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ORIGINAL ARTICLE

Child-centered game development (CCGD): developing games with children at school

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Abstract Children represent an increasingly relevant target group of the game industry. Nevertheless, they are rarely involved in development processes. This article introduces child-centered game development (CCGD) approaches for the game design within the context of the school. Therefore, suitable HCI approaches from user-centered and participatory design as well as educational principles and approaches were used as a foundation. The CCGD approaches illustrate how to guide the involvement and participation of children aged 10–14 years in school classes within the development process of games. Approaches for the analysis, conceptualization, and design phases were developed and applied.

Keywords User-centered design · Participatory design · Child–computer interaction · Game design · Educational pedagogy

1 Introduction

Children are becoming experienced and frequent users of software as well as technology and are emerging as an important user group [25]. They encounter and use software or technologies in their daily lives, for example, mobile phones to communicate, computer games for individual or collaborative entertainment, and educational technologies for learning [47]. This is studied in child–computer interaction (CCI), which is a growing subfield of human–computer interaction (HCI). In recent years, many CCI approaches evolved, which enable children to take an active role in parts of the development of technologies, but most of these approaches address evaluating interactive technologies [21]. There is a lack of profound knowledge for the involvement of children throughout the whole development process of games, beside the recently published work of Tan et al. [53] on *Child-Centered Interaction in the Design of a Game for Social Skills Intervention*.

Children's enjoyment is one of the most important goals for games, otherwise children will not play the game again and again [42]. In order to meet children's needs, an adequate consideration of them in the development process of technologies is necessary [1]. For game developers, it would thus be an advantage to work together with children to satisfy their range of desires (e.g., [6, 54]) and not to see them only in the role of game consumers. However, children are rarely involved in the game development process, as they are a challenging target group (e.g., they have developing motor skills or shorter attention spans). Furthermore, the development of games already requires a lot of cooperative effort of at least software and sound engineers as well as user interface and domain experts (e.g., world builders or writers).

In general, when doing research with children, four ways of involvement have been identified: children as objects, subjects, social actors, participants, or as coresearchers (see [9, 34]). Furthermore, after performing a case study with 10–11 year old children, Garzotto [16] concluded that they cannot only act as users (e.g., [28]), testers (e.g., [22]), informants (e.g., [43]), or design partners (e.g., [14, 21]) in the development process, but can also take the role as experience design innovators. With their freshness, imagination, and technology experience, children discover new creative forms of digital artifact usage that goes beyond the expectations of a research or

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development team [16]. The downside is that some of their ideas are technically unworkable [50]. Nevertheless, following the principles of user-centered design (UCD) and participatory design (PD), the children's creative and innovative ideas should guide the development of games.

In the proposed child-centered game development (CCGD) approaches, children are participants and coresearchers. They are actively embedded in the different research activities during the game development process. Although the participation of children in this process entails complex policy, legal, and ethical issues [1], this was accepted in order to get first-hand data and benefit from their freshness and creativity. In the Games4School project, which is a nationally funded research-education-cooperation, mini-games are developed together with 60 children of three classes of the secondary school Wals-Viehhausen. The aim of these games is to be fun while supporting co-experience and movement of children aged 10–14 years during the school breaks, instead of focusing primarily on innovation in the gameplay. The children participating in the project, aged between 11 and 13 years, are embedded in the different research activities by applying different CCGD approaches. They take over the role of a user, a tester, an informant, and a design partner within the context of the school. Each class participates in a 4-h project day every month together with two researchers (mostly in school throughout one school year). Therefore, it is necessary for the researchers to enter the children's worlds of imagination and understanding [45] and for the children to get familiar with the researchers in order to work in a confidential setting [50]. In the context of the school, this is less difficult than in other contexts (e.g., private context of the home) as children in classes are used to adults being around them as helpers (e.g., on school trips) [35]. This simplifies research and development in schools to a great extent, although methodically the context of the school generates new challenges [35], such as how to involve an entire school class in the development process. Furthermore, it needs to be considered that the organizational structure of schools necessitates not only the involvement of the children, but also of their parents, teachers, principals, etc. [1].

2 Child-centered game development (CCGD)

In HCI a lot of different development approaches have been defined, like scenario-based design [48], contextual design [2], experience-centered design [55], learner-centered design [51], PD [39], or the UCD approach by Norman and Draper [40]. PD, for example, enables users to participate actively in the design process of software or technologies [39], whereas UCD provides designers with approaches for involving users throughout the whole development process [30]. Scaife and Rogers [50] note that within UCD, it "has been typically to position users as a testing or evaluation service for designers to ensure those users' needs are met." Furthermore, traditional UCD approaches have been criticized for focusing too much on HCI principles for adult users and neglecting issues related to children [33]. Therefore, HCI methodologies should be adapted to address the needs of children by considering children's different perceptions and making sense of the world around them [53]. Within the HCI community, there are lots of separated methods available for UCD and game design in general. There are also a few approaches for the development of games with children in small groups, like in PD [13]. However, there is still a lack of methodological approaches for the involvement of an entire school class. There is also no collection of methods available in CCI that supports the involvement of children throughout the whole development process of games.

Pagulayan et al. [42] distinct three phases in the game development: conceptualization, prototyping, and playtesting. The first phase typically involves the identification of goals, challenges, rules, controls, mechanics, skill levels, rewards, story, etc. These specifications are done by game developers and recorded in game design documents. The second phase is used to quickly generate playable content in the form of prototypes. These prototypes can then be used for playtesting in the last phase. For detailed information, see also Fullerton et al. [15]. For the CCGD approaches, this three phases are extended with an analysis phase (typical for UCD) and a design phase, in order to separate the design from the implementation of the games.

The CCGD approaches build a collection of approaches suitable for the active involvement of school classes throughout the game development process. They were developed for the different UCD and game design phases (broken down into analysis, conceptualization, design, prototyping, and evaluation) and combine UCD with PD and educational principles. The combination of educational principles with HCI is explained in the following. Afterward, the different CCGD approaches are described highlighting the benefits of the combination.

2.1 Combining educational principles and HCI

Bruner [8] describes learning as "an active process in which learners construct new ideas or concepts … The best way to create interest in a subject is to render it worth knowing, which means to make the knowledge gained usable in one's thinking beyond the situation in which the leaning has occurred." Good and Robertson [19] believe that allowing children to design and develop their own games will lead to a deeper learning experience where

skills will be transferred. This should be achieved within the CCGD approaches through linking traditional HCI approaches with educational approaches and learning content.

