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Evaluating First Experiences with an Educational Computer Game: A Multi-Method Approach

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Abstract. This paper presents our evaluation approach for a specific case study, namely the evaluation of an early prototype of an educational game with children aged between 12 and 14 years. The main goal of this initial evaluation study was to explore children's first impressions and experiences of the game on the one hand and to assess the students' ideas and wishes for the further development of the game on the other hand. The main challenge for the evaluation activities was the selection of the appropriate methodological approach, taking into account children as a special user group. We opted for a combination of different, mainly qualitative and explorative methods that were reported beneficial for work with children in the human-computer interaction (HCI) field. By presenting our multi-method approach, in particular the different steps and procedure within our study, other researchers can get inspirations for follow up activities when evaluating games with children as well as benefit from our experiences in exploring more collaborative methods and methodological combinations.

Keywords: User Experience, Methods, Evaluation, Children, Educational Computer Game, Peer-Tutoring, Co-Discovery Approach.

1 Introduction and Motivation

Games have always been a powerful mediator for learning throughout the whole life [1]. In the past two decades efforts to create computer games for learning have continually increased, with the goal to provoke active learner involvement through exploration, experimentation, competition and co-operation. Although the effectiveness of computer games in education is widely discussed, also with respect to serious games [2], many studies report that computer games are an engaging medium for learning and can stimulate cognitive processes like reading explicit and implicit information, deductive and inductive reasoning, and problem-solving (e.g. [3, 4]).

Apart from an elaborate pedagogical concept, iterative development, user-centered design and the pursuit of a good user experience (UX) of the learner are essential to make educational computer games successful. User-centered design ensures that needs, requirements and expectations of the target users are incorporated into the design and development iteratively. Finally, putting the experience of learner into focus of the design enables the development of a game that truly delivers the desired experiences.

Within this paper, we present the evaluation of an educational game prototype called Augmented.EDU as part of an iterative design process, focusing on game design and development. The Augmented.EDU game deals with renewable energy as learning content for students aged between 12 and 14 years. To fit the needs of this specific target group as well as to reach the goals of user experience assessment and game co-design, we introduced a multi-method approach. Although the game is intended to support learning purposes (i.e., acquiring new knowledge through playing the game) on the long-term, the goal of the presented study was, however, directed towards the exploration of the initial experiences children have with the game. Previous research highlights that first impressions and experiences often define people's long-term attitude towards a technology [5]. Starting from user experience as a main research focus within the game development process, we were particular interested on how user experience could be investigated, and what methods would be appropriate when targeting children. Thus, the research goal and guiding questions can be summarized as follows:

- How to explore children's initial user experience with an educational game prototype?
- How to elicit input from children for the further development of the game regarding design, functionalities and features, and possible contexts of use?

Within the following sections, we will first give an overview on related work concerning the evaluation of games for children. Next, we introduce the educational game, which was the object of the evaluation. Then we describe the evaluation set up, including a description of our study participants as well as a description of the evaluation procedure. This is followed by a detailed description of our methodological approach. Further, the evaluation results are sketched to illustrate the potentials of our approach. We finally conclude with insights gained during our case study and lessons learned on the selected methodological approach for evaluating children's experiences.

2 How to Investigate Children's Experiences

To design educational games three important issues should be considered: educational theories, game design and game development [6]. Moreover, the impact of an educational game needs to be assessed. Currently, the assessment of educational benefits of the game is primarily a pedagogical research field, while the evaluation of the game design and the development are rooted in Human-Computer Interaction (HCI) and its methods. Within HCI, different approaches for evaluating games exist [7] that have also been used for to the design of educational games. Additionally, HCI

has a tradition of investigating research methods for the design of technologies with and for children (e.g., [8] [9] [10] [11]), with a distinct conference devoted to this topic (IDC - International Conference on Interaction Design and Children). Different methods have been developed and studied over the last years. Hanna et al. [11], for instance, studied how to evaluate computer game concepts. The children had to answer questions and explain their views, as well as rank ideas and rate game concepts on a scale.

