parts of their game (MH-T3,T4, T5). Albeit, in M4, objects tended to be chosen for their aesthetic appeal and not so much for their functionality in the game, afterwards children started to argue on which objects could be most useful for their game.

Children showed enjoyment and satisfaction in collecting **coins** as rewards for finishing challenges from the very first mission, M1. In line with cooperative learning findings (Graves, 1991), coins as symbolic tangible rewards seem to have given children a sense of effectiveness and control over their work.

The **progression map** received high praise, especially in the early missions. Often children went near the map, watched it and wanted to touch it. In addition, during a mission, the expert often referred to the map to reflect on the work done and to help children to predict the next steps, giving them a sense of progression. In the early missions, children showed difficulty in interpreting the map, but, helped by the expert's explanation, quickly learned how to interpret it. Rewards gained at the end of a mission were source of curiosity and enjoyment for children, who happily wondered how to use them to complete their work.



## 6.4.4 Children's Achievement Emotions and Quality of Products

Both studies, of 2014 and 2015, inspected the nature of the relationships between emotions and quality of products. Our hypotheses G3.H1 and G3.H2 were partially confirmed for positive emotions, enjoyment and relaxation, which correlated positively with performance.

As in the 2014 study, in the 2015 study the quality of products, as assessed by experts, correlated significantly and positively with those of subsequent missions, indicating a certain level of coherence in children's quality of product over time. Moreover, quality of products, correlated positively to enjoyment in the same mission, and frequently there was a positive correlation between positive emotions of a mission and the quality of products of the subsequent missions, indicating a sort of expectation effect created by emotions on future performances. Such results seem to indicate that the more children enjoyed the GaCoCo mission, the better was quality of the released products.

## 6.5 CONCLUSION

This chapter reported the 2015 GaCoCo study organization and results. As in the 2014 study, the 2015 study aimed at empowering children by engaging them and by promoting their learning of game design. To achieve such aims, the novel 2015 study had the following goals: **G1**, assessing children's design performances, considering issues affecting the quality of children's products (game design documents and prototype); **G2.1**, assessing children's emotional engagement, considering achievement emotions and their intensity; **G2.2**, assessing the overall engagement of children, considering children's behaviors; **G3**, assessing the relationship between children's achievement emotions and the quality of children's game design products. There are similarities and differences between results from the two studies, recapped in the following. Specifically, Table 9 lists the major changes in the 2015 study organization with respect to the 2014 study organization, which may explain the reported differences.

**G1: QUALITY OF PRODUCT FOR LEARNING.** In relation to the first research goal of this paper, **G1**, the study results are in line with the 2014 study findings but with some differences. As in the 2014 study, in 2015, the quality of children's products tended to improve in time, suggesting that children were learning by doing design together. Such improvement was also due to the new GaCoCo study organization. In particular, in 2015, we aimed at improving the quality of products,

*MH: giving more feedback to children on specific game design stage, by expert or by teachers — provide a training to teachers on such critical game design stage (e.g., defining rules and game elements for a game.)*

Changes in 2015	
<b>Training</b>	In each mission, before starting the activity, the game design expert had a training on the related game design stage
<b>Technological Probes</b>	Gamified probes were enhanced with low-technology (e.g., Arduino)
<b>Mission differentiation</b>	Each mission had a clear and valuable goal, each one was different from the others
<b>A class game</b>	Each group prototyped a level of a unique class game
<b>Storyline</b>	Storyline was created by children during a mission
<b>Avatar-based Game</b>	The player interaction model was set by the expert; the player was the main character of the storyline
<b>Work at class level</b>	Several cooperative learning strategies included working at class level
<b>More formative feedback</b>	In general, and during critical stages, the design expert provide more feedback to groups

Table 9: Major changes in 2015

and removing some issues present in the 2014 products. In spite of that, some issues still remained, e.g., issues related to gameplay and mechanics inconsistencies or unclear functionalities. Such issues may well be due to the limited cognitive maturity of children in the considered age range. For this reason, the expert should take specific care of the remaining issues for a future GaCoCo study, for instance, feedback should be focussed on such issues.

**G2.1 AND G2.2: ACHIEVEMENT EMOTIONS AND ENGAGEMENT.** In relation to **G2.1** and **G2.2**, the 2015 study results are in line with the 2014 study results, albeit with some differences. Also in 2015, the whole GaCoCo activity engaged children, and their engagement changed in time. Positive emotions of enjoyment and relaxation were significantly higher in intensity compared to negative emotions of anxiety and boredom. Like in 2014, also in 2015 enjoyment and relaxation decreased in intensity, whereas anxiety increased when children conceptualized their game ideas, possibly due to the complexity of this challenge. Thereby, when professionals conduct game design with children, they should take into account that game design stages which are more abstract in nature, such as the game idea conceptualization, can be cognitively taxing over children, creating anxiety states. Children who are 7–11 years old are in a concrete operational stage (Piaget, 1952) and hence they may not be able to think abstractly or hypothetically, but they can apply logic to physical objects and concrete examples. How-

*MH: giving concrete examples or forms for abstract game design stage, e.g., conceptualization of the game idea—instruction on how to pass from the game storyline to a game idea by showing examples from existing video games.*

ever, in 2014, enjoyment decreased and anxiety decreased towards the end of the study. This is not the case in the 2015 study, in which enjoyment intensity is significantly above average and tends to significantly increase towards the end of the study.