Hinze-Hoare [23] introduced educational principles for evaluating virtual learning environments, which build on the essential components of effective learning from Bruner [8] (in his work on educational theory *The Process of Education*):

1. *Collaborative learning* brings children together to help each other grasp the essence of the topic, to solve problems more effectively, and to promote learning. The value of collaborative learning is that children, who study together, learn more than those who study alone. Furthermore, Blatchford et al. [4] state that group dynamic processes have positive impacts on the children's motivation as well as on the development of creative solutions.
2. *Active learning* means that the children are in control of their learning process, which was highlighted by Hinze–Hoare as one of the primary educational principles. They actively seek information (e.g., discover background information), which engages themselves more effectively in the learning process, than if they passively receive instructions for learning (e.g., method of proof by assertion).
3. *Reflective learning* enables children to reflect on the process, which engaged them while learning.
4. *Cultural learning* refers to the community or cultural environment that enables and gives meaning to interactive learning.
5. *Reinforcement* is the stage after learning when the children establish and maintain their learning.

Collaborative, active, and reflective learning are important for the CCGD approaches, as well as the cultural environment that enables children to develop games together with researchers within the context of the school. Robertson and Good [46] stated that by enabling children to create computer games, learning opportunities are provided, for example, developing narrative skills through character creation, plot planning, interactive dialog writing, etc. In other words, through putting the children in the center of the development process (i.e. UCD), they actively get to know the game development process and thus actively learn. Through supporting group dynamic processes, not only single ideas but group ideas will be developed that are discussed and initially evaluated by the group. Additionally, through the integration of educational approaches in the CCGD approaches, practice-based learning [3] is supported. Thereby, a win–win situation emerges. On the one hand, the children benefit from learning educational approaches not only in class, but also from practically applying it in the game development process, where active knowledge transfer is enabled. On the other hand, the educational approaches help the researchers or game developers to explain particular CCGD approaches (for example, personal descriptions can be used to explain the child-game-persona approach, see Sect. 2.3.1).

In the following, selected CCGD approaches for the first three phases (i.e. analysis, conceptualization, and design) are described. They are part of a collection of approaches that can be applied in the development of games together with school classes. The CCGD approaches for the other two phases (i.e. prototyping and evaluation) are still under development. Each CCGD approach is described independently, and additionally application sights from the Games4School project are given.

2.2 Analysis phase

In the analysis phase, children's requirements, needs, and game preferences (like favored game controllers) are investigated by conducting user, task, and environment analyses.

2.2.1 Idea cycle

The goal is to get an understanding of a topic by creating and discussing ideas in a group. The idea cycle is a modification of the World Café method [7] (also called Knowledge Café). The World Café is a simple, effective, and flexible format for hosting large group discussions. It starts with a 20 min round of conversation about a topic with the small group seated around a table. After 20 min, each member of the group moves to a different table. One person may be left as the "table host" for the next round, who briefly explains what happened in the previous round. The rounds can continue until all of the participants were at each table [7].

In order to work with 11–13 years old children, it is necessary to reduce the complexity. Prepared posters with different questions (or statements) for the discussions are put on tables for four children in the classroom. The children can, for example, work out what has to be done within the five different phases of the game development, in order to get a better understanding. Each group is asked to write down its ideas (responses) on post-its in order to answer the provided questions (e.g., questions for the analysis phase can be: What is an analysis?, How can we analyze something?, What do we need to know about gamers, games, etc. to develop our own games?). Using post-its allows discussing, arranging, and rearranging the ideas (see Fig. 1). After every 10 min, the groups rotate (without splitting up) until every group provided input for each

poster. The advantage is that the children do not only mention their spontaneous ideas but also create ideas out of the others. The collaborative knowledge enables them to answer the questions and work out the different phases of the development process. This is especially important for the analysis phase, as the children can come up with lots of ideas and examples of what needs to be analyzed and how, before the development of the games can start. The researchers need to sort the post-its in order to use them afterward for explaining to the children the different activities within the five phases. The interpretation of the post-its and their content can only be done by researchers, who are familiar with the different phases.

Application insights: For the analysis phase, the children came up with ideas to ask or observe other children in order to find out: What kind of games do children play, why do children play games, why is playing games fun for other children, where are games played and why, and what is important to consider when developing games. The children liked the collaborative and active learning in this activity and were proud of their collective knowledge. The teachers were also impressed with the output of this approach. Through the ideas on the post-its, the researchers could get familiar with the user language of the children. This approach enabled also the children to ask questions, for example, they did not know the meaning of the word "analysis". This was explained then by the researchers to the class.

2.2.2 *W-question cards for games*

This approach aims at figuring out questions to investigate within the analysis phase. Therefore, the W-questions (Who, When, What, Where, Why, and How) are used, which are common in educational settings. Examples may be found for learning grammar [12] and comprehending stories [10]. The children should form groups of two in order to support group dynamic processes. The children should create W-questions for collecting user needs (requirements) and provide exemplary answers. As motivation, the children are given a stack of cards (with a W-question word as shown in Fig. 2) to write down questions that collects answers on the users' behaviors, needs or preferences with regard to games. The analysis of the cards needs to be explained and discussed with the children beforehand, so they know what is happening with their work. The researchers start to summarize similar questions, and sort out the ones that are not appropriate/unimportant for the project goal (e.g., Who explained the game to you?). They select the most suitable from the remaining ones to investigate end users' behaviors, needs, or preferences with regard to games (e.g., Which games are children playing?, Where do children like/dislike to play games?, How often do children play games?, or How long do children play games?). Additionally, the researchers need to add missing questions to cover all important aspects for game design. The advantage of this approach is that the questions are authentic, as they are phrased by children, address children and can be used in other approaches to collect data (e.g., interview or probes study).

Fig. 1 Results of the idea cycle

Application insights: The children were very motivated, and the approach worked out satisfyingly. However, some groups needed special attention in the beginning, meaning the instructions needed to be repeated, and they needed help to fill in the first card. Therefore, the researchers and teachers walked around to look after the children and their work. By applying the W-question approach in the three classes, 231 questions were collected. The researchers analyzed the cards and selected the most suitable questions regarding the kind of game to be developed. Additionally, the researchers added missing questions to cover all important aspects (e.g., What is annoying while playing a game? Which rules are important while playing a game?). In the end, 20 questions remained regarding game structure as well as personal, social, temporal, spatial, and technological contexts. The authentic questions were used in the probes study as described in the following (see also [37]).