A detailed comparison of different methods was conducted by Edwards and Benedyk [12]. With the aim to evaluate an educational game for children aged between 6 and 10 years in terms of usability they compared three different methods: active intervention, peer tutoring and cross age tutoring, summarizing that peer tutoring offers the highest potential. Its basic idea is that children teach one another how to play a game and thus reveal information on usability issues. Hoysniemi et al. [13] come to a similar conclusion. To get suggestions on improvements regarding the design of an interactive game for children, they stress the peer tutoring method. Van Kesteren et al. [14] regard the method as useful to evoke verbal information on how the game is perceived.

A method to investigate UX of children is the co-discovery method. It enables two children to co-operate in performing tasks and express their opinions. The aim behind this method is, that children can talk in a more natural way to each other, which proved to be more valuable than a think aloud session [14]. Multi-method approaches in HCI especially rely on both, quantitative and qualitative data. For measuring user experience of educational games, Ardito et al. [15] used observation, focus groups, analysis of essays and drawing to gather qualitative data and questionnaires, multiple choice learning tests and behavioral analysis to get quantitative data. They stress, that qualitative data allowed them to get insight into results that only quantitative data would not have allowed.

The aim of our study is to evaluate a first educational game prototype with regard to children's initial UX. Furthermore, input and feedback for the further development of the educational game with regard to design and functionalities should be gained. Thus, we selected a multi-method approach enriched with co-design methods, which have already proved to be valuable in previous research for exploring additional user needs [16], also including educational games [17].

3 The Game Prototype and Study Set Up

In this section, we give a short overview on the evaluated game prototype and the conducted study set up and procedure.

3.1 The Augmented.EDU Game

The overall topic of the developed educational game prototype is the up to date and urgent issue of ‘renewable energy’. The concept of the game – an important part of the game design - is an adventure story, where the player (child) comes back to the

abandoned earth in a far future in order to reactivate power plants based on renewable energy to prepare the return of mankind. The aim is that children learn about the different kinds of energy production that use renewable energy sources, about how the technologies work and what limitations they have.

The evaluated game prototype (see Figure 1) enables the player to control a robot character in a virtual PC-based environment. Toggling between a third and first person perspective, the player explores the environment of the game and finds himself or herself confronted with a series of challenges. Using simple control mechanisms, the player can make the robot move through an area, look at and learn about objects, collect certain items, and use them in order to complete the given missions.

The gameplay, background story, and puzzles are embedded in a narrative framework that allows the players to acquire more and more knowledge as they make their way through the game from one challenge to the next. The interactive 3D environment (realtime 3D technology) enables exploration, participation, and hands-on experience to trigger intrinsic learning. The game can also be played online. Here, the key feature is an online user profile connected to top social media platforms.

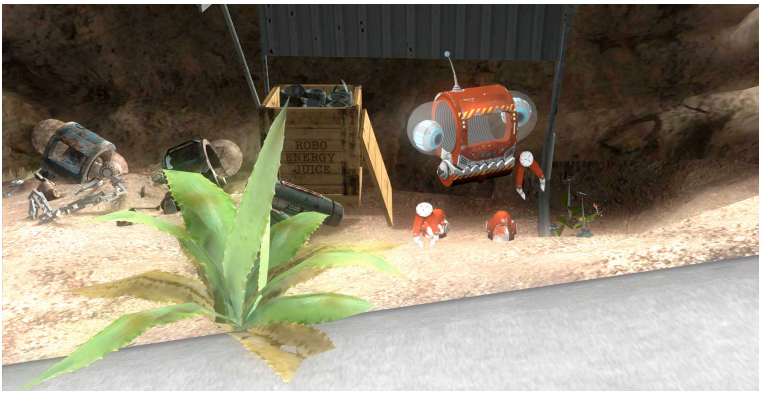

Fig. 1. The Augmented.EDU Educational Computer Game

In order to integrate the pedagogical perspective right from the beginning, the design concept was developed together with a physics teacher. Apart from delivering knowledge on renewable energy, the game should also enable non-native English speaking children to improve their English skills. Thus, the user interface and the game itself were in English.

3.2 Pre-Evaluation

Prior to our user experience study a pre-test was conducted to ensure that the prototype was running stable. 21 students aged between 12 and 14 years took part in this pre-study. The students reported several stability problems, which were addressed and eliminated for the final study. The pre-study also allowed us to check whether or not the students understand the storyline, the interface elements and the goals of the game. A proper understanding of the English language used in the game was a

prerequisite to conduct the evaluation and provide valid data on UX. Therefore we created a short questionnaire with closed and open questions, such as rating the difficulty of the language used in the game, as well as letting the children shortly describe the game story. The questionnaire revealed that the students in general understood the story of the game and its concept.

