Towards Tangible Gamified Co-Design at School *(Preprint)*

Two Studies in Primary Schools

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ABSTRACT
Co-design is an ideal approach to design with users. It allows designers to create products, such as games, with their intended users and in their natural environment, e.g., children and their teachers in their school. Nowadays school contexts, however, pose their own requirements to co-design, which can affect its success. For instance, school contexts tend to be associated to boring rote by learners, who are used to interactive digital games. Gamification can then help in creating a positive engaging experience for school classes that co-design, as games do. This paper takes up such a view: it gamifies co-design contexts in order to positively engage school classes. To this end it presents two studies with gamified co-design in primary schools: heterogeneous teams co-designed prototypes by resolving missions as in a game, in the first short-term study; they did it in an even more gamified context, in the second long-term study. Results of both studies are encouraging for the approach. The paper also advances basic guidelines for tangibly gamifying co-design at school, grounded in the studies and literature.

Author Keywords
Game design; co-design; gamification; empirical studies; performance; engagement; children; schools

ACM Classification Keywords
H.4 Human-centred computing: Interaction design Interaction design process and methods

INTRODUCTION
Co-design, in the sense of [**?**], is a general approach to design that extends several others and can be used in any stage of the design process by designers and non-designers for "collectively creating". When designing products for children such as games, co-design with children becomes the ideal companion to *user experience* (UX) design [**?**]: with co-design methods and techniques, children and teachers become members of design teams in their own environment, that is, in their school. Nowadays schools pose their own challenges, listed in [**?**]. At school, educators face heterogeneous classes, having children with diverse learning styles and social skills. Moreover children are exposed to interactive products and environments [**?**, **?**], in particular games. As Prensky states, "unlike previous generations of students, who grew up without games, [these generations] know what real engagement feels like" and, at school, "they know exactly what is missing" [**?**]. Positively engaging all children at school is thus becoming increasingly difficult, and can be determinant for the success of (co-)design in such a setting. Given that, we propose to gamify co-design contexts for positively engaging children at school as in a game.

For studying the viability of the approach, the authors of this paper ran several pilot studies, and then three main studies with gamified co-design at school. This paper reports two out of these three studies, run in two primary schools: one at the start of 2013; the other at the start of 2014. The main goal of this paper is to outline results from the first study, and how they affected the design of the second study. The latter study shows a more tangible gamification of the co-design context, namely, of both the environment and tasks for co-designing.

The paper starts presenting the strictly necessary background on co-design with children; a comprehensive survey of methods and techniques for co-designing with children is [**?**]. The essentials of gamification are also presented. Then the paper speculates on how one can gamify co-design with children at school, leveraging on the literature and the authors' first-hand experience. The authors' two main studies in primary schools are then presented, and general results of the studies are highlighted in the conclusions.

BACKGROUND

Co-design with Children in a Nutshell
Sanders and Stappers characterised co-design as an approach that extends several others, such as participatory design and co-creation, and aims at involving stakeholders as collaborative designers [**?**]. When stakeholders are children, specific methods are used. *Cooperative inquiry* is among the best known co-design methods with techniques for children, and that collaborative teams of adults and children can use throughout the design process [**?**, **?**, **?**, **?**]. Examples are sticky noting, for offering design suggestions on existing artifacts, and layered elaboration, for expanding on others' ideas

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by layering transparent sheets over others, without affecting the original sheets and ideas.

In this view of co-design, team members are involved in the design process on equal footing, albeit they have diverse roles: users become co-designers as "experts of their experience"; researchers become facilitators to ease users' expression of creativity; designers, expert of the product under design, will bring in their professional experience. When co-design studies take place at school, the latter two roles are often merged, and teachers can also be members of the co-design team, mainly as experts of education and of school context. See [**?**, **?**].

Co-design at school, albeit not new, has received increasing attention in recent years [**?**, **?**]. However, co-design in current formal learning contexts, such as schools, presents several challenges [**?**]. In particular, the work of Garzotto and others stresses that co-design tasks at school should be engaging, possibly fun, for children [**?**]. However, *how to design tasks and environments that positively engage* wide and diverse groups of nowadays' learners, who are used to engaging interactive products, and often equate school with boring rote? We unveil our proposal in the following section.

