Designing Interactive Outdoor Games for Children

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Abstract Mobile outdoor games for groups of children have emerged recently as a credible technological proposition and as an area of research and development that promises substantial benefits for children regarding a more active lifestyle and the development of social skills. This chapter examines specifically the design of Head Up Games, which are outdoor games that support embodied interaction and where players are collocated, e.g., in a playground, alley, park; the traditional loci of children's play over centuries. Designing such games and the emerging gaming experience presents its own set of challenges, such as designing the interaction of a group, ensuring pace in the game, and fairness for different contexts and groups of players. Not least, the added value of enhancing outdoor play and games with technology needs to be ensured. We describe some of the lessons learned from the design of a few of these games, how different design methods may contribute to the design process, and methodological issues concerning the early design, the prototyping, and the evaluation of these games.

Keywords Games for change · Serious games · Sustainability · Behavior change · Procedural rhetoric · Emergent dialogue · Persuasion · Design framework · Design guidelines

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1 Introduction

Advances in technology are contributing to the increasing portability and ubiquity of mobile devices. As a consequence, interesting venues are opening up for outdoor, social gaming, supported by interactive technology—an area that is of growing interest to the research community. Our particular research interest is in Head Up Games (Soute et al. 2009b): interactive, outdoor games for children that resemble play behavior of "traditional" outdoor games (such as tag and hide-and-seek), i.e., games that are played collocated, encourage physical activity, and support social interaction. The concept of Head Up Games stems from the observation that outdoor pervasive games for children (e.g., Savannah (Benford et al. 2005); Ambient Wood (Rogers et al. 2004)) heavily rely on screen interaction. As a consequence, children are playing these games "head down" and we argue that this interferes with how children naturally play outdoors: running around, while engaging in rich face-to-face social interaction. Therefore, we proposed the concept of Head Up Games—to emphasize that these games are played with the players' heads up, and we aim to include technology to support, instead of interfere, with play behaviors as seen in traditional outdoor games.

Over the last few years we have designed several of such games and in this chapter we will reflect on the lessons learned regarding the design process of these games.

A generally accepted design process in HCI is the User Centered Design (UCD) process. This process advocates the involvement of users in all stages of the design process to ensure that the end product is valuable in terms of usage and experience for the user. Typical of a UCD process is that it is *iterative*, i.e., the product is iteratively created, tested, improved, and refined. It generally starts with a user requirements phase, in which users are interviewed or observed to gather requirements. Initial concepts are typically generated in brainstorm sessions. Next, a low-fidelity version, e.g., a paper prototype, of the intended design is created, which is evaluated with users. Results of such an evaluation are fed back into the design process, the concept is improved, and the process of creating and evaluating a new prototype is repeated. Typically, each cycle sees an improvement of the fidelity of the prototype, meaning that each time it increases in resemblance to the intended end product.

The literature in the field of (computer) Game Design advocates a similar approach: to adopt an iterative design process and to playtest often and early (Salen and Zimmerman 2003; Fullerton et al. 2004; Lundgren 2008). In this process, in contrast to the UCD process, game designers appear to be less concerned with involving their end users in all stages of the process; there is less emphasis on getting to know the user and gathering users' requirements. Instead, the concept generation phase is mostly attributed to the game designer, relying on his/her experience in this field. However, Game Design literature does emphasize the importance of iteratively designing the game, in combination with play-testing: as Salen and Zimmerman (2003) put it: "the act of play becomes the act of design." The general opinion is that the resulting play experience of a game cannot be predicted at the 'drawing'-table. A game designer designs the rules and mechanics of a game, but the resulting game experience is ultimately generated by playing that game (Costikyan 2002). As such, to be able to properly judge the game design, the game *must* be played. The design process proposed is to rapidly prototype a playable version of the game, starting with low-fi paper prototypes and increasing fidelity in subsequent iterations.

Our experiences in designing Head Up Games have generated insights into the design process of these games and how existing methods can, or cannot, be deployed in this process. We will discuss the value of a brainstorming session within the context of game design. Furthermore, we discuss several lessons learned from involving children, and also adults, in the process. Finally, and arguably the most significant lesson learned, we offer insights into the use of prototypes in the design process, more specifically regarding the fidelity of these prototypes.[1] We argue that to properly design for and judge the added value of novel interaction styles in Head Up Games, designers need to create working, interactive prototypes, in early stages of the design process, so that users can truly experience the gameplay.

In the next sections, all lessons will be described and illustrated with experiences we gained during the design of several Head Up Games.

2 Lesson 1: Idea Generation

A game design process typically starts with an idea generation phase. Inspiration can come from anywhere, at anytime, and there are many methods and tools available for kick starting the designers' creativity. One widely known method is brainstorming, either alone or in a team. Though issues have been identified that can reduce the effectiveness of brainstorming (Stroebe et al. 2010), when prepared well, a brainstorm session can definitely assist in generating concepts; Rossiter and Lilien (1994) provide a set of general principles for conducting successful brainstorm sessions. More specifically for gaming, Fullerton et al. (2004) give pointers for brainstorming (computer) games. In related work, many research projects in game design mention some form of brainstorming, e.g., (Kern et al. 2006; Valk et al. 2012).