3.3 Study Participants and Procedure

The user study involved 12 participants (5 female, 7 male), aged between 12 and 14 years (mean = 12.7). The parents were previously informed about the study goals and procedure (info sheet) and provided us a signed informed consent. The informed consent comprehended the allowance to participate in the study and agreement to use the recorded materials for further analysis as well as the publication of selected pictures for scientific purposes. Out of all 12 participants, 9 children attend a general-education secondary school, and 3 a grammar school. None of the participants took part in the pre-study mentioned above. All participants indicated to have German as their first language and to have at least basic knowledge in English. As main activities on the Internet they named chatting and gaming. The participants further stated to regularly play games on a console and computer. Thus, all participants were familiar with computers and games.

The study was conducted with groups of either two or four children (mostly friends, which know each other). As the recruitment process was challenging we extended the initial defined two children group set up towards four children groups. The evaluation sessions were performed at the premises of our research institute as well as once at a youth center. In total, there were four groups; two groups consisted of two children and two groups consisted of four children. Two researchers conducted the evaluation and led the children through the two hours evaluation sessions. The detailed methodological approach and each step in the evaluation of the game are described in the following section.

4 Multi-Method Approach

Finding an appropriate methodological set up to evaluate an educational game for children is challenging. The procedure has to balance task-based activities and creative collaborations between the children embedded in a comfortable atmosphere.

4.1 Methods Used and Evaluation Phases

Based on the findings of Ardito et al. [15] we designed a multi-method approach to get insights on the children's initial UX on the one hand, and to elicit their feedback for the further development of the education game. Mainly collaborative methods, i.e., peer tutoring and co-discovery were chosen. These methods allowed children to work in pairs for exploring the game. The focus is set on explaining the game to a

peer and jointly uncovering different levels of the game instead of reporting experiences to the scientists.

In addition to these verbalization methods, we observed the children's gaming behavior, and integrated methods of self-reporting to let the students express their first experiences when interacting with the Augmented.EDU prototype. To capture the first game experiences in a quantitative way, we used the Kids Games Experience Questionnaire (KIDS-GEQ) developed by Poels et al. [18], which proved to be useful but still needs further validation. For collecting ideas how to further develop the game we used a co-design inspired approach. This creative phase was not only intended to answer the second research question, but also to provide the children an interesting and enjoyable evaluation end, following previous research stating that evaluation with children should be kept short, writing should be limited, and it should be made fun as well [19].

Overall, the study was structured in eight phases, involving free exploration, peer tutoring, co-discovery, co-design, feedback cards, and questionnaires. During all phases the children collaborated to solve tasks, allowing constructive intervention – natural thinking-aloud [20]. The only exception was phase 3, in which the children were separated and had to either fill in a questionnaire on their gaming behavior or to explore the game on their own for the following peer-tutoring session. The kids game experience questionnaire, which we used in phase 6, was filled in by each child on its own. Below a detailed description of each phase is given.

Table 1. Phases and Used Methods in the User Study.

	Phase & Objective	Method Used
1	Welcome & Introduction	-
2	Gathering of demographic data	Questionnaire
3a	Single (1 kid) exploration	Free exploration
3b	Investigation of gaming behavior	Questionnaire
4	Impressions and understanding	Peer Tutoring
5	Co-operative (2 kids) exploration	Co-Discovery
6	Feedback on the game experiences	KIDS-GEQ, Feedback cards
7	Ideas & wishes for design	Co-design
8	Debriefing	-

Phase 1 – Welcome & Introduction. In the first phase, the two researchers conducting the evaluation welcomed the participants and introduced themselves. Further, they gave an overview on the goals and procedure of the study and collected the agreement forms, which were previously signed by their parents.

Phase 2 – Demographic Questionnaire. Some basic demographic data was collected with a short questionnaire. The following information had to be specified by the participants in order to understand their pre-experiences and daily technology usage: sex, age, type of school, knowledge of languages, and media usage habits (usage of PC, laptop, internet, games on the computer and consoles).