Gamification in a Nutshell

Designers can create games moving from game mechanics to game aesthetics [**?**]. At the core of the mechanics is the view of a game as a transition system [**?**]: a game needs a *goal*, an *initial state* and *terminal* states, intermediate states with *challenges* to overcome, and a set of *actions* of players that allow them to move from state to state, according to the game rules. Other game elements are [**?**]: *competition* or *cooperation* elements; *reward* structures with juicy *feedback*; game *missions* whereby players progress from one mission to the next one(s) as they move toward the termination of the game; *story lines*, providing context to the game. All such game elements are experienced by the player by means of the game aesthetics, that is, how the game "looks, sounds, smells, tastes and feels" [**?**].

Game design, from mechanics to aesthetics, is behind the broad area of gamification. In its most common acceptation, gamification means properly using game-based elements, such as those listed above, for a non-game goal and in a non-game context in order to positively engage people, e.g., see [**?**]. Participants are then regarded as players.

Diverse motivation theories are invoked to explain why gamification can positively engage players [**?**]. In particular, this paper follows researchers that base their work on *self determination theory* (SDT) [**?**]: in brief, a gamification that nourishes a sense of competence, control and autonomy, as well as social relatedness can lead to a positive engaging experience, e.g., an experience of enjoyment and deep concentration. The literature reviews of Hamari et al. and Kapp show that, depending on the context and types of players, gamification provides players with positive experiences for engagement, at least in the short term, and possible negative effects such as increased competition [**?**, **?**].

GAMIFICATION OF CO-DESIGN AT SCHOOL

If one wishes to apply gamification to co-design contexts, firstly one should design and present co-design tasks as missions of a game, one building upon the other, with a goal valuable for all co-designers. The relevance of the adult designer that is expert of the co-designed product should fade though missions.

The design of each mission for schools also requires to think of learners as players. According to Lazzaro classification, there are four main player profiles: hard-fun players who go for challenges and strategy-based play, easy-fun ones who love intrigue and curiosity, altered-state ones who play for escaping from their world, and people-factor ones who use games for social experiences [**?**]. However school classes tend to be highly heterogeneous, which means designing missions for all player profiles, or for teams that group children with different player profiles.

By referring to SDT, independently of their profile, all children should experience a sense of progression through missions, so as to feel more and more competent. To this end, according to their complexity, missions can be chunked into small progressive challenges, disclosed when needed with clear rules, of which the first challenge should be easy to take up by all learners. Growing avatars, progression maps or completion rewards, which are contingent to co-design, help in conveying the idea of growth through missions and challenges. Rewards can be tangible or not. For instance, tangible rewards are (fake) coins that are earned on completion of co-design challenges or missions. An example non-tangible reward is positive oral feedback in case of errors.

Positive failure feedback is also important for enhancing a sense of control; to the point that game designers invest considerable time in creating failure feedback that is immediate, fun, spectacular so as to make players "more optimistic about [their] odds of success" [**?**]. To this end, the adult designer should congratulate learners every time they try out hard and fail a difficult challenge, and help them with rapid constructive feedback on demand. His or her role can be made clear and visible, for instance, via expert-cards, which children can spend whenever they feel in need of the adult designer's help.

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, as prescribed by SDT. A simple example is a context that allows children to choose different co-design challenges from a map. An even simpler example is as follows: on completion of a mission or challenge, children are invited to choose one among different completion rewards, which they may also customize or seek in the environment, and to use the reward for their next co-design challenge or mission. In this manner they gain the feeling that their actions have a tangible effect on their co-design work, and that they are in control of choosing parts of this.

Relatedness needs are also important components of games according to SDT. Gamification of co-design contexts, however, should be done fostering cooperation, so as to be faithful

to the co-design partnership principle, e.g., rewards should not increase competition within groups. Such a constraint can be met by providing rewards that mildly favor only inter-group competition so as to promote "intra-group positive interdependence" and cooperation [**?**], and still satisfy relatedness needs.

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 co-design challenge, and are available for sharing their co-design experience and acquired expertise.

THE FIRST STUDY

Goals

Our 2013 study was run in primary schools. Classes read aloud and discussed a story with their teacher. Then they were asked to develop a game for applying what they had read about in the story[1], e.g., story setting or characters. This study aimed at using gamified co-design for producing low-fidelity prototypes of such games.