Below we describe two brainstorm sessions that were held during the development of a Head Up Game because they illustrate possible benefits and challenges when brainstorming for these types of games. For the setup of the brainstorms we

[1] The notion of prototype fidelity was introduced by Virzi (1989) as a measure of how authentic or realistic a prototype appears to the user when it is compared to the actual service. Paper mock-ups of an interactive system are a typical low-fidelity prototype that allows a user to experience a simulated interaction and to help identify areas of improvement. The notion of fidelity was enriched in later years (McCurdy et al. 2006) to distinguish between different dimensions along which prototypes may seek achieve higher or lower realism of the intended design intent, namely visual refinement, breadth of functionality, depth (detail) of functionality, richness of interactivity, and richness of data model.

followed the principles of Rossiter and Lilien (1994), which are: (a) brainstorming instructions are essential and should emphasize, paradoxically, number and not quality of ideas; (b) a specific and challenging target should be set for the number of ideas; (c) individuals, not groups, should generate the initial ideas; (d) groups should subsequently join and refine the ideas; (e) individuals should provide the final ratings to select the best ideas, which will increase commitment to the ideas selected; and, (f) the time required for successful brainstorming should be kept remarkably short.

2.1 First Brainstorm Session

In the first brainstorm session eight designers participated, with backgrounds ranging from industrial design to game design. The session was organized as follows: first, as the participants did not know each other, we played a few games to familiarize them with each other. As the participants were not familiar with the concept of Head Up Games, we introduced it to them. We asked the participants to individually think about the games they liked to play in their childhood. Next, the participants were divided in three groups and we asked them to discuss their childhood games and identify elements of these games that added to the appeal of the games. We then asked them to create a new outdoor game for children. The participants should at least provide details on how the game could be won, though more details, like specific game rules, how many players, where to play, etc., were also encouraged. For inspiration we provided them with a set of commercially available board and card games; the participants could use these, or any other game that they knew themselves, as inspiration. At the end of the brainstorm session each group presented their final game concept and each participant picked out his or her favorite concept.

The results from this brainstorm were game concepts on paper; most of them included elements of tag, hide-and-seek, capture the flag, or a combination of these. Furthermore, what we concluded from the game concepts generated in this brainstorm is that many games seemed to be fun already, even without technology. This insight prompted us to conduct a second brainstorm session, but change the setup; with the change we hoped to generate concepts that would more meaningfully include technology in the game.

2.2 Second Brainstorm Session

The setup of the second brainstorm session was similar to the first brainstorm session. However, instead of asking the participants to use childhood memories or existing games as inspiration, we gave them several possible technologies for outdoor games as inspiration. Based on earlier experiences designing Head Up Games we compiled a list of technologies that we deemed appropriate for outdoor use. They were: RFID, distance detection, accelerometer, and a rotation encoder. All participants of this workshop were industrial design students, who where familiar with these types of technology and also with participating in idea generation sessions.

The second brainstorm session we started, similar to the first brainstorm session, by giving the participants an individual task: all participants were seated around a round table, and in the middle of the table a set of papers was placed. Each paper was marked with one of the technologies. We asked the participants to randomly pick a paper from the table, quickly jot down a game idea on that paper, and put the paper back. These game concepts need not be very elaborate or detailed. Next they could take a new paper and repeat the process. If the paper already contained an idea of one of the other participants, the participant could either start a new idea, or add to the idea already on the paper. After approximately half an hour many ideas had been generated this way.

Next, we grouped the participants in pairs of two. We provided them with two of the papers with ideas from the previous exercise and asked them to discuss and take inspiration from the strongest ideas to create a new, detailed concept of a game. This exercise took around 10 min, next we regrouped the participants and provided them again with two of the papers of the previous session and repeated the process. Afterwards, the game concepts were presented, discussed, and rated.

2.3 Reflecting on Idea Generation

The brainstorm sessions rapidly generated many ideas and concepts. However, we observed that in the first session some of the ideas appeared fun enough by themselves, without needing to add technology. This is not really surprising, as we did not explicitly ask participants to consider technology. In the second session we did ask participants to take technology into account in their game design. It turned out that in this case some of the ideas suffered from a "technology push," in that the games would have been fun when taking the technology out and replacing it by a nontechnical counterpart. We conclude from this that it is difficult to meaningfully include technology in game designs and we attribute this to the fact that the participants had never experienced such a novel form of outdoor play before.

Furthermore, we observed that ideas generated in the brainstorms were very extensive with regard to the number of rules and details. From a game design perspective this is undesirable; from our experiences creating Head Up Games we know that games typically do not benefit from having many rules. However, from a brainstorm perspective it is a good outcome: apparently the context of the brainstorm sessions allowed the designers to continuously create and expand on concepts. We need to keep in mind that concepts are not games yet; they serve as inspiration for designers. In that process, the observation that participants too easily add rules to game concepts is important to acknowledge and take into account when further developing concepts into games.

3 Lesson 2: Involving Children Early in the Design Process

The User Centered Design (UCD) process focuses on the user's wants and needs for interactive technology. To gather the user's requirements in an early phase of the design process, many methods are available: for example, user surveys (questionnaires, interviews) or observations can be conducted. The role of the user in these methods is more or less passive, in that he or she only reacts to what the designer proposes. A more active participation of children in the design process is proposed by Druin (1999): the Cooperative Inquiry methodology is a set of techniques that put children in the role of co-researchers or co-designers. Scaife et al. (1997) put forward the notion of *Informant Design*. Although in this framework children are not seen as co-designers, they are acknowledged as valuable participants who contribute to the design process: children and adults can work together in design activities to generate input for the various stages of the design process.