2.2.3 *Probes study*

The probes study aims at investigating children needs. So far, probes have become an umbrella term covering everything from diary to user and field studies. Nowadays, the data collected with probes moves from being a source of inspiration toward gaining a more holistic understanding of the target group [5]. Gaver et al. [17, 18] originally developed the cultural probing approach. These are packages containing open-ended, provocative, and oblique tasks

Fig. 2 Example who-question card with sample answers

to support early user engagement within the design process. Cultural probing demonstrated to be suitable (i.e. useful and minimally intrusive means) for collecting data from children in order to gather user requirements in the analysis phase [56]. Therefore, they served as a starting point for the proposed probes study (see also [37]).

Iversen and Nielsen [24] mention that the probes approach is useful when designing with children as the probes material provides access to children's everyday lives. The main characteristics of probes material in general are that: (1) it is based on the user participation by means of self-documentation, (2) it is looking at the user's personal context and perceptions, and (3) it has an exploratory character [32]. The probes study gives participants, in this case, the targeted children (aged 10–14 years), a voice to interpret, explain, and document their own practices and experiences with games. Additionally, the context where games are played can be taken into account. With the study, the participating children can be enabled to be in control of when, where, and how to provide their feedback [37].

In order to gain a holistic understanding of the children and their gaming behavior, the different qualitative probes material (e.g., (post)cards, collage, and maps) and quantitative probes material (e.g., pre-structured diary) can be triangulated. This is contrary to the cultural probing approach of Gaver et al. [17, 18], who only use qualitative probes material, and as a primary source of inspiration. The triangulation allows being more confident about the collected data (i.e. consistency check). It stimulates also the creation of inventive ways to capture a richer understanding of a problem or activity by addressing different aspects [26, 52] or the same with different probes material.

The W-question cards approach (explained before) can be used to identify questions for the probes study. As the questions are mainly phrased by children, they are easy to understand for the participating children and therefore are less misleading. Different probes material can be introduced to the children. Afterward, they are asked to assign the different questions to a certain provided probes material, which they believe suits best to gather answers. The suggestions are considered in the selection of the probes material, which can consist of instructions (post)cards, a diary, maps, a collage, a disposable camera, playful elements, creative material (e.g., Playdough), office supplies (e.g., scissor, glue, pen, text markers, or post-its), goodies, etc. The material can then be deployed by the children. Therefore, it needs to be appropriately designed in order to be self-explanatory and serve as inspiration, as well as motivation, for explaining and documenting their own practices and experiences with games. Once the data is collected, it needs to be analyzed by the researchers in order to guarantee a proper research standard. Afterward, it can serve as input to create child-game personas within the conceptualization phase. Nevertheless, the children should also be given the possibility to take a look at selected probes material in order to make their own experiences in analyzing data (i.e. no instructions are given). This especially supports the active learning of the children. If the children are less experienced in analyzing data, "living statistics" [36] are a promising approach to give them some first ideas. The researchers ask, for example, five children to voluntary participate. They tell the children different sort keys (e.g., order by body height or shoe size, alphabetical order of first or last names, or chronological order of age) to arrange them in an order. If needed the researchers can also provide sub-sort keys (e.g., if two children have the same age, they can additionally sort by their birth month), in order to illustrate how analyzing by sorting can work.

Application insights: The probes study gave 60 children, aged 10–14 years, who were not involved in the project (e.g., sisters and brothers, friends, or school mates), a voice to interpret, explain, and document their own game practices and game experiences. This enabled them to reflect about their game behavior and interests. In order to be inspired and motivated, the probes material for the 3-week study consisted of different material, such as instructions (post)cards, a diary, maps, a collage, a disposable camera, some office supplies (e.g., scissor, glue or pen), and goodies (as shown in Fig. 3, and described in [37]). A total of 38 completed boxes with a large amount of filled in probes material were returned to the researchers. This was

a very satisfying amount of probes material as in other studies, probes material was often perceived as a lot of work for the participants, and therefore, the return rate was very often low [20].

The children really liked the possibility to analyze parts of the data on their own. Therefore, groups of two children were given different kind of data gathered from different probes material. Some of the children were really creative and started to look for relationships in the data. For example, they looked for repeated combinations of answers in the data instead of just counting answers. Afterwards, the children prepared PowerPoint presentations, which they learned to make in their computer classes, with their results and insights gained from the probed material. They presented to the class how they analyzed the data and what they discovered. The presentations and outputs were commented by the researchers.

2.2.4 *Short feedback questionnaire (SFQ)*

In order to define user requirements regarding favored game input devices (controllers), the perceived fun of the game input devices can be analyzed with children, as most of them have never before used a large number of the available game input devices. This helps to find out which are preferred game input devices of children that should be considered in the development of games. Therefore, we developed the SFQ that builds on a one-page, pre-structured questionnaire used to evaluate the experienced fun in games [41]. In order to engage children to fill in the SFQ and not lose patience by filling in more than one, the design follows several guidelines of Read and MacFarlane [45], such as "keep it short", "limit the writing", "make it fun", and "use appropriate tools and methods" (e.g., by using parts of the Fun Toolkit [45] as they have already proved to be suitable [44]). The slightly adapted questionnaire for the evaluation the experienced fun of game input devices consists of three parts (see Fig. 4): (1) the question "How much did you enjoy the game input device?" to be answered with the "Funometer" (originally used by Read and MacFarlane [45]), (2) pre-defined opposed attributes describing the experienced fun of the game input devices, and (3) demographic data (age and gender).

Fig. 3 Probes material package

The original questionnaire [41] consisted of 12 attributes (boring, confusing, difficult, ugly, bad, childish, exciting, fun, simple, beautiful, great, surprising), whereof five attributes were not suitable to describe game input devices or were misleading. The following attributes were considered as not appropriate to describe game input devices: "ugly," "beautiful," and "bad" as they refer rather to the content and esthetics of the game than to the game input device. Thus, there would have been the risk of having evaluated the game itself instead of the game input device. The attribute "confusing" is removed as it would rather describe the configuration of the controlling buttons for the specific game and "surprising" as it can be interpreted positively as well as negatively. In order to complement the list of attributes, which adequately describe the experience of game input devices, the missing opposed attribute "tiring" for "exciting" was added. Furthermore, the list is extended with the opposed attributes pair "intuitive" and "impractical" as these are typical attributes for describing the interaction with the game input device. All attributes are selected with great caution to use in order to be easily understandable and familiar terms for children.