**G3: ACHIEVEMENT EMOTIONS AND QUALITY OF PRODUCTS.** With respect to (G3), results of the 2015 study confirm those of the 2014 study: quality of products was positively related to enjoyment and negatively related to boredom, with a sort of expectation effect created by emotions on future performances of children.

#### GaCoCo 2015 Study: Success and Failures

The 2015 study results shed light on what worked (successes) and what still requires adjustments (failures). Successes and failures are analyzed in the following, first across missions, and then mission by mission.

**ACROSS MISSIONS.** In line with MH-P1 resulting from the 2014 study, the 2015 study split the training to game design across missions. At the start of a mission, the game design expert always did the training necessary for the mission. Engagement observations reported that children showed high engagement during the training by expert: children were interested and interacted with expert asking questions and clarifications.

**FIRST MISSION.** In line with engagement results of studies of 2014 and 2015, the first mission has to create mutual trust, making children feel relaxed, in general activating positive emotions, and should enable children to practice working in group, creating their group identities. Moreover, results of the 2015 study, which had a brainstorming activity at the class level in the first mission, suggests that class brainstorming is important for promoting children's engagement and for involving the entire class in designing a class game in subsequent missions.

**SECOND MISSION.** In the second mission of 2015, each group of children first created a group storyline using stimulus cards created by them, and then those stories were used for creating a final class game storyline. The latter was more engaging for children and should be repeated in future studies. Moreover, it is worth noting that creating a class storyline may have brought benefits in terms of quality of products (see Section 6.4.1).

*MH: training by expert on game design focusing on concrete examples for more abstract concepts, e.g., game idea from a storyline.*

*MH: allowing children a self-confidence in using probes and tackling the challenge — giving to them a tool/objects with an immediate effect for ensuring their scaffolding.*

*MH: providing brainstorming sessions for eliciting children ideas on specific subjects.*

*MH: creating storylines using an engaging strategy for designing a class game.*

*MH: setting the payer interaction mode — a third person perspective with an avatar interaction model, e.g., the main character of the storyline.*

**THIRD MISSION.** In line with results of the second mission, also the creation of the player done at the class level was perceived as highly engaging. Therefore cooperative learning work in group and then at the class level should be maintained in future studies also for creating the game player. Moreover, M<sub>3</sub> also demanded children to conceptualize their game idea starting from the game storyline, a challenge which seems to have been cognitively too complex, confirming results of the 2014 study. To overcome that, future game design studies may: (1) give children gamified concrete objects or more examples, specific for assisting children in moving from the storyline to the creation of their game design ideas; (2) alternate the conceptualization work with feedback moments, and feedback should come both from the expert and peers, e.g., through sharing preliminary game ideas at the class level.

*MH: creating sub-levels of the storyline with the expert so as to facilitate the game idea for each game level.*

*MH: a single game level per group — a class game composed by several game level designed by groups.*

*MH: giving specific roles for designing the game level within a group, e.g. one member manages static setting, another the dynamic characters.*

**FOURTH MISSION.** During the fourth mission, each group prototyped their single game level, considering its mechanics, e.g. rules, points. Realizing one game level allowed children to spend more time on it, which may have contributed to keep anxiety intensity low, contrary to what happened in the 2014 study, when groups had to work on two game levels. However, group members did not always succeed in equally distributing work. In line with with results of the 2014 study (MH-G<sub>4</sub>), also in the 2015 study, children became more engaged in group work when they were explicitly assigned tasks for group work.

**FIFTH MISSION.** In both the 2014 and 2015 studies, children play tested the interaction with their game in the last mission, presenting their prototypes to the class. That is an important step that helps children in further explaining their design decisions, and reflecting specifically on the functionalities of game design elements. Moreover, presentations of games allows game design expert to further understand how children expect to interact with their game, because interaction is otherwise difficult to explain in paper format (such as the low-fidelity prototypes and the game design documents).

# 7 | GUIDELINES

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## 7.1 TOWARDS GUIDELINES FOR PARTICIPATORY GAME DESIGN

Driven by the analysis of the literature, inquiries with experts, and the experience cumulated through field studies, this section collects a set of guidelines for organizing, planning and executing participatory design studies with primary-school children, with a focus on game design.

These guidelines are a re-elaborated version of the “must-have” recommendations (i.e., those written as MH) resulting from the GaCoCo experiences in 2014 and 2015. Recommendations were presented respectively in Chapters 4 and 6.

Specifically, in 2014 we highlighted those fundamental aspects that a designer should take into account when designing games with children.

Then, the 2015 design activity was improved by considering the lessons learned in the 2014 study and what was listed as MH's. In particular, MH's were used in 2015 to explain the novel design choices of the 2015 study. A further set of MH's was extracted from the 2015 experience.

## GUIDELINES

The guidelines, presented in this chapter, are a collection of all the components for conducting participatory game design with primary school children. They were created through a thematic analysis of the MH's conducted by three design experts, who worked first independently and then discussed the emerged categories together.

The five main categories are: (1) research method; (2) how to organize a design activity; (3) game design tasks; (4) game design material; (5) what to track in a design activity; and (6) participants' roles during the design activity. Figure 38 summarizes the contents of the categories, and specifies the roles of adults involved during a participatory game design experience with children.

In the remainder of this chapter, we report each category with the related guidelines.