For eliciting children's requirements we have mostly involved children as informants; here we describe three methods we have applied in various projects designing Head Up Games.

3.1 Mission from Mars

Dindler et al. (2005) developed the method "Mission from Mars" to gather user requirements specifically for the design of children's technology. The method aims to create a shared narrative space that allows researchers to get insights into the user requirements in an informal, fun setting for the children. First, the narrative is established: children are introduced to the story of a "Martian" who is eager to learn more about a specific subject; the Martian is ignorant on this subject because it is nonexisting on Mars. Naturally, this subject is chosen such that it generates useful information for the researchers. As the Martian thinks that children on Earth are more knowledgeable on the subject, the Martian wishes to have contact to discuss and learn from them. Second, supported by the researchers, the children prepare for the encounter with the Martian. Finally, the children have the encounter with the Martian: a setup is installed, where the children can hear the Martian only, though the Martian can both see and hear the children, so that they can show what they have prepared. Practically, this means that the children are facing a video camera during the encounter; the children talk to a video camera and get feedback from the Martian through a set of speakers (see Fig. 1). That signal is forwarded to the room of the Martian, where the researcher acting as the Martian can respond to the children. The voice of the Martian is distorted, to make him sound more "believable."

The main reason for engaging in such an elaborate setup is to place children in the *expert* position, in which they feel free to share many details. The setting

Fig. 1 The Mission from Mars setup. *Left* the interview room for the children. *Right* the room with equipment for the Martian

allows the researcher to ask 'stupid' questions about details that would have been impossible to ask in a conventional setting. For example, during the development of *Camelot* (Verhaegh et al. 2006), the Martian asked the children what a ball was, to which the children gave a serious and elaborate answer. In a post hoc interview one of the children mentioned that in a conventional interview setting she would not have provided this level of detail, because she assumed adults to know what a ball is.

Dindler et al. (2005) used the method to gather insights for the creation of 'eBag', an electronic school bag. They applied the method with children 10–11 years. During the development of *Camelot* we applied Mission from Mars to obtain information on what games children prefer to play. We applied the method with children aged 7–9. Similar to Dindler et al. we concluded that indeed a significant amount of information is gathered using this method. Furthermore, Dindler et al. reflected on the credibility of the Martian narrative. Some of the children did not believe the story about the Martian to be true; however, this did not have an effect on the outcome of the study because the children played along anyway. In contrast, we observed that children from a younger age group did believe the narrative, and though the majority of the children enjoyed participating and communicating with the Martian, some of the children were quite anxious about meeting the Martian. This indicates that one needs to consider for what age group this method is appropriate: for younger children the method could arguably be too intimidating or at least to design the whole method to be more reassuring and comfortable for children, e.g., making contact with a more comforting or familiar character like an animation film hero.

3.2 Collage Making: A Creative Exercise

Another early user requirements gathering method is KidReporter (Bekker et al. 2003). In the KidReporter method, children are asked to undertake various activities that result in creating a newspaper with children's ideas on a certain topic. For example, children could take pictures and describe why they took these

Fig. 2 Making collages as preparation for the encounter with the Martian

pictures and what is on them. Furthermore, children could interview each other, reporting on that, or independently write an article about a topic. The KidReporter method inspired us to do a similar activity during the Mission from Mars method: to inform the Martian about the games children liked, we asked the children to create a collage of their favorite games. As a preparing activity, we gave the children small cameras so they could first take pictures of their favorite games and subsequently use these pictures in their collages.

This idea worked out well: the children really made an effort to take photos of their favorite games; most children documented the games they were playing that afternoon at school, and some children went as far as to stage all their favorite games after school hours so they could take photos of them. What we did not anticipate was that the act of making the collages, which we did the next day at school (see Fig. 2), would generate a considerable amount of information. Each group was guided by an adult whose main role was to make sure that children were kept focused on the activity. It turned out that, while the children were engaged in making the collages, they were very open to elaborate verbally on details of their favorite games. It was very easy for us to unobtrusively pose many questions to which the children answered freely. We attributed this to the fact that for the children the main activity was to make the collage, which they enjoyed, and they did not feel as though they were being interviewed.

During the development of a series of Head Up Games (see later in this chapter) we decided to again create collages with children to gather information. The main difference with the session described above was that this time we did not include the photo making activity—instead we brought crafting materials. Furthermore, the context was different: instead of children at school, we engaged with children of a Scouting group in the Netherlands.

Based on our previous experience with making collages with children we expected it to be a good opportunity to simultaneously interview the children. However, totally unexpected, this time our experience was very different: in contrast to the school children, the scouts did not enjoy the activity, fooled around a bit and did not provide us with any information.

Reflecting on this we argue that the context in which we executed the activity has a significant influence on the proceedings. At school, children are normally required to behave calmly and an activity such as making a collage is a welcome deviation from the normal school routine and thus perceived as fun. In contrast, children go to a scout meeting to be playful, active, and engage in games and play outdoors; it is a venue for the children to release pent up energy from a week's worth of attending school. In that context, an activity as collage making, which required the children to sit at a table and be relatively calm, was *not* seen as fun.