Application insights: For the evaluation of game input devices, a laboratory setup in a big meeting room was chosen in order to have the same (pre)conditions available for all participants. The three original classes participating in the project and an additional class were invited to participate in the user study (in total 72 children aged 11–13 years). Seven playing stations with different game input devices were provided for the children to try them out in 10 min gaming sessions. These playing stations represented and provided the three categories of game input devices described by LaViola [31]: traditional input devices (the mouse and keyboard as well as the Xbox game controller), physical props (the microphone, the Wii Balance Board, and the Wii Dancemat), and for 3D tracking (the PlayStation Move Controller). Additionally, the recognition of facial expressions was provided as an input device for body-based interaction. Unfortunately, kinect was not available at the time the user study was conducted. As there is no game available, which can be used for all the different game input devices, the trial mini-games were used that are provided from the respective producer that demonstrated best the usage of the different game input device. Nevertheless, the SFQ proved to be valuable to evaluate the experienced fun of different game input devices within the laboratory setting (taking limitations like the played game into account).

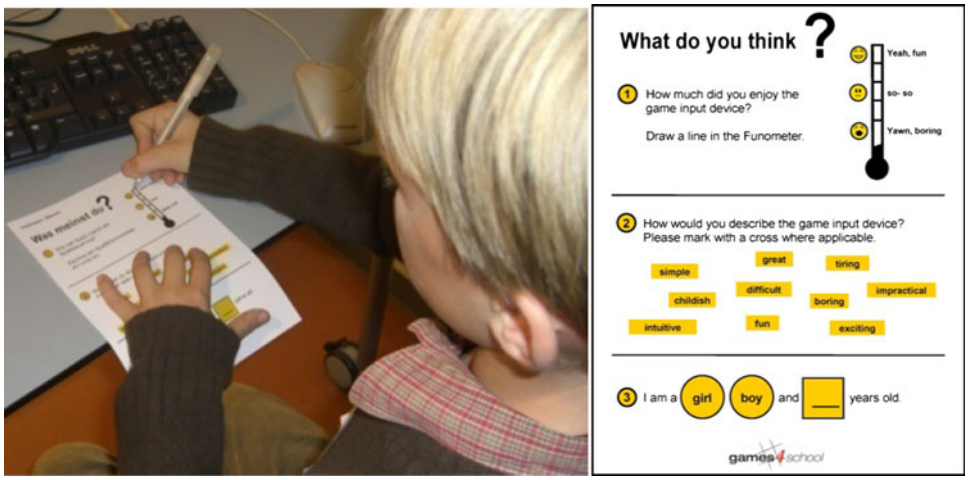

Fig. 4 A boy filling in the SFQ

The 72 children ($M = 45$, $F = 27$) between 11 and 13 years (mean age 11.8 years) filled in 497 questionnaires (seven questionnaires were missing). The concrete sample is indicated by N (number) for each part of the analysis. The following results allow only a limited interpretation, as the researchers are aware of the fact that the data might be biased by the chosen trial mini-games. As mentioned before, it was not possible to use the same game for every input device. Thus, the children might have evaluated not only the input device, but to some extend also the trial mini-games they were playing. The results of the "Funometer" revealed that 70 % of the children ($N = 70$) experienced the Balance Board as very much fun "yeah, fun", 50 % of the children ($N = 72$) rated the Xbox controller, as well as about 50 % ($N = 71$) rated the microphone as very much fun "yeah, fun". The Wii Balance Board, Xbox controller, and the microphones were perceived as "great" and "fun" (assigned attributes). Furthermore, 50 % of the children ($N = 72$) experienced the PlayStation Move Controller as very much fun "yeah, fun" and assigned the attributes "great", "fun", and "exciting". According to these findings, the following user requirements were derived for the project.

The Wii Balance Board, which 70 % of the children experienced as very much fun, seems to be very suitable for breaks in school. It offers a variety of exercises like sitting, kneeling, or standing on the board for being active and forgetting about (stressful) everyday school life. The same can be assumed for the PlayStation Move Controller. The traditional Xbox game controller (and thus the presumably the Wii controller, which was not evaluated separately) is also considered as a suitable game input device for breaks in schools, as half of the children rated the Xbox game controller to be very much fun. As the games will be played during the break in school, the microphone is considered as not being suitable because of the associated noise, although 50 % of the children had a lot of fun. Our observations revealed that most of the children were not familiar with the dancemat resulting in a not very high fun rating (only about 35 % of the children indicated to have very much fun), but it provoked curiosity. Similar to the balance board, this game input device offers the possibility to be active during breaks in school and is therefore also considered as an interesting game input device.

2.3 Conceptualization phase

In the conceptualization phase, personas are created with the collected data of the analysis phase. Additionally, different game concepts are brainstormed, and one specific game concept per class is further developed referring to one or more personas.

2.3.1 Child-game personas

Personas are used to represent the target users in the conceptualization and design phase. They are descriptions of imaginary people created out of gathered data, which aim to help developing technologies that real people will use. They are "fictitious, specific, concrete representations of target users" [43], enhance and make assumptions about users, explicit and place the focus on specific users rather than on all. They also help developers and researchers to make superior decisions appropriate to the target group and support the engagement of the design and development team. Based on the assumption that current methods of designing interactive technologies for children do not adequately consider children's needs and developmental abilities, Antle [1] developed a methodological framework for designing child-based personas. She uses theoretical, empirical, and experiential data for creating the personas. The challenge of Antle's personas is to translate theories from psychology to concepts, which are useful in interaction design. The child-game personas focus on school

children that are between Antle's child-based personas (children aged 8–12 years) [1] and Cooper's "adult personas" [11]. Therefore, a new approach can be tried out with children to gather data for the persona creation [37]. Different approaches to create personas and their suitability are described in [38].