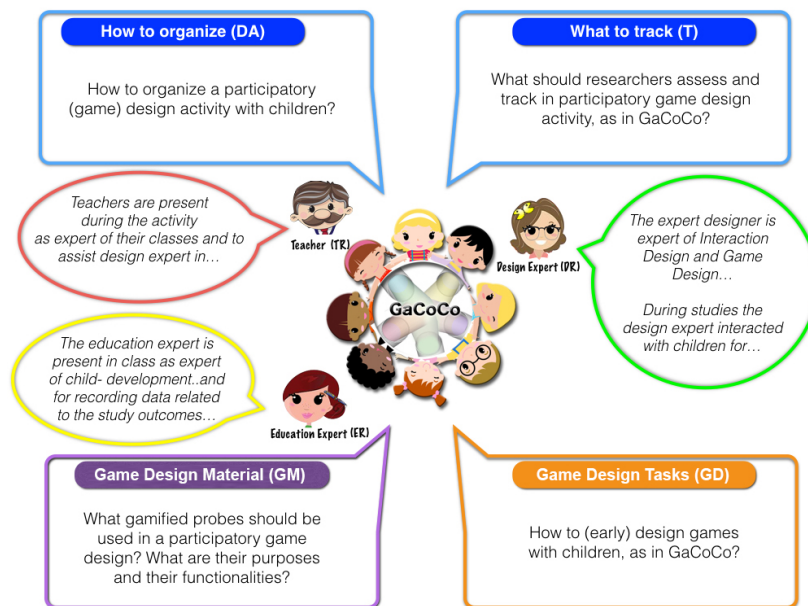


Figure 38: Representation of the guidelines categories and the participants involved in a participatory game design, as in GacoCo

## 7.2 RESEARCH METHOD

As reported in Chapter 3, knowledge in participatory methods is co-constructed through practice: it is context bound, and it belongs to different sorts. As a consequence, a participatory game design, should use a **mixed-method research approach** to assess its outcomes (see Section 3), as done in the GaCoCo studies reported in this thesis. Specifically, in those studies, quantitative data were collected and analyzed;

qualitative data were then used to explain quantitative findings. The related general guideline is as follows:

- (RM-1)** A participatory (game) design should follow a mixed-method research approach: quantitative and qualitative data should be collected in order to assess outcomes of the activity.

### 7.3 HOW TO ORGANIZE A DESIGN ACTIVITY

The following guidelines focus on how a designer should organize a participatory game design activity with children so as to empower children, and to enable their cooperation.

- (DA-1)** Brainstorming sessions should be organized in the ideation stage, for eliciting children's ideas.
- (DA-2)** The design activity should be split into progressive missions with progressive challenges in order to empower children.
- (DA-3)** Each mission or challenge should be organized with its own clear goal, and such goal should be valuable for participants.
- (DA-4)** Each challenge should have a specific design task—ideation task, conceptualization task or prototyping task.
- (DA-5)** Each mission should be differentiated as much as possible w.r.t. other missions, for improving children's engagement over time.
- (DA-6)** Missions should interleave challenges with conceptualization or ideation tasks with challenges with prototyping tasks, so as to require and train different skills, thereby fostering the participation of all children and the growth of alternative design ideas.
- (DA-7)** Each mission should start with a recap of previous work, so as to orientate children in the design activity, creating links across missions and promoting coherence in design products.
- (DA-8)** The first mission should be easy to take up by all, so to create a positive relaxing atmosphere, to promote mutual trust and engagement in the activity, and to allow designers to train children to the design work.
- (DA-9)** The design activity should provide multiple feedback opportunities, from domain experts and from peers, mainly through scaffolding dialogues at the end of challenges/design tasks— formative feedback during missions; summative feedback across missions.

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- (DA-10)** The design activity should include cooperative learning strategies for individual work, for pair, group, or for class work, within the design protocol, e.g. subgroup work (pair work), so as to engage more those members that otherwise would be less engaged or isolated.
- (DA-11)** When design activity is split into missions over different work-days, and hence it is fragmented in time, gamified probes can be designed so as to visibly and tangibly sustain children's engagement and, specifically, to: convey a sense of progression across missions and challenges and help in orienting children in the design activity or tasks; support relatedness needs in group and cooperation; sustain a sense of control over their design work.

## 7.4 GAME DESIGN TASKS

These guidelines are concerned with specific details and tasks on how to design games with children.

- (GD-1)** Game design training should be given at each mission, explaining the mission goal and using concrete examples, clear and already familiar for children.
- (GD-2)** In the first missions, children can ideate and conceptualize the game storyline and use it to conceptualize their game design ideas. If game design takes place at school, the story can be related to a school topic.
- (GD-3)** When game design is carried on cooperatively at school, each group should be assigned just a single game level, and the class should prototype an entire class game by using a common story as storyline.
- (GD-4)** The conceptualization of the game idea requires specific scaffolding by the game design expert, as the game-idea conceptualization seems to be a cognitively demanding task at least for 8–11 olds.
- (GD-5)** Each game level should correspond to a specific episode in the game storyline, and children should elaborate on the episode before ideating their game level.
- (GD-6)** Designers should assign specific game design roles to group members, and such roles should rotate across missions, e.g., one member manages the static setting, another the dynamic characters.



- (GD-7)** When design is carried on with primary schools, designers should establish an interaction model for game (e.g., avatar based) and the form factor, posture and input methods (e.g., small games for tablet).

## 7.5 GAME DESIGN MATERIAL

These guidelines focus on material, namely gamified probes and generative toolkits, to be used in participatory game design with children.