Furthermore, our experiences show that information can be generated at unexpected times: while preparing the Mission from Mars, we had not expected that making the collages would give us this much information; we merely saw it as a means for the children to prepare for the session with the Martian.

3.3 Observing Children at Play

In most of the design processes for Head Up Games, we spent time observing children's free play in their natural context. In our experience this is a necessary activity, at least for inexperienced game designers. Though the methods described above will result in more and detailed information, they also take more time to prepare, execute, and analyze; time that is not always available. However, we argue that it is important for a designer to familiarize him- or herself with the target audience, and observing children at play is a way to gather insight into the types of games they play, the language they use and the context in which the games are played. Not only will it give valuable insights for the design process, it will also help the designer/researcher to better prepare for evaluations with children of prototypes of games later on.

3.4 Reflecting on Involving Children Early in the Design Process

We have shortly highlighted three methods for gathering insight. What method best suits a design process depends on several factors: the amount of time available in the process, the desired level of involvement of the children, and, from a practical point of view, the accessibility to children. A method like Mission from Mars requires a substantial effort in time and resources to execute and we have seen that the method's suitability depends on the age of the children. Then again, if the aim of the whole process is to involve children as design partners or informants it is worth the effort to spend time with the children to build up a relationship for subsequent encounters.

Similarly, we argue that an activity as collage making can also be deployed as a requirements gathering tool, and arguably as a relationship catalyzer; though our experiences suggest that the context in which the activity is conducted must be carefully considered. Spending time with the scouts in a shared activity that better matches the scouts' context arguably would have been more informing for the design process.

Based on our experiences with Mission from Mars and the collage making activity, we argue that spending time with children in a fun, creative activity, or a shared narrative can provide valuable insights for a designer. In general, it is advised to create a fun experience for children when involving them in a design process, e.g., (Markopoulos et al. 2008; Gielen 2008). We add to this observation that it is necessary to carefully select the right activity that matches the children's context.

Finally, we acknowledge the fact that given the time frame of a design process it is not always possible to actively involve children, or alternatively, it is not possible to find a venue that allows for such active cooperation. For example, we found that it is not always easy to find a school willing to cooperate given the involvement we ask from them. Regardless the (desired) involvement of children, we feel that, especially for inexperienced Head Up Game designers, an effort should be made to at least (passively) observe children at play.

4 Lesson 3: Playtesting with Adults

A key element of user centered design is to involve representatives of the target user group, in our case children, and have them test intermediate prototypes with the aim to converge iteratively at a successful design. Such an involvement of children takes time and effort to arrange, and to ensure that the children's time is well spent, it is important that as many as possible glitches in the games have been already been identified earlier. Therefore, during the development of many of the Head Up Games we designed, we asked adults to playtest intermediate prototypes. It is commonly acknowledged that we should not treat children as miniaturized adults, and as such evaluations with children will benefit from methods especially designed for children (Markopoulos et al. 2008). In doing so, it is worth considering to what extent we can treat adults as oversized children for the purpose of evaluating Head Up Game prototypes. Comparing our experiences of evaluating both with children as well as with adults we observed the following.

First, the behavior of adults before playing the game was different from children. Before the game children often behaved excited, eagerly anticipating the gameplay. In contrast, adults acted placidly and seemed less excited about playing a game, or at least did not express this. Furthermore, we observed that adults patiently listened to our explanation of the game rules and game details, while at least half of the children did not bother to listen to the details once they had grasped the main goal of the game.

However, the moment a game started, instantly the behavior of adults changed and closely matched the behavior of children during gameplay: both groups became physically active, there was social interaction (shouting, cheering etc.) and adults responded similar to breakdowns in a game as children did. For example, in evaluations of *F.A.R.M.* (Soute et al. 2013, see also Textbox 1) we did not set a rule for the starting distance between the one player and the rest of the players. Adults responded in a similar fashion to this as children did; both commented that "it was unfair" if the distance was too close and both groups resolved the issue within seconds (see also next section).

F.A.R.M. (Finding Animals while Running and Mooing) is an individual chasing and collecting game. At the start of the game, each player receives an assignment to collect a set of animals, e.g., a cow and two horses. The player who first completes his assignment wins the game. Players take turns in being the "farmer". At the start of a turn the farmer gets assigned an animal, which can be won by other players if they tag the farmer within 10 s. Players are allowed to trade animals to better match their assignment.