The data to create the personas can, for example, be gathered with the above-described probes study. The triangulation of the investigated data allows being more confident about the collected probes material and provides workable, as well as sufficient, qualitative and quantitative data to create personas. If the probes material consists only of qualitative ones, the mapping for the personas needs to be done by the researchers through grading each participant against the variable range [11]. Within the probes study, this step is done by the participating children through working with the probes material, for example, by rating their behavior according to the items given in the probes material. By applying a cluster analysis on the quantitative data, different clusters can be identified. The most distinct variables of the quantitative data are the starting points for summarizing data to describe the three according personas. The qualitative data is finally assigned to the respective clusters and used to enrich the data for the persona creation. For more information see [37].

The children in the next step are responsible to create fictive personal descriptions with the summarized data of one cluster. Personal descriptions they learn to compose in their writing and reading class. Through the integration of this approach, in the writing and reading class, the teachers are actively involved in the project and take over responsibility (if they are willing to). Groups of two or three children receive the summarized data for the different research questions and an empty pre-structured template to create a personal description (see Fig. 5). They form sentences in a narrative way with the provided data for the different section of the persona. The researchers use these personal descriptions from one cluster to create one child-game persona using the narrative phrasings of the children in order to make the persona authentic (see [37] or Fig. 6). The collected data enables the children and the researchers to generate representative and expressive personas. These can be used in the following to focus in the game concept creation on children's behavior, needs, preferences, etc.

Application insights: The group work in pairs enabled the children to extend their knowledge about personal descriptions through active and collaborative learning. Each group was responsible to create one description, which was finalized in their reading and writing classes. In the following, an example is given of how children created the personal descriptions. The quantitative data of the cluster showed that this group of children (named Tobias in the final persona) favors the mouse and the keyboard as input device. This finding was provided to the children and is the basis for this narrative sentence: "preferably Tobias controls computer games with mouse and keyboard" (see Fig. 6). Another example for qualitative data was the places Tobias likes to play certain games or the locations he does not like to play at all. By taking a closer look at probes material (in this case the location map) for this cluster, the researchers found out that Tobias likes to play in the garden, basically tag or soccer, and that he does not like to play in the kitchen or on the street. Furthermore, the data from the (post)cards was used to find out about the reasons why Tobias likes/dislikes some places. The creation of child personas using the probes material and the personal description approach worked out satisfactorily with the children. For the different game ideas, different personas were selected, which were addressed during the creation of the game concepts to consider, for example, the likes/dislikes of the targeted children.

2.3.2 *Game idea booklet*

In order to develop a game concept, the game idea booklet was developed. It is based on the brainstorming method [54], which is an individual or group process for generating alternative ideas or solutions for a specific topic. A booklet is chosen as it looks more proper than simply stitched together pieces of paper. Furthermore, it is designed to look

	Name: **Age:** **Place of Residence:** **School:**
Games: Which games are children playing? Do children play alone or in groups? With whom do children play?	
Playing Venues: Where do children like/dislike to play?	
Playtimes: Where do children like/dislike to play? When are children not allowed to play?	
Game Features: What is important in games? Which elements are important? Why do children stop playing? Which rules are important? What is the best way to explain rules? What is the favored input device?	

Fig. 5 Persona template with W-questions

like a manuscript in order to motivate the children to carefully think about their game idea, and document it in an appealing way.

In the game idea booklet (see Fig. 7), brainstorming ideas are written down or drawn in small groups of two to three children. These relate to different topics concerning a specific game idea (e.g., title, idea, goal, course of the game, motivation, rules, characters, opponents or obstacles, controller). The game idea booklets can be used in the following to create PowerPoint presentations to explain the different game ideas to the other children. Afterwards, a voting can be done to find one game idea per class that will be refined, designed, implemented, and evaluated in the next steps within the project. Therefore, a poster can be prepared with all of the game names on it, and each child should receive a sheet of paper to write down one game name. They are not allowed to vote for their own game.

Application insights: The game idea booklet enabled the children to actively discuss the different topics and develop a first draft of their game idea. As the booklet looked very professional, most of the children were very careful in filling it in, which made them proud of their idea. The notes in the game idea booklet formed the basis for the children to explain their idea to the researchers, and they could ask additional questions to strengthen the idea. The structure of the game idea booklet also enabled the children to make a structured PowerPoint presentation about their idea. This means that the same topics were presented for the different ideas, which made the voting for one game idea easier.

2.3.3 *Concept creative thinking*

After one game idea is chosen, the game concept needs to be advanced (extended and reconsidered). Therefore, the concept creative thinking approach is applied that builds on the mixing ideas technique [21] and also the brainstorming method [54]. This approach can be seen as the follow-up to the game idea booklet approach that enables reflective learning. The different parts of the game idea are refined by brainstorming in small groups of two to three children on one topic (e.g., title, idea, goal, course of the game, motivation, rules, characters, opponents or obstacles, controller). Before the children start with the brainstorming, future game developers (e.g., master students) can give an inspiring lecture about game development and design. This is important within the game conceptualization in order to

Name: Tobias
Age: 12
Place of Residence: Graz, Austria
School: Second grade student in secondary school

Games:
Tobias prefers playing **games of skill or action** on the computer or on the console. However, he dislikes games, which primarily aim at killing and violence. On the computer he also likes **role plays**, like Sims or "Die Stämme" as long as the fellow players do not cheat or think that they are better than him. In his spare time he is also fond of **tile-based games**, e.g., doing jigsaws with his parents or playing **card games** with his friends.

Playing Venues:
In school, Tobias prefers playing ball games in the **gym** or on the **sports ground** as well as playing tag in the schoolyard. He perceives the entrance area and the corridor as being too loud, thus he rather plays in the **classroom** if the teacher allows to. In breaks Tobias does rarely play, as he is too distracted.
When Tobias is at home, he likes playing in the **child's room** a few times per week due to its coziness and quietness, so he does not get distracted while playing there. Since Tobias' game console is placed in the **living room**, he also likes playing there. Furthermore, when his friends are visiting him, they play in the living room games of dice or cards, e.g., ludo. If the weather is fine, he also plays in the **garden** with his friends, mainly tag and soccer, or card games (e.g., UNO) on the **terrace**. He does not like playing on the street, as it is too dangerous there. Additionally, he avoids playing in the kitchen as it is often very loud there.