The study inspected several UX goals. Hereby we focus on the following two: (g1) children's performances with co-design missions; (g2) children's engagement in relation to gamified co-design. As typical in measuring UX, performance as in (g1) can be used to estimate children's behaviour with gamified co-design—if it allows them to produce prototypes. Instead, engagement as in (g2) can be used to estimate children's perception of gamified co-design. See [**?**].

Participants and Roles

The study was conducted with four primary-school classes: two of younger learners, 8–9 year old; two of older learners, 10–11 year old. In total, we involved 56 learners, 4 teachers, and 4 designers.

Roles of participants were as follows. Children were the main game prototype designers. Their work was organised for either small groups of 4 or for individuals, or for the entire class. Designers were experts of the product under design: among them, one was more experienced in child development studies, whereas the others were more experienced in digital game development. They were one per group of learners in this study. Each designer took care of illustrating the organisation of work, coaching and scaffolding proper development in their group (e.g., to resolve possible doubts, assist learners in case of serious risks of failure) by providing rapid but non-intrusive feedback. Teachers took care of composing small groups and reporting group composition by using a pre-defined group form, conducting the story reading and their comprehension interventions in class, and stimulating conversation in class when required by designers.

Study Design and Execution

The study was organised as an empirical one along 3 main activities: pre-activity, main activity, post-activity.

[1]The term "application" is used in the sense of Bloom taxonomy [**?**].

Pre-activity: Training

During the pre-activity, designers organised a meeting with the school dean and interested teachers in each school. Therein, the study design was explained and discussed. A week before the main activity, a training session for all teachers was organised, specifying the role of each co-design team member. During the latter meeting, teachers were asked to choose a child story for creating games, and to fill in the group form. This mainly served to create balanced and heterogeneous groups of learners in terms of their learning and social styles.

Main Activity: Prototyping

Missions. The main activity took four sessions, one per school class, with always 4 designers and a teacher per class. Each session was split in 3 missions with predefined timings, lasting c. 2 hours and a half also due to school constraints. In the first mission teacher and learners read and discussed the chosen story in class, under teacher guidance. The second and third missions required to work in groups, that were organised with cooperative learning methods [**?**]. In the second mission, groups of 4 children worked for co-designing a game prototype. See Figure **??**. Each group prototype was discussed with the class in the third and final mission, and then displayed as in a gallery tour, see [**?**] and Figure **??**. Figure **??** shows two game prototypes, one by a group of younger children and the other by a group of older ones.

Rapid feedback. Rapid feedback was mainly verbal across missions. In the first mission, it was the teacher feedback for their class. In the second, it was the designer feedback for their group and peer feedback within the group. In the third mission, feedback was of the class for each group.

Rules and challenges. Each mission came with its own rules and progressive challenges. Challenges were linearly organised, each building on the previous one, so that each had to be completed before moving to the subsequent one. The second mission challenges required diverse skills. For instance, its first challenge required groups of children to discuss and negotiate the so-called game idea [**?**] in relation to the assigned goal. Verbal skills were then those mainly elicited. When realising the game scenario on paper in the second challenge, visual-motor skills were those mainly activated.

Cooperation, competition and rewards. At the end of the first mission and before children were divided into small groups for the second mission, teachers made it clear that groups would be competing against each other in creating game prototypes: the group best collaborating according to designers and teachers, and realising the best game according to other learners would see a valuable reward: their prototype implemented as a 'real' game for tablets, to play with. However children were also told that the work of each group would receive a reward: their presentation of how to play with their game prototype was video-recorded in the third mission, and made available online to all school participants.

Post-activity: Debriefing

In the post-activity, debriefing interviews were run by teachers with the help of designers. Moreover, children were sub-

Figure 1. Work in groups of 4 children for prototyping

Figure 2. Game prototypes: the top by younger children, the bottom by older children

sequently questioned in class by their teachers to report their interest and enjoyment for the study experience.

Figure 3. Gallery tour during the third mission

Material and Environment

The study material included: a TERENCE [**?**] child story; envelopes; paper bins; A2, A3, A4 paper sheets; post-it paper sheets; pencils and markers; story characters and elements; scissors and glue. Co-design was in classroom which was big and full of light. Tables were arranged in groups of 4 for the study, with sufficient distance between groups and allowing every member of the group to easily grab the study material from a central table. The organisation of tables was thought so as to promote face-to-face work and avoid distractions.