### 7.5.1 Gamified Probes

The guidelines explain the usage of the gamified probes and its main functionalities.

- (GM-1)** Designers should train children to the usage of gamified probes.
- (GM-2)** Gamified probes for children should be affordable for them, each should have its own clear functionality, yet it should be open to different usages, even unforeseen by designers.
- (GM-3)** Gamified probes can be enhanced with technology, e.g., micro-electronics, so as to interact with children, and to enhance their engagement in the design activity, as well as to track relevant interaction data.
- (GM-4)** Gamified probes should tangibly convey and support cooperative learning roles, rules and strategies.
- (GM-5)** Gamified probes should convey a tangible sense of progression across missions and challenges.
- (GM-6)** Progression maps or leaderboards should convey a sense of progression and control by enabling way-finding across missions and challenges.
- (GM-7)** Symbolic rewards, for conveying a sense of progression and control, should be customizable, contingent and perceived valuable for children's design work, e.g., rewards might be objects useful for customizing design prototypes.
- (GM-8)** A specific gamified probe should allow children to ask for help from the design expert, when they feel in need of him/her, so as to give children the feeling of being socially related to him/her throughout the activity, and not being left on their own.

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### 7.5.2 Game Design Generative Toolkits

The guidelines explain the usage of the generative toolkits and its main purposes.

- (GM-9)** Generative toolkits and tools should be distinguished per mission goal and challenges/tasks, and designed so as to be usable by the involved children; e.g., it should be designed by game design experts and education experts and revised with teachers/adults familiar with the participant children.
- (GM-10)** Generative toolkits should allow children to easily prototype their game (e.g. using reference frames for the device under consideration), and prototype material that children are familiar with, or that allows immediate use for prototyping.
- (GM-11)** Game design documents should be provided as forms to fill in for children, using a language for scaffolding children's ideas and a visual layout adequate to their age and skills—using examples from popular video games.
- (GM-12)** Children should have different opportunities to share, at the class level, their early game design results, in the form of high-level concept documents, core mechanics documents or prototypes, so as to evaluate them and improve on them through peer feedback.
- (GM-13)** The game design documents should be divided into smaller units (e.g., game idea, game mechanics, game aesthetics), each one cast as a form usable for the participant children.
- (GM-14)** Game design should use stimulus cards (e.g., the lenses of [Schell \(2008\)](#)) for stimulating children's ideation or reflections over specific game elements.

## 7.6 WHAT TO TRACK IN A DESIGN ACTIVITY

The following guidelines focus on what should be assessed and tracked in participatory game design, and why.

- (TA-1)** Children's engagement, and their experience with the material used for designing (e.g., gamified probes), should be tracked during the activity.
- (TA-2)** Children's emotional engagement should be tracked in relation to key challenges or missions, given its relations with performances of children.

- (TA-3)** Children's performance should be assessed during each mission and across missions, so as to track the progression of children's work over time.

## 7.7 PARTICIPANTS' ROLES DURING THE DESIGN ACTIVITY

The following participants, besides children, should be present in participatory game design: (1) a designer, expert of the considered design domain; (2) an education expert, skilled in child-development, and (3) teachers. This section inspects the main roles and tasks of those adults.

### 7.7.1 Design Expert's Role

- (DR-1)** Designers should provide formative design feedback during mission, and summative feedback across missions.
- (DR-2)** Designers should provide more feedback in design stages which are being critical for children.
- (DR-3)** Designers should train teachers into the design activity prior to its execution with children; this would allow teachers to be involved as active researchers, to manage the activity according to their role, and it would allow the expert to assist teachers during critical design missions.

### 7.7.2 Teachers' Role

- (TR-1)** In order to create balanced cooperative groups, teachers should form small groups of 3–5 children, heterogeneous in terms of social and learning skills; this task is very important because the teacher is the expert of the class.
- (TR-2)** In order to use cooperative learning effectively in their class, teachers should assign cooperative learning roles to group members, and rotate roles across missions, according to children's skills and to missions.
- (TR-3)** Teachers should illustrate the organisation and material to be used according to the protocol for each mission.
- (TR-4)** Teachers should assist the design expert in the communication with children to scaffold group work.

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### 7.7.3 Education Expert's Role

- (ER-1)** The education expert should be present during the whole activity in class, possibly acting as passive observer.
- (ER-2)** The education expert should gather data according to the activity goals. In particular, he/she should record data (e.g., by taking notes) on class behavior and interaction with design material, as well as children's engagement during the activity itself.
- (ER-3)** The education expert should maintain a constant dialogue with teachers and the design expert, concerning class behavior and children's well being.
- (ER-4)** The education expert should assist the teachers during group formation, so as to create groups respecting children's relationships and social and learning skills.

# 8

## CONCLUSIONS

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This chapter draws conclusions on the research reported in this thesis. Firstly, Section 8.1 recaps the research and its whole process. Secondly, Section 8.2 details the answers to the research questions posed in Chapter 1. Thirdly, Section 8.3 outlines the major contributions of my research. Finally, in Sections 8.4 and 8.5, the limitations and the future directions are presented.