Phase 3 – Free Exploration & Game Behavior Questionnaire. In this phase (approx. 10 minutes), the groups were divided: one child was staying in the room and explored the game on the PC, whereas the other child was guided into another room,

where he or she filled in a questionnaire on gaming behavior. The first child played the first level of the game that introduced the player into the story and had a duration of approximately 10 minutes. Observing the child we saw how children initially explored and handled the game (phase 3a). The questionnaire was primarily designed to collect insights into the gaming behavior of the target group. It consisted of six questions with pre-defined answer categories, and of six open questions. The closed questions asked for example which games they play, where or with whom they play how important games are for them, which game they like most, etc. The open questions dealt for example with prior experience with game-based learning, and desirable application areas of educational games (phase 3b).

Phase 4 – Peer Tutoring. In this phase, we adopted the peer tutoring method to get insights on the first impressions and the understanding of the Augmented.EDU game. In a first step the child being tutor shortly narrated the game story and goals, and in a second step taught the other child how to play the game walking it through the first level. In both steps the tutor children verbalized their first experiences. We observed the tutors' explanations, expressions and game behavior, and additionally audio recorded their comments. Together with the observation notes of the researchers the transcriptions provided rich qualitative data on tutor-children's first experiences. The results provided insights on how well the game was understood and liked by the tutor, and which adjectives they used for describing the game as well as which difficulties the other child had to understand the game play. The peer tutoring lasted about 10-15 minutes.

Phase 5 – Co-Discovery. After the children had gained a basic understanding of the game in the tutoring phase (aims of the game, basic functionalities provided, operating of the robot), the children were invited to play the next level of the game together, alternating the one being in control (duration about 30 to 40 minutes). The children cooperatively explored and played the Augmented.EDU game, very often commenting and discussing the game. In this phase we got deeper insights on experiences, behaviors and difficulties of all stages by observation.

Phase 6 – KIDS-GEQ & Feedback Cards. This phase was intended for getting insights on how the children retrospectively experienced and judged the Augmented.EDU game. Therefore, the children were first handed out the KIDS-GEQ [18]. This kids game experience questionnaire is a self report instrument to assess in-game experiences of children, consisting of seven game experience dimensions (immersion, tension, competence, flow, negative affect, challenge, positive affect). It provided us with a quantitative means to assess the game experience in its major dimensions. The results of the questionnaire should complete the recorded as well as observational data. After each child had completed the KIDS-GEQ, we handed out feedback cards with a short, open question and pictures taken from the game (e.g. the robot) on each card to the children. The children were asked to fill out all cards they liked together. The different feedback cards prompted the children for input concerning positive and negative aspects of the game, as well as suggestions for improvements of the game and other comments. The main purpose of the cards was to encourage the children's reflection and stimulate a discussion between the children. They also revealed what game elements stayed in mind and/or were considered important by the children. Thus, we could gain more insights on how specific

characteristics of the game were experienced, completing and approving the recorded as well as the observational data.

Phase 7 – Co-Design. In this phase, a creative co-design session revealed insights for further design improvements and the integration of additional features. To visualize the ideas and suggestions for improvements, the children created a poster. The poster was pre-structured into three areas for stimulating the idea generation process: game-design and functionalities, the story and topics of the game, and environment and possible contexts for playing the game play. The children received crayons and post-it notes to collect their ideas. The researchers proposed to use the filled in feedback cards from phase 6 as a starting point and discuss their ideas and thoughts concerning the 3 areas. During this phase the researchers actively interacted with the children by asking questions (e.g., remember when you played the game, what did or didn't you like? What do you miss?). Thus, the poster creation presented a lively and funny end to the evaluation session.

Phase 8 – Debriefing. In this final phase the researchers summarized the evaluation session shortly and thanked the participants. Finally, the children received a little present (a voucher for cinema and popcorn) acknowledging their participation.

5 Study Results on Children's First Experiences

In this section, we give a very brief overview on our findings to illustrate the potentials of our multi-method approach, being aware of the small sample size of our study. Overall, the children's first impression of the game was positive, indicated by the kids questionnaire as well as the data collected in the phases 3 to 5. Especially the peer tutoring phase revealed insights on how the game was perceived in terms of first impressions. Moreover, the game was, for instance, described as "it's quite funny", "especially the robot is funny", but it was also mentioned to be challenging to play: "at the beginning… the introduction was a bit boring", "I just managed to fulfill one task". We further observed a high positive motivation of the children to play the game during the exploration and co-discovery phase.