Data Collection and Results

A mixed-method approach was used for gathering data: data were collected with quantitative and qualitative methods. For the main activity (prototyping), we employed triangulation as much as possible for quality reasons [**?**]. During it, data were collected by designers using a pre-defined common protocol and form. Each group of children was video-recorded. Transcribed data and videos were jointly revised by designers in meetings, then discussed and revised with teachers. In brief, the main activity had multiple data sources, investigators and collection methods.

This section presents the main data analysis results, relevant for this paper, and related to the study goals—performance and engagement—besides issues with our gamified co-design.

Performance

We assessed groups' performances by tracking their success in establishing game elements. We distinguished game elements that children were explicitly required from those that children spontaneously produced. Required game elements are those necessary in every game, e.g., in order to distinguish games from drawings: rules with player moves and challenges; termination conditions; feedback; scenario, that is, where the gameplay takes place.

For each group, success per required element is equal to: 1 if the group established the element in time, under the guidance of their designer, who did not produce the element on behalf of the group; 0 otherwise. For each group, success for an emerged element is equal to: 1 if the group by themselves established the element; 0 otherwise.

For each element, we computed the proportions of groups producing it and related 90% *confidence intervals*[2] (CI's) with the Adjusted Wald method [**?**].

All groups managed to produce all required elements, with CI$[0.88, 1]$. Additional game elements spontaneously emerged. In particular, .81 of groups layered their game into levels, with $SD = 0.4$ and CI$[0.6, 0.92]$; .12 of groups created a storyline, with $SD = 0.34$ and CI$[0.03, 0.32]$. Results are rather homogeneous across age groups.

From such results, it seems that children would tend to create diverse levels for games; the majority of levels were of progressive difficulty whereas some levels were totally independent from one other. The absence of a storyline could be due to the fact that game prototypes were designed starting from a given story.

Engagement

Engagement was mainly assessed through observations of designers during the main activity (prototyping) and interviews to children during the post-activity (debriefing). In line with [**?**], engagement is the culmination of: concentration;

[2] A CI for a sample statistics gives an estimated range of values which is likely to include the unknown population parameter. Were this procedure to be repeated with future groups of learners, the calculated CI would encompass the true population parameter 90% of times.

interest; enjoyment. In this sense, results of our study were generally positive, e.g., all classes showed to have enjoyed co-designing: except one, all asked designers to do the experience again and again,"every week".

Other Issues

Several issues emerged with the 2013 gamified co-design. Post-activity (debriefing) interviews highlighted that the majority of children felt highly constrained in expressing their ideas by timings in mission challenges, which children perceived as too short. The most difficult challenge to start for children was the drafting of the so-called game idea [**?**].

Such findings are also confirmed by designers' notes taken during the main activity (prototyping), according to whom: children required no more designers' help for starting the subsequent challenges, still designers were necessary for maintaining consistency of group choices across mission challenges; children felt too often in a hurry to complete their missions and complained about it.

Discussion

The reported study assessed that the gamified study was generally effective in terms of: (1) performances of groups of children in designing their prototype elements, by tracing which elements children successfully designed within the given timings; (2) children's engagement, by reporting their concentration, interest and enjoyment.

Specifically, performance results show that gamified co-design can be effectively used at school by working groups of 4 children coached by a designer. Engagement results are mainly due to observations. Therefore, even if we tried minimising biases as best as possible, caution should be used with these results. That said, they are mostly positive.

Moreover several issues emerged that gave indications for future editions of gamified co-design. For instance, the role of designers required refinement. Designers were necessary for their groups of children mainly for maintaining the consistency of their product design choices across missions and for starting the drafting of the "game idea".

Most importantly, the majority of children perceived mission challenges as too short, and so did teachers. In other words, even if the co-design study was generally effective for producing game prototypes and children felt engaged, the quality experience of children could be be improved so as to allow them to fully express their ideas, as independently as possible from designers.

THE SECOND STUDY

According to the 2013 study results, the co-design of game prototypes should take longer to allow children to better express their ideas. Therefore the new study protocol had to be planned for running on different days with other children, and be even more integrated within school activities, thereby bringing benefits related to learning as well as experiential school objectives. Maintaining participants' engagement became even more important and difficult.

In order to engage children, we moved the yardstick of gamification of co-design contexts a step further. We gamified the co-design protocol even more, with more missions and challenges, each with its own game-like material for co-designing. We also added something totally new: the gamification of classrooms, enriched with low-cost game-like tangible material, which classes could easily pick up, imitate or adapt for their future needs. Explaining how we did is the focus of this section.