### 8.1 SUMMARY OF THE RESEARCH

The research reported in this thesis revolves around participatory game design with children. As discussed in Chapter 2, participatory game design poses several challenges. The main challenges and research questions investigated in this thesis are related to: (1) **democratic collaboration** in design groups, which is threatened by the difficulty of managing social relations and, especially, of balancing power structures in participatory work with children; (2) **children's empowerment as learning and engagement**, which are challenging to achieve if the design activity is fragmented over extended periods of time or is cognitively demanding for children, thus hampering the promotion of focused attention on tasks and their enjoyment; (3) **adults' learning**

of children's ideas through the participatory game design activity and its products.

Challenges emerged through an analysis of the literature and through inquiries with experts. In particular, the analysis of the education literature and education experts' feedback highlighted relevant theories for tackling such challenges, reported in Section 2.6.

Starting from the analysis, Chapter 3 presented a **PD method for designing games with primary-school children: GaCoCo**. This chapter analyzed GaCoCo through five lenses, explaining its pillars and positioning it in the overviewed literature: epistemology; values; stakeholders and their roles; outcomes, tangible and not; game lifecycle. GaCoCo epistemology relies on cooperative learning and gamification of learning, taking from them its views on **collaboration, engagement and learning**. In GaCoCo, children's engagement, learning and collaboration are in fact key values, treated as outcomes to measure. In addition, stakeholders of GaCoCo have two different types of expertise: one is the design expert, skilled in interaction design and game design; the other is the expert of child-development. The design expert conducts evaluations of children's products, so that design and evaluation are interleaved in the GaCoCo lifecycle.

The method itself was tested and refined through **field studies** in different learning contexts, specifically, in **diverse primary schools**. These contexts include the presence of other stakeholders, namely, class teachers. Chapters 4 and 6 reported the two main GaCoCo studies, executed in 2014 and 2015, for designing **low-fidelity game prototypes** with and for children in primary schools. The values of engagement, learning and collaboration were assessed throughout the field studies. Results concerning collaboration, learning and engagement were positive.

The experience cumulated through field studies as well as the analysis of the literature and experts' feedback were distilled into a set of **guidelines** for organizing, planning and executing participatory game design studies with primary-school children.

## 8.2 ANSWERS TO RESEARCH QUESTIONS

The research reported in this thesis considered the aforementioned challenges and the associated research questions, listed in Chapter 1: **(RQ.1)** how to include all learners' game design ideas, that is, how to foster democratic **collaboration** among children and with adults, so that all children "have a voice" in the design process; **(RQ.2)** how to empower children in terms of **engagement** in participatory game

design; **(RQ.3)** how to empower children in terms of **learning**, e.g., of early game design; **(RQ.4)** how to empower **designers** in terms of **learning** of children's game design ideas.

The thesis devised a method, namely GaCoCo, reported in Chapter 3, for tackling those questions, and tested it in the field with empirical studies.

In relation to the first research question (RQ.1), GaCoCo mainly relies on cooperative learning to promote collaboration and inclusion of all children's ideas. Specifically, GaCoCo used specific strategies, rules and roles of cooperative learning; these are supported in GaCoCo via tangible gamified probes. GaCoCo studies indicate which cooperative learning rules, roles and strategies were used in participatory game design and promoted collaboration. In particular, children with low-levels of engagement participated more when working in pairs with pair-work strategies. Participation increased also when members within a group were assigned a precise design task. Tangible gamified probes allowed to observe their usage in relation to collaboration. For instance, it was observed that the use of tangible gamified probes for specific rules (e.g., taking turns) helped in supporting concretely the rules, and promoting collaboration.

In relation to the second research question (RQ.2), different cooperative learning roles, and gamified probes to make them tangible were used to increase children's engagement, by giving each child the feeling that his or her contribution is as important as the other children's contribution. More generally, GaCoCo uses gamification to organize design tasks as missions of a game, with clear and valuable goals, so as to sustain: (1) a sense of progression, achieved by progressive missions and challenges built one upon the others, and made tangible through gamified probes (e.g., progression map); (2) a sense of control and autonomy, by using completion contingent rewards useful for customizing children's design products; (3) relatedness, sustained by using gamified probes for enabling connection and interaction among children.

Results of the 2014 and 2015 studies reported in the thesis confirmed the overall engagement of children: their positive activating emotions were generally higher in intensity than their negative deactivating emotions; high levels of interest, concentration and enjoyment were observed by the education expert.

However, in both 2014 and 2015, children's anxiety grew when children were asked to conceptualize their game ideas, which may be due to the intrinsic complexity of this task. A difference was also noted between the 2014 and 2015 studies: whereas enjoyment decreased towards the end of the design activity in 2014, enjoyment remained sig-

*RQ.1: how to foster democratic collaboration among children and adults*

*RQ.2: how to engage children in participatory game design*

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nificantly above average and it even increased towards the end of the activity in 2015. That may be due to a different organization of design sessions in 2015, which, in particular, reserved longer times for formative feedback. In 2015, groups worked towards a common goal, that is prototyping a class game, to which each group contributed by designing one level. In 2014 each group worked on their own game, composed of two levels. It is also interesting to observe that intensity of relaxation was significantly higher in the first design sessions, confirming the role that GaCoCo envisions for them, that is, creating a relaxed atmosphere for building mutual trust. Moreover, when children worked strategies at class level, engagement was always high for all. This result confirmed the fact the working with a common goal fosters not only collaboration but also engagement within groups.