Fig. 2. Co-Discovery Phase during the Evaluation Session

During these phases (3 to 5) we could observe that longer instructions or explanations integrated in the game were often skipped. A reason for skipping information was that the children did not consider reading or listening as necessary for game play. This could be assumed to be a reason that children did not use certain functionalities and were not able to complete some of the tasks within the game. The discussion and observations during the peer tutoring and co-discovery sessions also revealed that the children strongly relied on their previous experiences with other games. The interaction modalities with the keyboard, especially the usage of shortcuts, and the mouse did not pose any problems for the children. Further, we observed that children explore new games mainly by trial and error and hardly paid any attention to written or oral instructions of the game.

The children's suggestions for improvements for the game were collected during the co-design phase (phase 7). The feedback cards, which were filled before (during phase 6) turned out to be a good trigger for the co-design task. For example, a card with negative issues often inspired them to give suggestions on how to improve the game, which consequently triggered other ideas.

This data collected during co-design reflect the observational results in the phases 3 to 5. For example, most of the children proposed to give shorter explanations and instructions and to make the environment more diverse. Integrating more challenges as well as different levels into the game was also requested by some of the children. This mirrors the children's desire to actively explore the game environment, an issue that was considered in the further development of the game. The results of the KIDS-GEQ (phase 6) showed that the factor “competence” was ranked highest with a mean of 3.92 (scale ranging from 1 to 5, with 5 as most positive experience), followed by the factors “challenge” (mean = 3.19), “immersion” (mean = 3.11), and “flow” (mean = 2.72). The factor “tension” was ranked very low (mean = 1.61). These results show that the evaluated game prototype gives the kids a feeling of success, challenges them in an adequate way, and is experienced as interesting.

Overall, the children's feedback was positive with regard to the game design, graphics, and narration. They as well suggested improvements, such as extending the game towards other learning subjects. The children proposed to use such a game in biology for exploring the human body “from the inside” (e.g., cruising in the cardiovascular system). During the evaluation we were in close contact with the game developers. When presenting them the results of the study, they especially liked the output of the co-design phase (posters) which provided valuable and visually appealing feedback for the game developers, providing them with ideas of what to improve or implement in a next phase of the game development.

6 Main Findings on the Multi-Method Approach

The multi-method approach revealed in-depth insights and a better understanding of how the children experience the game. The methods in the different phases incorporated different ways collecting feedback: verbalizing comments through the peer tutoring and the co-discovery, writing down the experience with the educational game on the feedback cards, discussing the game filling in the feedback cards as well

as in the co-design phase, and finally being able to draw impressions and ideas onto the poster. It has to be stated, that no generalization of the data is possible based on the small number of participants and due to the lack of a control group enabling single player experiences. However, the findings can provide some inspirations on how to involve and engage children in an early design phase by combining different methods.

Examining the different methods used within the approach, it can be stated that the peer tutoring method proved to be valuable to elicit comments about the game, confirming previous study results of [12] and [14]. Having a co-discovery phase after the peer tutoring enabled the children to explore the game in more detail. We did not observe any differences between the tutor and the tutee in handling the game during this phase. However, we did not further investigate differences of UX between the children caused due to the different roles. Instead our aim was to elicit more comments from the children on their perception of the game. This data was especially valuable for the researcher. Very often one child commented on the action of the other, or gave hints when the child playing was struggling to solve a mission. Thus, important insights on how children handle and experience the Augmented.EDU game were revealed and were considered in the overall interpretation of the data.

We could also observe that befriended pairs of children collaborated more intensively while playing the game together and gave more comments and feedback in general. Two out of the six pairs did not know each other well. These two pairs gave less feedback in all of the phases. Although the number of children is too small to derive general conclusions, this observation corresponds with the observations of Als et al. [20] that acquainted pairs of children testing an interactive product found more usability problems than non-acquainted pairs and individual testers. We are aware that the game experience differs when playing together (as in our study) and playing alone (as is the intention of the game). Nevertheless we opted for pairs of children for the positive effect of a richer verbalization of the children, and to create a comfortable situation for the children when exploring the game. Especially children often find the evaluation situation intimidating, trying to give answers they think are the right ones, negatively influencing validity of the data. Thus, a particular emphasis has to be put on the attempt to make the evaluation situation as enjoyable and pleasant as possible for the children.