Textbox 1: F.A.R.M

After playing the game, when we asked players for feedback, there was again a noticeable difference between adults and children: adults were more fluent in providing feedback than children were, which is not really surprising. Children have not yet properly developed the ability to reflect on a meta-level and/or simply lack the vocabulary to do so (Markopoulos et al. 2008). Furthermore, there was a difference in the type of feedback given. Children mostly reflected on actual events of the playtest; though children generally did not have problems to detect and fix "broken" game rules, they did have trouble to give feedback on the game at a more abstract level. Adults did not have trouble doing this and also commented more on the tactics of a game; they readily provided many more rules that they thought would enhance the gameplay. Nevertheless, adding rules does not necessarily improve the game: perhaps due to the fast pace of many of the games. There simply is less time to consider all these rules while playing the games. Also, children seemed to appreciate other challenges in games than adults: adults put more emphasize on developing play tactics in the game, and also favored rules that would support this. After playtesting *F.A.R.M.* the adults suggested to add more tactics to the game, for example to allow players to trick other players into losing their animals. In contrast, children seemed to be less concerned by this; and were less inclined to listen to the game rules at the start of the playtest. Interestingly, this did not seem to have a big influence on the gameplay. Not understanding all the rules while playing a game inevitably did result in confusion for some of the children, but in general they would just continue, figuring out most rules while playing. This observation was reflected in the informal interviews: when asked what children favored most in the games, some children referred to the physical activity, other children mentioned the fact that they were playing this game with their best friend. So in contrast to the adults, children did not seem to have a need for more (tactical) challenges in the games. Similarly, Sellen et al. (2009) concluded that the reaction to the same concepts can differ due to differences in age of the user groups. Thus, the play experience of adults may not be representative of how children would experience a game. Arguably, this is be expected since playing has a different importance to each.

Summarizing, we observed that it is indeed beneficial (and practical) to have adults playtest the games; the behavior adults display during play is similar to children's behavior in terms of physical activity, social interaction, and reaction to the game devices. Observing adults playtest the game can therefore identify usability issues with the game devices (e.g., sounds being not clear enough) or issues concerning the rules (e.g., when situations occur in which the rules are inconclusive, or conflicting). However, we would certainly not advise testing with adults only; though the behavior of children and adults is similar, children experience and value games differently than adults, and this cannot be revealed by testing with adults only.

5 Lesson 4: Tapping into the Children's Tacit Knowledge on Well-Played Games

Game Design literature, e.g., (Salen and Zimmerman 2003; Fullerton et al. 2004), states that it is impossible to design all the rules and mechanics of a game and predict the emerging game experience without playtesting. Therefore, Game Design literature stresses the importance of an iterative design process, in which designers playtest the games; based on the observations designers can improve the gameplay.

DeKoven (2002) argues that players implicitly know when a game is played "well." He states that a "well-played game" is impossible to define, as it is dependent on too many variables. However, the *experience* of a well-played game is familiar to every player. Hughes (1983) makes a similar observation: children intrinsically aim to play "nice," e.g., it is implicitly agreed that players will not hurt each other. Furthermore, Hughes, and also Salen and Zimmerman (2003) suggest that some rules are implicit, ingrained by the social context in which children play the games. For example, a child playing a game like *F.A.R.M.* with his younger brother would allow the younger child more leeway than he would were he playing with his best friend, who is roughly of the same age.

A designer can make use of this implicit tendency to “play well.” First, we acknowledge the fact that a designer is not able to predict the game experience beforehand, and therefore is not able to design a definitive set of rules for a game in a single iteration of the design. Thus, we propose to purposefully design a limited, basic set of rules only. It is possible that during playtesting situations will arise that will “break” the game, because the basic set of rules is insufficient. If such a situation arises, we propose to rely on the children’s tacit knowledge of a well-played game and their ability to come up with a new or changed rule to fix the gameplay. If possible that rule will take effect immediately, which allows us to instantly reflect on the suitability of the rule.

During the design process of the Head Up Games we have encountered examples that this way of working is indeed useful for informing the design process. For example, while designing *F.A.R.M.* we did not explicitly state in the rules what the starting distance between the players should be. At the start of the game, it immediately became clear to the players that this distance had a big influence on the chances of winning for the player who was the *farmer*. Players commented on the unfairness of this situation and we discussed with the players how to improve this. The players suggested giving the *farmer* some leeway; they argued that this was common in other games as well, and this largely solved the issue as we experienced immediately during the subsequent playtest.

Another example occurred during the evaluation of *Save the Safe* (Soute et al. 2009a, b). In *Save the Safe* two teams compete to capture a key that opens a safe to win the game. At the start of the game the key is randomly assigned to one of the players. We compared two types of gameplay: one with a digital (virtual) key and one with a physical key (a ball). Unexpectedly, the game with the physical key, the ball, ended very rapidly, because the first player grabbed the ball and sprinted to the safe to end the game. Immediately, the opposing team started protesting that this was “unfair,” since “you are not allowed to walk with the ball!” In fact, we had not imposed any rule stating such a thing, but many ball games indeed have such a rule: the player who has possession of the ball is forbidden to move. After a very short discussion—the winning team, at first reluctantly, agreed, since they saw too that there was no fun in playing a game that ended this abruptly—we agreed to impose the rule (not walking with the ball) for this game.

5.1 Reflecting on Tapping into Tacit Knowledge

Concluding, we argue that we can make use of the observation that children are in fact domain-experts to our advantage for informing the design process. However, we should keep in mind that children are domain-experts regarding gameplay, though not regarding technology. It is mostly impossible for children to comprehend in what ways technology can be used in the game; and this can result in either children not being able to imagine novel interaction styles in games, or alternatively, children imagining game interactions that are technically infeasible. By having children create rules and immediately play them, we are certain that these rules are playable. Still, the “blue sky” suggestions of children, combined with observations of children playing the game, can provide valuable hints to a designer on what direction to take in the game design process.