*RQ.3: how to  
empower children  
in terms of learning*

In relation to the third research question (RQ.3), in line with GaCoCo, learning of early game design was supported by progressive design challenges, which built one upon the other, and were made “tangible” via ad-hoc gamified probes. Moreover, learning was also supported through multiple feedback opportunities for children, as recommended by GaCoCo: from peers, with cooperative learning for sustaining discussions and sharing ideas; from domain experts, with rapid feedback conducted through scaffolding dialogues during design sessions, and with feedback on missions’ products, resulting from the summative evaluation conducted in between missions.

In fact, the 2014 and 2015 studies showed that the quality of products (game design documents and prototypes) tended to improve over time, suggesting that children were learning by doing early design together. Such results, of an exploratory nature, are positive for the GaCoCo method, which recommends that design should empower its participants. It is interesting to notice that quality of products, as assessed by experts, was also correlated to children’s achievement emotions, assessed via a questionnaire for children. Such results confirm and extend previous findings in the education literature, which considered the role of achievement emotions for traditional activities in learning domains (Pekrun and Perry, 2014). More importantly, they provide professionals with indications for conducting a participatory (game) design experience with children when the activity is prolonged in time, and is related to key emotions to be monitored in relation to quality of products, by tracing their evolution across design sessions.

*RQ.4: how to  
empower adults*

As for empowerment of adults, GaCoCo relies on the presence of different adult stakeholders for planning and executing studies. In particular, the design expert must be always present during a participatory game design. In line with GaCoCo, the empowerment of the designer means empowering her with knowledge of children’s ideas and expect-



tations. The design expert learns by interacting with children: scaffolding each design group through formative feedback during missions, and summative feedback across missions.

Moreover, it is important that the design expert learns how to “read” children’s game design ideas, so that children’s design products, i.e., games, can be developed. Specifically, after the 2014 study, children’s products (i.e., a game with two level, per each group) were carried a step forward in the game lifecycle: they were actually developed by adults programmers, not previously involved in participatory game design sessions with children. In such cases, the role of the design expert becomes important for carrying over the ideas of children. The related experience was reported in Chapter 5.

In particular, computer-science university students took children’s game design products, released at the end of the 2014 study, and then developed children’s products into interactive game prototypes. Issues that students found in developing games were tracked and categorized. According to the conducted analyses, children’s products were considered to be in general clear but were not always sufficient as “early design specifications” for university students, mostly due to incompleteness or unclear functionalities of gameplay and mechanics elements designed by children. This result indicated that the game design expert, present during participatory game design sessions, should be also present during the initial development of children’s early game design products: he or she should explain or resolve what is unclear in children’s products to game developers, based on the scaffolding dialogues she conducted with children during design sessions, and on her domain expertise.

### 8.3 RESEARCH CONTRIBUTIONS

The specific results of the research of this thesis are:

- the method for conducting participatory game design studies in learning contexts, so as to tackle the aforementioned challenges emerged from the analysis of the participatory game design literature;
- replicable protocols for organizing, executing and assessing participatory game design with children, with an emphasis on the assessment of the experience; in fact, according to our literature review, the evaluation of the experience tends to be a weak point in several game design studies with children, e.g., engagement

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tends to be only qualitatively assessed and not quantitatively evaluated;

- a collection of modular guidelines for the early design of interactive products with children, in particular, early game design products, which game design practitioners can easily pick up and adapt to their needs.

Each contribution is described in the remainder of this section.

### 8.3.1 The GaCoCo Method

GaCoCo was developed as an intermediate theory, where field studies are used to propose relationships between constructs from different research areas, as explained in details in Chapter 1. In such a manner, field studies allowed us to move GaCoCo one step further towards becoming a mature theory. The ideas upon which the method is based are analyzed in Chapter 3, thereby clarifying what can vary across GaCoCo activities and what on the other hand would represent fundamental aspects of GaCoCo, in particular: its epistemology and values, and its measurable outcomes, tangible or not.

**Epistemology and values.** Children's empowerment, as well as democratic collaboration, are key values of GaCoCo. In order to promote them, its epistemology integrates cooperative learning and gamification of learning within PD and game design. As far as we know, this is the first time that such research areas are brought together. Specifically, GaCoCo uses gamification and gamified probes to promote engagement by creating a sense of progression, control and satisfying relatedness needs.

GaCoCo also recommends that children learn of interaction design through the design process. In such a manner, GaCoCo fosters computer science education<sup>1</sup>. GaCoCo is a problem-solving process that includes several skills (Stephenson and Barr, 2011): from the most obvious of creativity, ability to explain and team work, to the more specific ones, such as analyzing and logically organizing data; data abstractions and simulations; identifying, testing, and implementing possible solutions. These are those skills that are promoted through computational thinking, a problem solving activity "involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent" (Wing, 2006). However, GaCoCo is not a specific instance of computational thinking in that it does not consider a relevant char-

<sup>1</sup> Note that interaction design has been recently included in the new release of CS Unplugged activities for teaching computer science, without computers (Bell et al., 2015).

acteristic of computational thinking, namely automating design solutions through algorithmic thinking.

**Outcomes.** GaCoCo treats the aforementioned values as outcomes, and therefore GaCoCo researchers have to assess them. GaCoCo studies use a mixed-method research approach to assess their outcomes, gathering and analyzing quantitative and qualitative data. A mixed-method approach with triangulation allows us to increase validity of findings, and to generate greater understanding of the mechanisms underlying quantitative results, in field studies such as these, where not all factors are controllable.