Playtimes:
In **school** Tobias plays rather **infrequently**, except for the gym class. But in his **spare time**, on **weekends** or **holidays** he plays **up to two hours per day** as long as there is nothing else to do.
Tobias' parents do not allow him to play in case he needs to learn, has an exam on the next day or a test in school. Furthermore, he is not allowed to play when he is expected to help his parents or tidy up his room. He is also banned from playing e.g., as soon as he does not adhere to rules or is cheeky.

Game Features:
Tobias thinks that games need to be **fun** and **exciting**. Furthermore, he wishes for **good and realistic graphics**. Players should not only be able to choose their token, but also configure them by themselves. The **plot** of the game should not be repeated frequently and the **levels** should not be too difficult. Tobias prefers games, in which it is possible to collect as **many points** as possible or in which the winner is the one, who reaches the goal first and the last loses.
As soon as a game is too difficult and he cannot get further, or if the end cannot be foreseen, Tobias loses interest in the game quickly. In order to avoid this, he requests **game instructions** to be not too long and complex, but **short** and **appropriate for children** by using **understandable pictures**. He also prefers having the **rules of the game** explained within a **trial**.
Preferably Tobias controls computer games with **mouse and keyboard**, as long as the configuration of the buttons is described accurately at the beginning of the game. Several times a week he also likes playing games with a **controller**, e.g., the move controller on the console.

Fig. 6 Outline of child-game-personas [37]

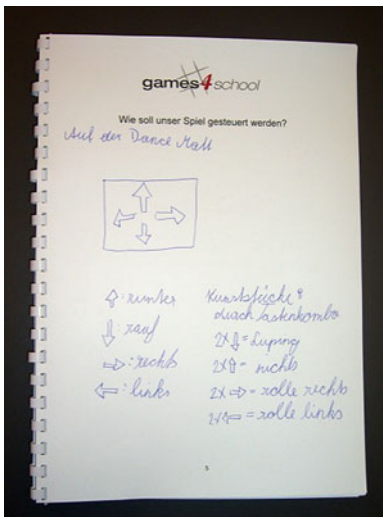

Fig. 7 Example of the game idea booklet illustration showing how the game should be controlled (with a dance mat)

get an understanding of how complex game concepts are and what has to be considered. Afterwards, the children can again be provided with trigger questions for the next round of brainstorming (e.g., game goal—what is the goal of the game and how can it be achieved? game character—what abilities does the different game characters have? game controller—how should the game character movement work?). They can take notes, make drawings, or write texts on alternatives for the discussed topics. The children in the groups of three to four children must not agree to the same thing, but instead are able to collect and discuss different alternatives.

Afterwards, the different alternatives regarding the game parts are presented to the other children and discussed with them. The children should be instructed that the presented ideas are a starting point for discussion and that new ideas can be created. Agreed ideas for the game concept (that more than half of the children liked) are noted down on a poster to create one big vision (i.e. mix the ideas). At the end, another round of discussion should be done to see whether the agreed parts of the game ideas really fit together, which means that sometimes modifications are necessary. The presentation order of the topics is highly relevant for the flow of the game conceptualization. The following order should be used: (1) the goal, (2) the course of the game (storyline) and environment, (3) the game character, opponents, or obstacles, (4) the game controller and interaction, (5) the game rules, and (6) the name of the game. The discussions and decisions can also depend and build on each other. If another order is used, there might be repeated discussion on ideas for several topics.

Application insights: As the researchers in the project were not professional game developers, they invited master game design students to give a talk about game development, which aimed at inspiring the children to create good game concepts. This approach also enabled children to actively learn how to develop good game concepts. The discussions after the concept creative thinking were also very fruitful, as the other children got inspired by the presentation of the different ideas and sometimes also came up with new ideas. If the children could not agree on an idea, a voting was performed. For the researchers as well as the teachers, it was great to see how the concept of their game idea grew and how the children were involved in this process.

2.3.4 Game concept description

After the concept creative thinking, the children are asked to write proper game descriptions, which they learn in the reading and writing classes. Therefore, the poster of the concept creative thinking approach is transcribed, and hand-outs are given to the children in order to work with the agreed and mixed ideas. The goal of the game concept description is to create texts describing, for example, the goal, interaction, procedure, rules, or needed material for the game.

These texts are then used to create a merged game description, which should have the length of one to two A4 pages. It can explain and contain everything that has been agreed upon. This game concept description can be used for a proof of concept evaluation with game experts in the evaluation phase (e.g., to find out whether the idea lacks in certain game aspects or the game play might cause problems). Special attention needs to be given to the description of the game goal and the course of the game. Otherwise, the experts will have a hard time in understanding the game idea, and a lot of questions will arise. The game concept description can also be hung up in the classroom, as children tend to forget things easily, if the information is not needed immediately or of great importance.

Application insights: For the preparation of this approach, the researchers asked the teachers of the reading and writing classes to repeat how to write game concepts with their classes. The teachers confirmed to the researchers what was covered in the classes in order to avoid confusing instructions while writing the game concepts. In the first step, the concepts were written by hand, and afterward, a clean copy was made on the computer in the reading and writing classes. Those copies were sent from the teachers to the researchers, which simplified the process of merging the game concepts.

2.4 Design phase

Once the game concept is finished, the design phase can start, where storyboards, design sketches, low-fidelity

prototypes of the game concept are developed. Suggestions for game characters (see Fig. 8) and levels (see Fig. 9) are made mainly in drawing classes, together with their teachers and researchers (e.g., for the game levels collage material is provided).

2.4.1 Game progress storyboards

After the game characters and level design, the menu design can be investigated with storyboards in small groups [29]. Storyboards are typically used in the film industry for sketching or mocking up shots before they are actually filmed. They are also used for concept sketches or mock-ups of game levels (see [27, 49]). The game progress storyboards aim at illustrating specific progresses (e.g., in menus) or highlighting certain aspects within games (e.g., game play scenes). One advantage of using these types of storyboards is that they allow children to experiment with changes in the storyline of the game and discuss, as well as describe, different outcomes.

As an example, the game progress storyboards can be used to describe menu procedures (see Fig. 9). The children describe, on the right hand side, the interaction with the interface as well as animations of interface elements for the designers and developers. In order to support the children during the creation of the progress storyboard, they can be provided with important aspects of menu design that need to be considered (e.g., selection of difficulty level, game world, or amount of players). For the implementation of the games, the storyboards were very useful for the designer, who merged the ideas and created one menu with recognizable elements of the storyboards.