6 Lesson 5: Using Prototypes

The generally accepted approach for designing products in HCI and Game Design is to start with low-fidelity prototypes that, through subsequent iterations, gain in fidelity and start to resemble the intended product more closely. In the design process of early Head Up Games we adopted this approach. For example, during the development of *Camelot* (Verhaegh et al. 2006) we playtested three game concepts using simple paper cards and boxes that represented some of the game ideas. Similarly, during the development of *F.A.R.M.* (Soute et al. 2013) we playtested the game using paper prototypes. Although these evaluations were successful at first sight in that they provided a considerable amount of insight in the gameplay, the question arose whether or not the information gathered using paper prototypes was valuable for informing the design process of Head Up Games.

One of the challenges for the evaluation is the high pace of the games; often, the games are designed such that, at least in parts of the game, players are running or chasing each other. Using low-fidelity prototypes (e.g., paper prototypes) in a playtest can seriously disrupt the intended flow of the game, or at least alter the game mechanics to such an extent that it is no longer valid to compare the experience of playing with a noninteractive prototype to the experience of playing with an interactive prototype. As a consequence, the feedback generated with the nontechnical prototypes is reflecting on irrelevant game mechanics, which results in the design process optimizing towards a game that is playable as is, i.e., without interactive technology. Subsequently integrating technology degrades new interactive features to unconvincing post hoc add-ons that do not integrate well with the game.

Therefore, to evaluate the impact of interactive technology on the game experience of outdoor games, we argue that high-fi prototypes should be employed in an early phase of the process. Furthermore, the games we intend to design are to be played by multiple players in an outdoor context. As a consequence, not only the player technology interaction plays a role in the emerging game experience, but also the player–player interaction and player context interaction have a significant impact on the game experience (see Fig. 3). For that reason we argue that the games should be evaluated in situ, i.e., in a context where children normally play games, as opposed to a lab setting. This poses high demands on the robustness of the prototyping medium.

In similar games where the design process is disclosed in related literature (e.g., *Ambient Wood* by Rogers et al. (2004), and *StarCatcher* by Brynskov and

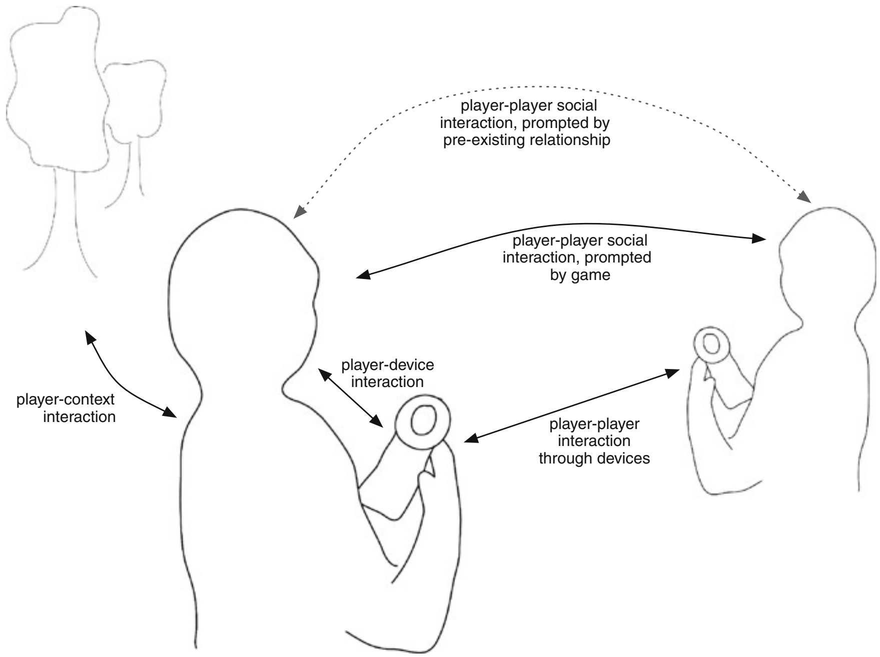

Fig. 3 Types of interaction in multiplayer, outdoor games

Ludvigsen (2006)), it is only reported in the last design iteration that a partially or fully working, playable prototype is created that covers a reasonable part of the game mechanics. Most commonly in this field, authors report only the final game design, how that was evaluated by users and suggested potential improvements of the 'final' game. None of the papers report or reflect on an iterative process for improving the game design using interactive prototypes.

To enable a rapid, iterative design process using interactive prototypes we developed the RaPIDO (Rapid prototyping of Physical Interaction Design for Outdoor games) platform. Early Head Up Games had been developed from scratch each time—a time-consuming activity. Thus, based on the earlier experiences of building prototypes we designed the RaPIDO platform to include useful technologies for outdoor games. The platform consists of a set of player devices (see Fig. 4) that offer several modes of interaction: e.g., visual, haptic, and auditory, see Table 1.

Besides offering the hardware, the platform includes software libraries to easily address all hardware components and program new interactive games. Furthermore, the exterior of the devices is robustly designed, to survive multiple outdoor evaluation sessions with children.