GaCoCo studies of 2014 and 2015 showed positive results in terms of their outcomes. GaCoCo can thus be adopted by professionals and researchers in PD with children, so as to foster adults' learning of children's ideas, to promote collaboration and to engage children through learning of early game design. To the best of our knowledge, children's learning via co-design has been rarely systematically investigated, e.g., see (Holbert et al., 2014). Moreover, according to (Hamari et al., 2016), most studies concerning gamification or game based learning, fall into two categories. The first category investigated the relationship between game design features and learning directly, without measuring mediating factors such as emotions. The second category investigated the relationship between game design features and psychological factors, without extending the measurement to further learning outcomes. The empirical study by (Hamari et al., 2016) is an exception, in that it showed how engagement in game-based learning had positive effects on learners' perceived learning. The studies reported in this thesis investigated the correlation among emotions and an expert-based assessment of learning, considering children's products and their evolution in time.

### 8.3.2 Protocols for Replicating Studies

Game design protocols are reported in Chapters 4 and 6 in relation to the 2014 and 2015 studies. Protocols can be used by professionals and researchers for conducting participatory game design with children, using cooperative learning and gamified probes.

In fact, protocols are presented in a uniform manner using a recurring structure, which specifies: (1) specific roles and rules for all participants, adults or children, and their level of expertise; (2) for each session, its design material and tasks; (3) for each session, its gamified probes, how to use them, and cooperative learning strategies; (4) for each session, its outcomes and how to assess them. In such a manner,

protocols can be used and adapted according to researchers' or professionals' needs, considering the aforementioned dimensions.

Protocols are meant for repeated-measure studies, fragmented across weeks of work. However, parts of the protocols can be re-used in short-term design activities. For instance, children may only design the game storyline using the related part of the protocol of the 2015 study. Other children may then be involved in continuing the game design starting from the storyline as prescribed in the same protocol.

### 8.3.3 A Set of Guidelines

The insight derived from direct field research with GaCoCo allowed us to gain a deeper understanding of how to conduct PD with children, and how to conduct early game design activities with children. The acquired knowledge was used as a starting point for the development of the guidelines reported in Chapter 7.

Guidelines are more general in scope than the method and the study protocols. They were compiled for assisting researchers and professionals in conducting participatory game design with children, with a specific focus on learning contexts. Guidelines inspect five main categories: (1) the research method to adopt when researchers aim to use participatory design with children; (2) how to organize a participatory design activity, and (3) what researchers should track during it; (4) the roles of adults involved, such as the design expert, education expert, and teachers in case the activity is at school; (5) gamified probes, such as objects and tools for the activity, and (6) game design recommendations and specific tasks for early prototyping games with children. The categories from 1 to 5 were related to a general participatory design activity using cooperative learning and gamification contributions as in GaCoCo. The last category instead is more focused, and it is related to early game design only.

Therefore professionals or researchers in PD or in game design can differently read and use the guidelines. For instance, PD researchers or professionals, interested in interaction design but not in game design, will find useful indications in the guidelines for conducting PD activities using cooperative learning and gamified probes. Professionals or researchers of game design can find useful information concerning how to design games with children, e.g., with or without cooperative learning, with or without gamified probes.

## 8.4 RESEARCH LIMITATIONS

### 8.4.1 The GaCoCo Method

GaCoCo is a participatory game design method, for the early design of games with groups of children. The method is context bound, conducted through field studies, and hence it suffers from limitations typical of context-bound research (Frauenberger et al., 2015).

**The Role of Experts.** Firstly, it requires researchers with specialized skills. GaCoCo and the studies reported in the thesis envisage the presence of two researchers: one expert of interaction design and game design; another who is expert of child development and is trained to qualitative research. The presence of two researchers might influence and affect both the conduct and the outcomes of participatory game design with children. However, the participation of researchers in field studies allows them to gather important insights concerning the context.

With the scaffolding support of the design expert, in GaCoCo studies of 2014 and 2015, children released game design documents and prototypes, some of which were developed in 2014 by university students. When design decisions by children were unclear or incoherent for developers, the game design expert acted as mediator. On the one hand, the studies suggest that the same design expert working with children should also be working with developers to pass on relevant information which is missing or unclear in children's products. On the other hand, the double role of the design expert may create biases in results.

**Generalizing and Extending GaCoCo.** The studies reported in the thesis were conducted in different primary schools. However the same game design expert was present in each school. Moreover, studies allowed for correlational analyses only. Further studies are therefore needed, e.g., with larger samples or control groups, to determine causality relationships, e.g., concerning the influence of gamification on engagement. Extending the studies to other schools, involving other teachers as well as new design experts, will also allow to transfer the approach used in the thesis to further contexts.

### 8.4.2 Protocols

**Game Types.** A limitation of the studies is concerned with the types of games children can design using the protocols of the GaCoCo studies. With the exploratory studies of 2013 and through an analysis of the literature (see Chapter 1), we aimed at understanding what game

design tasks we could assign to children working in groups: in 2013, we focused on what game genres and elements emerged frequently in children's products (Melonio, 2013; Dodero et al., 2014b). Such knowledge served to create the protocols of the studies reported in the thesis, which ask children to work on third-person action-adventure games.

On one hand, the study protocols fixed the "forms" that games can take in terms of storylines, characters and levels but, on the other hand, protocols gave children an adequate structure to work within. Moreover, the studies reported in the thesis were conducted within schools and therefore the game design activity had to be framed within a learning activity. Firstly, starting from stories allows teachers and researchers to frame game design as a continuation of a school traditional activity, which is centered around a story. Secondly, children are familiar with narratives, and hence using a story as starting point may increase children's confidence and engagement in the game design activity itself; as claimed in Tan et al. (2011), elaborating a storytelling component for a game is stimulating and it is often a fascinating topic for children.