Application insights: The problem here was that most of the children had a hard time being creative in menu design or made very similar storyboards. Therefore, the researchers recommend asking the children in advance to take a look at the menu design of the games they play. Nevertheless, some children were really creative, such as the first storyboard in Fig. 10. Notes on the side stated that the sun should be in a different place on every screenshot (e.g., the course of the sun from morning till evening). On the third storyboard, the children mentioned that the planes should fly into the screen from different directions.

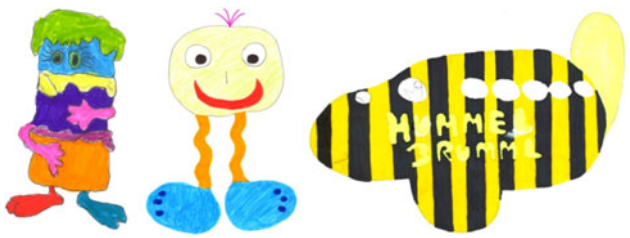

Fig. 8 Example game characters for the three games

2.4.2 Creative low-fidelity prototyping

At the end of the design process, creative low-fidelity game prototypes can be developed. The goal of creative low-fidelity prototyping is to create tangible game prototypes in groups of four children, which are sketchy, incomplete, and quickly built working models. Druin [13] mentioned in her work that "there is never a need to teach people how to prototype, since using basic art supplies comes naturally to the youngest and oldest design partners." Nevertheless, children need a starting point for prototyping [50] and therefore, started with the creation of a game progress storyboard to illustrate a short sequence of interactions within the game and build the according game prototype. Similar to Knudtzon et al. [29], the children are provided with Playmais, Playdough, Lego, and other creative material to create prototypes. The prototypes are used to illustrate parts of game levels (see Fig. 11) and reenact scenes of the previously created game progress storyboard (as explained before). The children can try out game procedures/mechanics and actively discover problems or challenges in the game play. For very complex game concepts, the low-fidelity prototypes might be problematic, as the implementation might be too difficult or simply impossible.

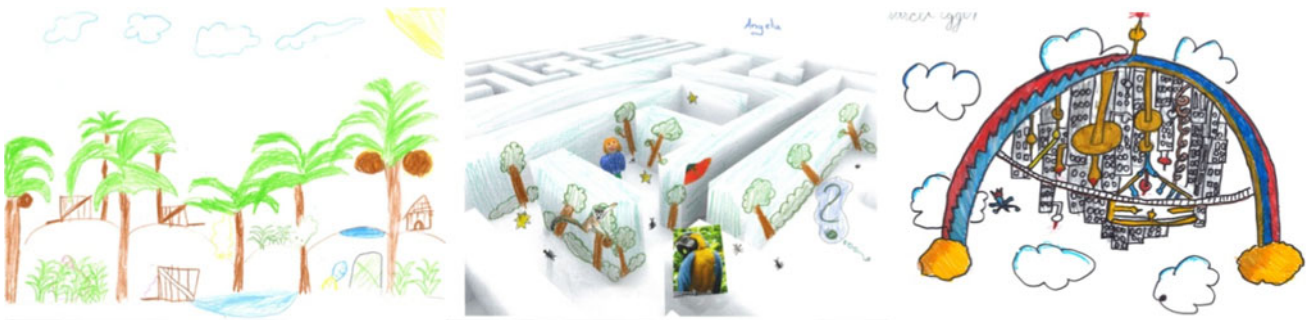

Fig. 9 Example game levels for the three games

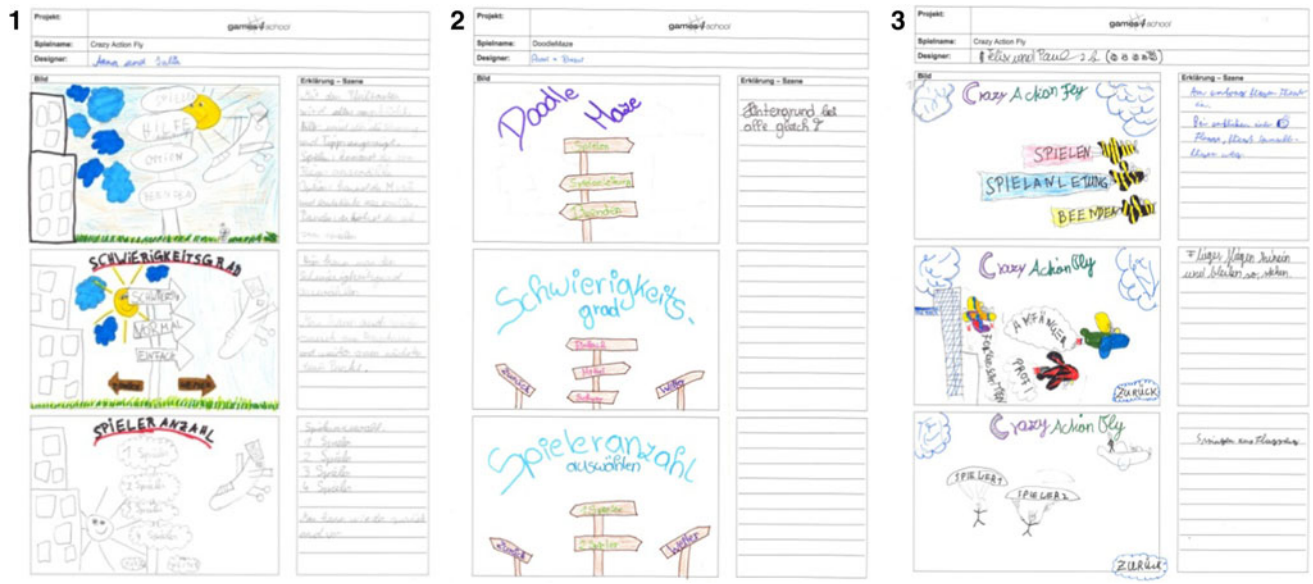

Fig. 10 Three examples of a game process storyboard showing. **1** The start screen, **2** the selection of the difficulty level, and **3** the selection of the amount of players

In the end, the creative low-fidelity prototypes are filmed, while the children played the gaming sequence of the game progress storyboard for the others. Afterwards, the other children can ask questions, make remarks, or improvement suggestions. These videos can be used to envision the game ideas of the children for the designers and developers, if they are not able to attend the creation process of the prototypes done by the children.