To evaluate the use of RaPIDO and its impact on an iterative game design process, we engaged in a study in which we iteratively designed several Head Up Games for children. Our approach shows similarities to the RITE method (Rapid Iterative Testing and Evaluation) by Medlock et al. (2002); the RITE method

Fig. 4 RaPIDO player devices

Table 1 Main components of RaPIDO

Technology	Interaction style
4 RGB leds	Provide visual cues, e.g. by blinking, or changing color
Sound chip + speaker	Provide auditory cues, can read and playback .wav files from SD card
RFID module	Detect objects tagged with RFID-tags
XBEE module	Provides: (1) inter-device communication (2) distance measurement between devices
Vibration motor	Provides tactile feedback
Rotation encoder	Measures degree of rotation of wheel
Accelerometer	Measures movements

advocates an iterative approach in which iterations are executed at an extremely high pace. Problems identified in the interface (in Medlock's case a tutorial of a popular game) are immediately changed, and more importantly, immediately evaluated, sometimes even within hours of implementation.

The games were repeatedly playtested with children (7–10 years) of a Dutch scouting association in an outdoor context. Details of the study can be found in Soute and Markopoulos (2013). Reflections on the iterative design process are discussed next.

6.1 Reflections

The experience of creating and evaluating several games has generated insights into different levels, namely (1) on the rapid, iterative, design process (2) on evaluating with children in this particular setup, and (3) on what interaction mechanisms and technology are appropriate for interactive, outdoor games for children.

6.1.1 Design Process

Most design changes that we implemented based on our direct observations of the gameplay and comments of the children, concerned directly the play and interaction functionality. Seemingly small details, like the duration of some interactions, influenced heavily the emerging game experience, showing the inadequacy of evaluating a mock-up of the game interactions for example when playtesting functionality with Wizard of Oz interventions. For example, in *Save the Safe* (Soute et al. 2009a) a 'key' is represented virtually, using tactile feedback. It is easy to see that replacing the virtual element by a physical object would alter the game: a physical object is clearly visible to the other players, especially when passing it around between players, so the element of guessing which player actually possesses the key (as is present when the key is virtually represented) is taken out of the game completely. And particularly that feature of the game turned out to be the most fun part. Thus, we argue that instead of playtesting with paper prototypes, for developing Head Up Games it is best to immediately focus on the actual, working, interactions.

With regard to the time it earlier cost to develop a working prototype, we conclude that with the RaPIDO platform we were able to bring this time drastically down. Over the course of 6 weeks we were able to develop, evaluate, and improve on four games. Furthermore, because it was relatively fast and easy to create working prototypes, the platform allowed us to play around with the technology, and thus freely explore the design space.

In our design process, we decided to keep a high pace in developing new iterations of the games—typically we took 1–2 weeks to develop new iterations. As a consequence, little time remained to analyze the results of the evaluations (e.g., run a structured observation, or content analysis of the interviews). Further, the interviews did not yield as much information for improving the games as we had expected; directly observing the gameplay was much more effective. Nonetheless, the little information that was deduced from the interviews was useful for corroborating our findings from the direct observations.

Another benefit of rapidly iterating over small changes is that it becomes easier to observe the impact of a small feature change. We argue that this way the design process becomes a "self-steering" process: if based on an observation a wrong conclusion is drawn and subsequently a wrong decision regarding the game mechanics is implemented, the next session will immediately show the (negative) effect and the design decision can be undone quickly.

Testing early and often in the design process makes sure that as a designer you do not "fall in love" with your own (features of the) games. After only 1 week of implementing a game, it is much easier to toss a feature in favor of an improved version or abandon a game altogether. In contrast, if one has taken months to implement a game, it is much more difficult to part from it, if at an eventual user test it turns out that certain features do not work out as expected.

6.1.2 Iterative Testing with Children

We found that repeated evaluations with the same group of children have a few distinct advantages: first, we got to know the children, which made it easier to interpret observations. For example, a child that behaves in a certain way may or may not do that as a consequence of playing the game and it is relatively hard to tell the difference from a single observation only. However, when observing the same children over time, as a (game) designer it becomes easier to tell which behaviors can be attributed to a child and which might be the result of playing a certain game.

The second advantage is that the children got to know us and because of that gained confidence and were at ease in their interactions with us. An often-argued side effect of the children getting acquainted to researchers is that the power imbalance that might exist between a child and an adult (Hennessy and Heary 2005; Markopoulos et al. 2008) is lessened. In fact, we even experienced this to the extreme; the power imbalance was *reversed* in a sense that we had to try hard to assert ourselves on the participants, simply to get and hold their attention. We attribute this to two causes: first, as we indicated, the children became familiar with us; and second, because the children clearly outnumbered the researchers, children did not feel at all intimidated by the two researchers (in contrast to evaluations where only one or two children are present). In our case, we eventually had to claim a leading role in order to quiet the group down, and make sure they were all paying attention. This did not seem to have a negative impact, possibly because the children equated us to their scout leaders and they too addressed the children in this manner.

This brings us to another observation: when observing "in the wild" (i.e., in the user's natural context, e.g., observing children playing at their regular playground) it is important to adjust to the context of an evaluation (see also Rogers (2011)), and more specifically how an evaluator should interact within that context. In our case this meant that we positioned ourselves in the roles of scout leaders. Related to our observation above is the notion that an evaluation method cannot simply be transplanted from one context to another. Certain patterns of behavior have been established between the children and the scout leaders and as a researcher we argue that you should be aware of this and plan your evaluation accordingly. An example of this is the observation that using collages to elicit information from children as a method did not work well in this particular context, simply because the children were not used to sedentary activities within this context. In contrast: we have applied the same method earlier in a school context where it worked well.