Goals

The second study was run in 2014 in primary schools. Also the 2014 study aimed at using gamified co-design for producing low-fidelity game prototypes, starting from another story for children. See Figure **??**. However, the 2014 study tried to make gamification more tangible so as to engage children in a long-term co-design activity, spread across different days. One of the goals of the second study, which we focus on in this paper, became to study the behaviour and engagement of children with the gamified material. More precisely, the goal became to assess whether (g) children grabbed the intended usage of the gamified material for co-designing (behaviour), and they were interested in it or enjoyed it (engagement). In the remainder, we give the essential information about study participants, material and environment, in relation to the reported UX goal.

Participants and Roles

The study was conducted with two primary-school classes: one of younger learners, 8–9 year old, and one of older learners, 9–10 year old. In total, the study involved 36 learners, 2 teachers and 2 support teachers, and 2 expert designers.

Roles of participants were as follows. As in the 2013 study, children were the main game prototype designers, mainly working in groups of 3–5 members, for a total of 9 groups. Within groups, roles in co-design were assigned by teachers and for each mission, e.g., of secretary or silence-keeper. Such roles rotated among group members so as to ensure that all children had a chance to play different roles and, hence, to use diverse cognitive and social kills.

In contrast to the previous study, teachers had a more prominent role: assisted by expert designers, teachers took care of illustrating the organisation of missions and related challenges, of supervising that children could progress in time through challenges, of coaching and scaffolding group work by using specific cooperative learning techniques.

Designers were two, with two different roles: one of game designer, who followed each group providing non-intrusive feedback and assisting each groups, when required, on their prototype development; the other, more experienced of child development studies, acted as passive observer, referred to as observer below.

Study Design and Execution

The study was organised as an empirical one along 3 main activities, like the 2013 study. Pre-activity training was different than in 2013. A workshop for teachers, lasting circa 6 hours, was organised and a more focussed training was thus

Figure 4. A game prototype developed in the second study

performed. For instance, during the workshop, the protocol of each mission was explained by expert designers, and so were the main ideas of gamification and game design. Teachers worked in group and experimented the protocol for children by co-designing games themselves. Also children were trained to game design principles. This training lasted circa 20 minutes.

The main difference between 2013 and 2014 was anyhow in the main activity for prototyping. This was by far longer, more structured, and in a tangibly gamified context (see the below subsection). The main activity consisted of 6 missions, of which the last was run in the university premises, whereas all the others were run in classroom.

Each mission lasted circa 2 hours and a half. Missions were organised linearly with progressive challenges. Challenges followed a recurring pattern, albeit each had different surprise rewards, its own objective, its specific co-design material, rules and feedback.

As in 2013, the last activity mainly consisted of a conclusive debriefing, with feedback from teachers and children.

Material and Environment

This part is concerned with the main activity for prototyping. During all missions except the last one, children worked in their classrooms. At the start of a mission, each group arranged classroom tables in groups of 4 as in the 2013 study. Each group had jute baskets for storing the different objects of each mission on their tables. Other gamified material for co-designing was arranged in classroom. See Figure **??**.

Figure 5. Gamified objects in a classroom

In particular, three A0 posters were used in the gamified co-design at school. One was a paper-version of a progression bar, on display in classroom during all missions. Another showed a country land, with spots for trees growing in relation to the growth of the groups' game prototypes. This is referred to as the tree map, and was on display in classroom across all missions as well. The third was a frame, one per group, for assembling parts of game prototypes. This was used only in the last mission at school, the fifth one. From the second mission onwards, a wood shop with objects to buy, resembling an automated one, was positioned in a specific location of the classroom, referred to as shopping point. Across all missions at school, children had also a signalling disk for expressing their opinions. Details of such material are described in the following.

Progression bar (Figure **??**). Each group had their place card, with their group logo printed on, to move across challenges of the progression bar, hung on the classroom wall. Each challenge in the bar had a tangible reward in the form of a removable coin, made of wood. When a group grabbed their coin, on completion of a challenge, they found a positive feedback behind it. Those coins work as completion-contingent rewards, that is, a group could earn a coin only after completing a challenge.