Application insights: This was the activity loved by the children. Therefore, the researchers decided to give the children more time in the project to work on their prototypes. Instead of one project day, two were spent on creating the prototypes and producing the video clips. The videos enabled the game designers and developers (master students) to get familiar with the different game ideas, as they were not involved in the project so far. Afterwards, the different material that was produced before with the children (e.g., game characters, game levels, game progress storyboards) was discussed with them. Together with the researchers, they decided how to prototype the game. As the researchers were present in most of the activities in the project, they knew what was especially important for the children. Therefore, they should guide and monitor the prototyping activities.

3 Lessons learned

Overall, the experiences of the Games4School project confirm that the CCGD approaches are suitable for involving children into the development process of games in the context of the school. The children were able to define and collect data in the analysis phase, to create game concepts in the conceptualization phase and to design valuable input in the design phase for the prototyping phase. In the following, the most important experiences when applying the CCGD approaches are highlighted:

- Before starting to work with the children, it is essential to get to know each other. The researchers should introduce themselves and afterwards have an icebreaker (e.g., asking them about their expectation of the project, finding out why or why not they are curious about the project). In a next step, the researchers need to get familiar with the user language (e.g., which words do they know and use); otherwise the children will have problems in understanding the researchers. The proposed idea cycle can provide valuable insights.
- The combination of educational principles (by Hinze-Hoare [22]) with UCD and PD approaches supported practice-based learning, meaning that the children learn to apply their knowledge through the participation in the game development process and also gain new knowledge (e.g., analyzing data). Children are also enabled to actively contribute their knowledge from educational approaches (e.g., applying personal descriptions in the child-game-persona approach).
- In order not to lose motivation, each approach should be split up in the steps/tasks, topics, questions, or explanations in case of unknown terminology. Furthermore, it is essential to give an introduction with clear instructions to the class to reach the defined goal of the

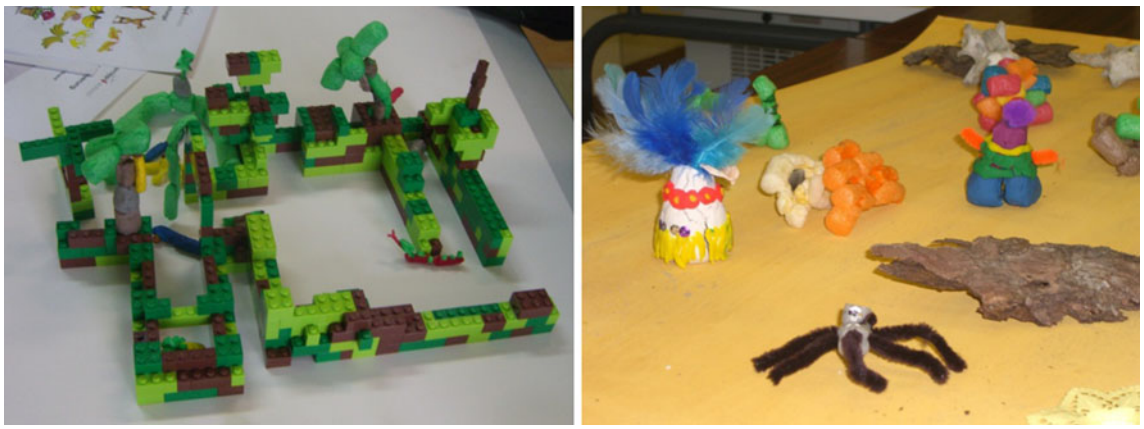

Fig. 11 Two example of creative low-fidelity prototype illustrating parts of the game world

approaches. During the group work phases, there is also the need to provide ongoing support for each group. As soon as the children know what to do, they are very creative and develop many interesting ideas. For example, in the concept creative thinking approach, the children were told in the first step to work in groups on the different topics and generate ideas that will be discussed afterwards with the others. For the different topics, trigger questions were provided to promote autonomous work and active learning.

- Small groups of two to four children are most suitable for the CCGD approaches and have the advantage that less time is needed (e.g., for brainstorming), but the benefits of group dynamic processes are not lost.
- When working with children, it has to be considered that they get bored faster than adults and require variations. Thus, the different CCGD approaches should not last longer than about 30–40 min to have the children concentrated throughout the whole development process. Except for the creative low-fidelity prototyping that can be extended up to 120 min.
- As the project days in school were distributed over 1 year (i.e. 1 project day/month), the children tend to partly forget the work that has been done so far. Therefore, it is helpful to let the children reflect on the previous and future work within the project at the beginning of a project day.
- Due to tests and exams, the children are sometimes already very exhausted or not motivated when the project day is starting. Therefore, it might be necessary to change the planned tasks/approaches and have backups in mind that can be performed (i.e. a certain degree of flexibility and creativity is needed when working with children).
- The CCGD approaches will work best, if a research-education cooperation is setup between the researchers/game developers and the cooperating school. Therefore, it is necessary to schedule the responsibilities of each party in advance.

More lessons learned will follow once the CCGD approaches for the prototyping and evaluation phase are developed.

4 Conclusion

The need for child-centered design methods for game development is there. Despite some minor difficulties when working with the children, the CCGD approaches were rewarding in terms of the created mini-games prototypes. They proved to be fun in the first evaluation with more than 600 children and are currently iterated for the final evaluations. The children were enabled to learn how much work and fun the development of games is. One male student stated "… I did not know how much work needs to be done in order to create a game, that is why I see now games from a different point of view …" They also learned how to practically apply learning content from different classes (e.g., reading and writing classes or computer classes).

The CCGD approaches described above for the analysis, conceptualization, and design phase were successfully applied to develop mini-games with entire school classes in the context of the school. They should illustrate how an active involvement of school classes throughout the different UCD phases can look like. Not all of these approaches need to be applied in the presented order. Rather, they should be seen as part of a collection of approaches for the whole game development process. Although some approaches seem to build up on each other, most of them were developed to be applied independently, but can easily be combined. For the prototyping and evaluation phase, further CCGD approaches will be developed. All approaches together will result in a CCGD framework, which should be seen as complementary to research of UCD and PD.

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