The experience with the two questionnaires used within the study was twofold. The KIDS-GEQ questionnaire additionally provided quantitative data on the children's game experience, although a generalization based on the small sample was neither possible nor intended as part of this initial study. Furthermore, the experience of the educational game in the collaborative gaming setting differing from single play experience was probably reflected in the results of the questionnaire. The high feeling of competence and the low tension experienced in the game was probably influenced by collaboration with a peer. However, issues that have already been found through, for instance, the feedback cards or observations were supported by the questionnaire. Regarding the game behavior questionnaire, we had to realize that children did not like the open questions of this questionnaire. Children sometimes did not seem to know what to answer or gave rather short answers when having open questions. Having only half of the participants (and thus a very small number) fill out the questionnaire, we did not further analyze the results. In an iteration of our approach we will consider that lesson, and apply a more structured and/or creative way to ask

questions, involving both children. Additionally, we will think of another way to keep one child busy while the tutor child first plays the game.

The usage of the feedback cards after the playing sessions turned out to be useful to enable the children to re-think their experiences and discuss them together. Their written keywords on their positive and negative cards revealed to be in particular useful as inspiration during the co-design phase at the end of the evaluation session. Using some of the cards as a starting point for suggestions of improvements and further functionalities of the Augmented.EDU game worked very well. The poster created by the children in the co-design phase presented a very wide range of ideas and wishes related to our second research question. The children liked the action of expressing wishes, drawing and jointly developing ideas. From our viewpoint the creative co-design session provided an enjoyable end to the whole evaluation session, leaving kids in a good mood. The posters additionally provided some data on how the game was perceived and how it could be improved in the future.

7 Conclusion and Future Work

In this paper, we presented the methodological approach we used for evaluating an educational game with children. The goal was to apply a multi-method approach in order to explore children's initial experience with a game prototype as well as to elicit input from the children for further development ideas for the game. Investigating the learning effect was not a concern at this stage of the development. Catching children's first reactions and opinions about the game was defined to be of higher relevance within the project team at this early design and prototype phase. Overall, a qualitative and explorative methodological approach was guiding our study set up, being aware about the limitations of our study due to the small sample size. We were not aiming towards generalization, but wanted to gain deeper insights on how children express their first impressions about the game and especially what engaging and collaborative approach would be appropriate to get the children's feedback.

Children represent a special target group, with particular needs and wishes. The core element of our approach was the combination of different methods, which enables us to triangulate the data on the children's experience with the game and ensures an interesting and diversified session, which does not overstrain children and motivates them to actively participate. This turned out to be valuable, both for getting insights on children's experiences while playing the game as well as for making the evaluation session enjoyable for the children. The adoption of a mix of different methods, ranging from the use of traditional observation, questionnaires, peer tutoring, co-discovery, to creative work with the children, proved its value for a successful initial exploratory study set up. Based on our observations and post-study reflections on the study, we could already identify some areas for improvements, mainly focusing on the collaborative setting of the study and a comparison of the output of the different phases. As far as we could observe, having children involved which did know each other well, resulted in a higher engagement with respect to the expression of verbal statements. Moreover, the group setting proved to be very useful to cover the two research goals, first of all to get feedback on the game itself and

second to elicit further ideas for improvements of the game. This is especially relevant with respect to timing. Each session took almost two hours, which is quite long for keeping children focused, thus providing a changing, but still comfortable, and creative study set up, is particularly relevant.

Finally, all results were presented to the game developers to inform their further development decisions. With respect to the fact that user experience and learning effectiveness are strongly linked to each other and both parts have to be investigated in detail, future research should strive for interdisciplinary approaches, incorporating both perspectives and benefitting from knowledge of both research fields. Future studies should therefore push forward the combination of methods on user experience on the one hand and measurements of the pedagogical effects of games on the other hand. Successful design of educational computer games can only succeed, if both perspectives are considered and if the different involved disciplines get into a dialogue about the overall goal of the game and the potentials, strengths and limitations of each other's methodological evaluation approaches. Moreover it will be important to compare single and group sessions in a more natural context (e.g., at home) in order to better understand the individual experience a child has with an educational game. Thus, the learning environment itself, e.g. school, home, or mobile context, will become central in future work and will particularly influence the interpretation of study results and children's experiences of an educational game.

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