Tree map (Figure **??**). In the progression bar, the end of each mission was represented with a door hiding special rewards, that is, parts of a tree in the form of stickers. Children had to use these in the tree map for assembling their tree, showing that they progressed in the completion of their game prototype. Each group had their dedicated portion of land on which to stick their portion of tree. Firstly each group had to plant the seed into the soil, secondly to water the seed and then to grow their tree, piece by piece across missions.

Shop (Figure **??**). At the end of each mission, groups could use their coins, found in the progression bar. Coins served to buy objects for the prototypes they were co-designing. Groups had to move to the shopping point, where they found the wood fabric shop with 20 jute pockets, containing objects

Figure 6. A screenshot of the progression bar: each group of children has its own row; each row shows challenges as coloured disks, grouped in missions

for prototyping. Groups could buy objects of their daily mission by inserting their coin into the shop fissure. The objects on sell were 20, including a special card for the "help of the expert card". This card gave each group the right to ask the game designer for extra-help concerning their prototype.

Prototype frame (Figure **??**). The last two missions were centred around a presentation of the co-designed prototypes. For their presentation, each group had a frame: an A0 poster with coloured shapes in which to insert pieces or information about their paper-based prototype, in a structured guided manner.

Signalling disks (Figure **??**). In group challenges, at specific moment, each group member had to vote on proposals made by other group members by using his/her signalling disk, carved in wood. Using chalk, children drew smileys or wrote their feedback, positive or not, on their signalling disks in relation to the voting task.

Data Collection and Results

Again, a mixed-method approach was used for gathering data, taking care of triangulating as much as meaningful, like in the first study. In particular, the observer observed groups, coding their behaviour and engagement with challenges and mission material. The teacher feedback concerning behaviour and engagement was also sought with interviews after each mission. Moreover, each child self-reported their engagement in each mission by using a standardised questionnaire for children, see [**?**]. At the end of each mission, class feedback was also orally elicited at different levels, e.g., concerning " today's most beautiful challenge".

Hereby we focus on the first available results concerning the behaviour and engagement of children with the gamified material, focusing on their interest and enjoyment. Such results mainly come from the observer's notes, and from teachers' feedback.

Signalling disk (Figure **??**). One of the elements that had the greatest success was the signalling disk for voting. Children were enthusiastic about this item, immediately showed the desire to use and re-use it, to draw and erase their opinion. They also tried voting with it even when they were not supposed to, satisfying their desire to use it but showing to do it in a creative and functional manner. Other times children were reproached for using it exceedingly by their teacher, which suggested that this risked to become too pervasive an object.

Shop (Figure **??**). After the signalling disk, the object that received major interest was the shop for buying components for their game design. We observed smiling faces lightening up at the sight of the shop, and interest in observing the different objects on display in the shop. We also noted that, whereas in the first missions children were more interested in buying an item for its aesthetic value, while they were advancing through missions they bought items more and more relevant and useful to the design of their game.

Expert-help card. It is also worth reporting observations concerning the expert-help card, which children could buy at the