The age of the children ranged from 7- to 10-year old. This is something we had not anticipated, but in the end had to adjust to: for some games it might occur that the challenge for a 7-year old to compete with a 10-year old becomes too high, resulting in a negative game experience for the 7-year old, and maybe even for the 10-year old, as the competition is too low for him. We observed this during the playtest of one of the games, and later adjusted for this by not randomly mixing the children but instead sorting them by age group. Then the chances for winning the game became more equal for all players, resulting in a better game experience.

6.1.3 Interaction in Outdoor Games

In the games we designed we used a variety of interaction styles and technologies, but the one technology most commonly used was radio communication. We used it for two purposes: for communicating game events between the RaPIDO devices, so they could appropriately respond to what was happening in the game with respect to other players. Further, we used radio technology for getting a rough estimation for distances between devices (and thus players). Both features contributed significantly to the novelty of gameplay, as it allowed us to introduce elements in the games that have no similarity to features in traditional outdoor games. An example is the virtual key in *Save the Safe*, which was transferred between players based on proximity.

Furthermore, for feedback to the players we often used auditory, visual, and tactile cues. We found all modalities appropriate for supporting outdoor games, though that does not automatically imply that every style of using it is appropriate in the context of outdoor gaming. To give an example: in one game we needed to convey to the players how many steps they could take in a turn. At first we implemented it by letting LEDs blink, each blink accounted for one step. However, this enforced the players to be paying attention to their device at a specific frame of time within the game. Also, the information is volatile, once it is shown it is gone. So, a moment of distraction, for example when team players are talking to one another (i.e., engaging in social interaction, which we want our games also to encourage!) would result in the loss of game information. Therefore, we redesigned that part of the game to have the LEDs continuously shine; the number of LEDs switched on corresponded to the number of steps. This was a more persistent way of showing the same information.

Another technology we made heavy use of was RFID technology. Each device is equipped with an RFID reader, which allowed us to program the devices to detect objects tagged with an RFID tag. Though we used it moderately in the games themselves, we employed the RFID tags mostly for setting up the games.

Based on our experiences we conclude that the process we followed is very suitable for games, where the emerging game experience is not only a result of interactive technology, but also of the context the game is played in, and other existing game rules; these games need to be really experienced and cannot be tested with lower fidelity prototypes. Arguably, a similar process might be valuable for other interactive systems that are novel to users and are designed to change behaviors in users. To valuably generate feedback from users on such systems, they have to be tested and experienced "in the wild," meaning in context, with actual users using a product under realistic conditions rather than those which are anticipated by designers or that are easy for designers to work with.

7 Recommendations for Designing Head Up Games

In this chapter we have focused on the design process of Head Up Games. Based on our experiences we can now present several recommendations that can inspire and inform first-time Head Up Game designers.

The first recommendation is the most radical, as it deviates from the generally accepted way of involving low-fi to high-fi prototypes in the design process. Instead, we emphasize the necessity of using high-fi prototypes from an early stage of the design process: these games really need to be played with working technology to assess the effect of the game design and technology on the game experience. Instead of gradually increasing the fidelity of the prototypes, we went ahead and immediately created high-fi (with respect to interactivity) prototypes. We argue that, for games involving physical activity, outdoor play, groups of players and embodied interaction, it is virtually impossible to test with paper prototypes as the lack of interactivity distorts the game dynamics intended by the designer and leads to very different play experiences. Moreover, we argue that, if children are involved, it becomes more apparent, as children might be less able to reflect on the impact of interactivity and the resulting game dynamics without actually experiencing it.

Furthermore, we suggest starting the design process with designing and implementing a limited set of game rules and rely on the players' ability to detect and fix a broken game.

We also discussed the process of engaging children in creative activities to gain insight into children's requirements for games. The amount of information gathered is dependent on the effort put in the activities. The Mission from Mars method is very time-consuming, but offers a considerable amount of feedback. However, the method relies on a narrative that might not be suitable for all children. We furthermore discussed making collages with children. This method was a success in a school context, leading us to repeat it during evaluations with scouts. Unexpectedly, in that context the method failed, suggesting that the context of the evaluation plays a large role in its success rate. Finally, we suggest that at least designers should make an effort to observe children at play, if time is too limited to execute the methods described above for gathering children's requirements.

Finally, we recommend to playtest with children as often as possible. Our experience suggests that some issues can also be identified by adults. Indeed, we would recommend letting adults playtest intermediate prototypes of the games to root out early usability issues.

In short:

- Use high-fi prototypes from an early stage in the design process. Head Up Games really need to be played with working prototypes, most notably with regard to the game interaction, to assess the effect of the game design and technology on the emergent game experience.
- Start with an incomplete set of game rules. Rely on the players' innate ability to detect and fix a broken game to fill the gaps.

- Engage with children in a fun, creative activity as a way to facilitate discussion. Though be aware that 'fun' is context dependent.
- Adopt an iterative process and playtest with children as often as possible. To prepare for these sessions, and/or to test intermediate designs, playtest with adults too.

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