**Evaluation.** Other limitations of the studies reported in this thesis are concerned with the evaluation of the quality of children's products.

The evaluation approached children's products as "adult's work" so as to carry on an authentic assessment, as done in the education literature when children's (design) tasks resemble adult's work (Meyer, 1992). Children's game design products were assessed with expert reviews, based on game heuristics by (Desurvire et al., 2004). Specifically, the studies in this thesis traced how the quality of children's products evolved in time, according to adult game design experts, who assessed products along the following lines: What playability issues emerged in products? Did products improve in time, with respect to issues?

Two design experts, both with knowledge of interaction design and game design, classified products against issues. Inter-rater agreement was computed. Generally game design experts agreed on evaluating products by children against issues. The most debated issue among game designers was the consistency of game design documents: one of the experts was not agreeing on it being an issue in an iterative incremental game design process.

In spite of that, the evaluation of children's game design products was exploratory and limited in scope. The main problem was the lack of adequate game design heuristics. Firstly, Desurvire et al.'s heuristics were compiled using interactive games developed by adults, which limits their applicability to the game design products of this thesis, which were developed by children. Secondly, as highlighted in (Desurvire and Wiberg, 2009), contemporary successful games have

been recently developed (e.g., Kentucky Route Zero ([Carboard Computer, 2014](#))) that would not have been rated excellent using the heuristics by ([Desurvire et al., 2004](#)). Had the studies in this thesis used such heuristics as heuristics evaluation, then the evaluation concerning the quality of children's products would have a very limited generality. Such limitations indicate routes for future work concerning guidelines for expert reviews of early game design products, in general, and of children's game design products, in particular, possibly starting from the issues emerged in this thesis.

Moreover, due to resource limitations and time constraints, the number of design experts assessing children's products was limited to just two in the 2014 and 2015 studies. That may have hampered the uncovering of less frequent issues, e.g., ([Sauro and Lewis, 2012](#)).

**Qualitative Data.** The education expert used diaries and videos for behavior observations with target behaviors related to engagement so as to allow for the emergence of unforeseen categories. Diaries and videos gave a large amount of data to analyze, and their subsequent thematic analysis was long and difficult. Future studies, on the other hand, will build on the studies' observations, considering the emerged categories of behaviors relevant for a GaCoCo experience.

Observations with one observer and videos were limited to visible behaviors. Important information passing verbally through groups may not have been noticed, except when groups explicitly asked the expert to validate design choices. If verbal information is important for a design experience with children, the one observer employed by our studies may be insufficient, and additional observation means, such as positioning a video camera per group, will have to be considered.

## 8.5 ONGOING RESEARCH STEMMING FROM THIS THESIS

The research contributions of the thesis generated also new research directions, which we briefly discuss in the following.

### 8.5.1 Replicating GaCoCo

**Different Subjects.** The studies in the thesis inserted game design within two traditional learning activities: one concerning literature; the other concerning science. Future work might adopt GaCoCo and our guidelines in other learning activities within primary schools, e.g., concerning history. That should be facilitated by the fact that both GaCoCo

studies started from a storyline, and their protocols can be adapted easily to different subjects.

**Different Contexts.** Furthermore GaCoCo could be used in other contexts than the Italian school contexts, the only one explored in this thesis.

**Children with Special Needs.** The work reported in the thesis included children with special needs, one of whom was deaf; protocols were adapted to their needs with the help of their teachers, support teachers, and the child development expert. The literature of participatory design for children with special needs was also investigated, see Chapter 2. Starting from the experience thus acquired, we are specializing GaCoCo and its guidelines for working with deaf children. To this end, we are also using the guidelines for designing games for children published in (Di Mascio et al., 2013), as well as the results of a study conducted at the Rochester Institute of Technology, USA, under the supervision of Professor Marc Marschark, during a research visit.

#### 8.5.2 Gamified Experience

In the PhD work of this thesis, we chose to design and assess the experience of participants over the technology or the material used in the experience. As reported in (Soegaard and , Eds.), studies show that experiential choices (i.e., the acquisition of an event to live through, such as a design journey) make people happier than material choices of the same value. However the study results indicated how future research might design non-invasive technology solutions for engaging children in a cooperative learning process, and specifically, for supporting a sense of progression and control over the process, as well as their cooperation.

**Gamified Probes for Cooperation.** The thesis studies designed and partly assessed (through observations only) gamified probes for engaging children. Some probes were designed for supporting specific rules of cooperative learning in groups, interacting synchronously—face-to-face, in-presence, same time. (DiMicco et al., 2007) investigated the impact of different visualizations of participation for sustaining post-task reflections in synchronous interactions in group: visualizations were projected on large screens according to participants' speaking times. However, to the best of our knowledge, there are no technology enhanced solutions, not mediated by screens, for synchronous cooperative learning processes, based on gamification. A possible research direction is then concerned with the design and assessment of gamified technology-enhanced probes for supporting cooperation in synchronous interactions.



**Gamified Probes for Progression and Control.** Other gamified solutions could be designed for supporting participants' sense of progression and control, as well as tracking relevant data for assessing progression and control. The gamified solutions might be designed considering the study results reported in this thesis concerning progression maps, the shop and their rewards.



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