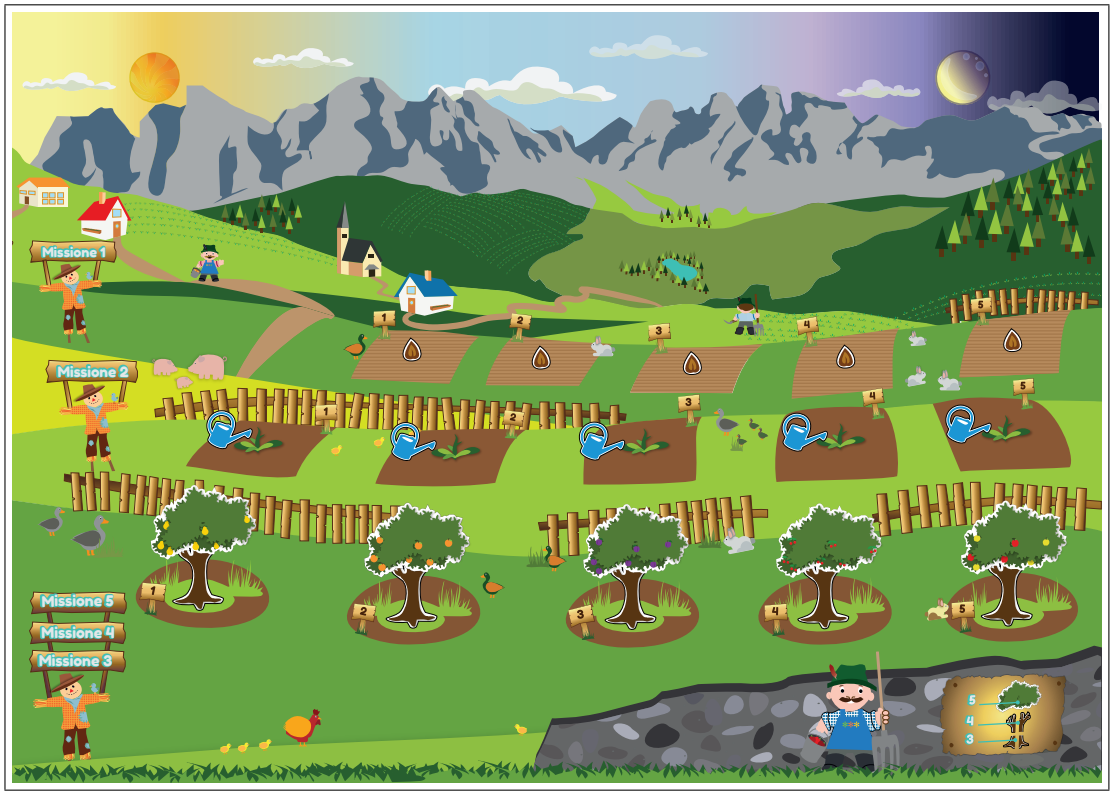

Figure 7. The tree map with trees, showing that each group had grown their own game prototype idea

shop. Groups behaved differently with respect to this item, albeit the majority of them bought and used it in each mission.

Progression bar and coins (Figure **??**). As for the progression bar, following the study protocol, teachers used it upon starting a mission in a twofold manner: to recap what children had done in previous missions; to give an overview of the structure of the mission about to start. Children immediately grabbed how to use this item, looking at it when they needed to figure out how many challenges were missing and how much time they still had to complete their current challenge. Also, every time they 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"—and the child wished to have his coin as soon as possible.

Tree map (Figure **??**). At the end of each mission, each group was eager to stick their portion of their tree on the tree map. However, after the first two missions in which they had shown surprise and interest for the piece hidden in the progression bar, their curiosity dropped: they had figured out that rewards hidden in the bar would be the subsequent pieces of the tree. In the last mission, instead, children were pleased to have completed their tree, and joyfully discovered that each group's tree had its own foliage, different than the others. Being in a hurry to complete the tree puzzle before the others, not every group bothered to wait for the green light of the expert and, in a lively and joyful manner, rushed for sticking their foliage on the tree map, discussing their achievements along the way.

Discussion

The first study was concerned with a short term co-design, of circa 2 hours per class. The second study was designed by leveraging on the results of the first study, and with 6 co-design missions, each of circa 2 hours and a half, split across different days. The classroom was also gamified with tangible objects typical of games. According to the preliminary results, children showed to enjoy and be interested in such objects, and could grab their intended usage for co-designing. In particular, children showed a preference for signalling-disks, which allowed them to express their opinions by drawing their own smileys, and the shop, which allowed them to buy objects for enriching their game prototype aesthetics.

Further analyses are on-going, also concerning the evaluation of the produced game prototypes.

CONCLUSIONS

Co-design is an ideal approach to designing with users. When moved in nowadays school, it faces school-dependent challenges [**?**]. One of them is how to promote positive engagement for co-designing products. This paper presents gamified

Figure 9. Signalling disk usage

Figure 8. The shop in the classroom for buying objects for game prototypes or the expert help

co-design as a viable solution for engaging school classes and producing products together. It does so via two studies in primary schools with gamified co-design: one run in 2013 as a short term study; one run in 2014 as a long term study.

Results of the first study show the viability of the approach as follows: all children managed to produce prototypes and were generally engaged with short term gamified co-design. However, children complained that short timings made them feel under pressure, constraining their ability to fully express themselves.

The second study picked up the challenge of allowing children to better express their ideas, and spread gamified co-design missions across several days. Engagement in such a long term fragmented co-design was more challenging to achieve, therefore gamification was moved one step further: tasks and environment were tangibly gamified with material for co-designing at school.

This paper ends by presenting preliminary results in relation to the behaviour and engagement of children with such material, showing that they grabbed the intended usage of the material and tended to enjoy it for co-designing.

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