Playing educational math games at home: The *Monkey Tales* case

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A B S T R A C T

In research on educational games, the majority of studies have been executed in controlled school settings: the home as a context in which educational games are played, is still underexplored. However, the home context is becoming more important, as children are increasingly encouraged or even required to engage with learning content at home through educational games. In this article, we describe a study of *Monkey Tales*, an educational math game targeted at primary school children. Using a combination of a multimodal game analysis and a six-month user study with eight children aged 10–11 and their families, we provide a detailed account of how players interpret and appropriate *Monkey Tales* at home. We investigate to what extent players develop tactics to appropriate the game to suit their personal interests. The study showed that in the home context, respondents used various tactics to avoid educational content. We describe the implications of these appropriation tactics for the generalizability of effectivity research, and for the design of educational games.

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1. Introduction

Video games are no longer designed for entertainment only: nowadays, numerous games target goals that reach far beyond mere enjoyment. The diversity of educational and serious games – games used for purposes beyond entertainment – shows that many areas can benefit from the engaging experiences that video games offer, including educational [14] and therapeutic [32] contexts. As the popularity of video games for learning purposes has increased over the past years, research on educational games has become more extensive. Numerous aspects of educational games have been researched and evaluated. Several game design and evaluation frameworks have been created [42,59] and effects on specific aspects such as student motivation [43], learning effectiveness [27] and teacher adoption [7] have been researched. The majority of evaluative studies of educational math games have been executed within controlled settings, typically in dedicated game sessions in school classrooms [9,45]. Other contexts, such as the home context, have been underexplored [44]. Where the experimental design does involve playing math games in the home context, this context is bracketed, with evaluations based on a comparative study of a pre- and posttest [8]. Nevertheless, the home context is becoming increasingly important, as children are increasingly encouraged or even required to engage with learning content at home through educational games.

In this article, we complement existing research by presenting an in-depth, qualitative study of children's play and learning practices while playing an educational game in the home context. Through a multimodal game analysis and a longitudinal user study, we will focus on the lessons learned from one particular case study: the math game *Monkey Tales.* Using this game as a case study, we will illustrate the varied practices of children playing educational games at home. Furthermore, we want to identify the impact of game elements on playing behavior, and, especially, relate unexpected playing behavior to the influence of game characteristics and affordances, as well as to the playing context. In sum, we tackle the wider question of the relation between educational games and the home context based on the specific *Monkey Tales* case study.

We combine insight into Monkey Tales' characteristics and affordances based on a multimodal analysis, with insights in contextualized player behavior based on user research. Based on these insights, we will show how players develop tactics that oppose or subvert the player behavior implied in the game when the game content does not match the players' needs. An analysis of these player tactics allows us to formulate recommendations for the evaluation and design of educational games. Concerning evaluation, we suggest that taking into account contextualized playing practices is crucial for a good understanding and evaluation of educational games. Concerning design, we focus on how to cope with the balance between game elements and educational content.

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2. Educational math games and the home context

Recently, math games, as a specific subdomain of STEM (Science, Technology, Engineering and Mathematics) educational games, have received considerable research attention. Previous work has been reported on the design and development of educational math games [2], design principles for math games [12,13] and the evaluation of various aspects of educational games. Typically, these evaluative studies use classrooms as a controlled research environment. For instance, Chang et al. [9] studied students' engagement in reaction to a fractions app on iPod Touch, paying special attention to student gender. Pareto and colleagues [45] investigated students' mathematics understanding, attitude and self-efficacy after playing the *Teachable Agent Arithmetic Game*, while Katmada and colleagues [36] focused on the usability of the *Volcanic Riddles* game. Castellar and colleagues [8] studied cognitive abilities and math performance in a longer-term study in which students played the commercial math game *Monkey Tales* at home.

While evaluative studies have focused on aspects such as usability, learning effects, and engagement, research into educational games in general, and educational math games in specific, has not looked in detail at the effects of the context in which games are played. Most studies are executed in controlled settings, with play sessions set in formal learning contexts, supervised either by researchers or teachers: classrooms are the settings that are researched most often [28]. However, educational games are increasingly used outside the classroom, in informal settings. Several manufacturers have created educational games targeted at children, to let them practice skills like spelling (Nintendo: *Scribblenauts*) or math (Die Keure/Larian Studios: *Monkey Tales*) at home. This use of educational games outside the class context warrants additional research into the influence of a less controlled home environment on the perception of and experience with educational games.

To date, there is little research studying in detail the way children play educational math games at home. The home context, being less rigidly structured and supervised than formal classroom contexts, can be expected to have an influence on how educational games are perceived and appropriated. At home, parents do not necessarily specify rigid rules, a planned pedagogy or a specific time frame for playing educational games [44]: the context is different in terms of supervision, and social norms and rules. Our overarching research question, then, concentrates on the influence of the home context: we study the role of a specific math game in the home context as a case study in order to tackle the wider question of the relation between educational games and the home context. Specifically, we investigate how children's contextualized play and learning practices and experiences are shaped, when they play *Monkey Tales* at home. We will formulate an answer to this question by focusing on the interplay between the game, the players, and their context in a study of game appropriation, exposing the consequences of game design choices in the home context.

3. Educational game appropriation: A multimodal and ethnographic approach

Appropriation is a well-known concept in HCI (Human–Computer Interaction): although interactive technologies are always designed to serve specific purposes, these technologies, including games [42], are not always used as their designers intended. Technology use is not a matter of passive reception: users actively construct and impose new meanings on the technologies they use. The creation of these new technology-related practices is often referred to as appropriation of technology – although similar concepts such as domestication or interpretation are also used [47]. Previous research has focused on various technological, individual and social characteristics that underlie technology appropriation. For instance, the Adaptive Structuration Theory [19] focuses on the relation in decision support systems between the structural features of an application, and the related organizational structures. Dourish [22] identifies several aspects of appropriation, including both technological (e.g., flexibility) and social characteristics (e.g., community), while Salovaara [47] focuses on individual cognitive aspects underlying appropriation.

In this study, we will rely on multimodality as the overarching theoretical and methodological framework for investigating the complex relations between technology, users, and context. Multimodality is a specific interdisciplinary approach based on social semiotics, which considers communication and representation to be "more than language, and attends systematically to the social interpretation of a range of forms of making meaning" [34]. Multimodality does not study language or other sign systems in isolation: in social semiotics, "social structures and processes, messages and meanings [are] the proper standpoint from which to attempt the analysis of meaning systems" [31]. This focus on the social context in the production of meaning makes social semiotic theory an appropriate lens to study educational game appropriation in the home context, accounting for the interplay between the characteristics of the game on the one hand, and the contextualized use practices on the other. We frame this relationship as a relation between *design strategies* and *user tactics* (a distinction based on De Certeau [16] and Dourish [24] – see Fig. 1). This analytic approach allows us to investigate children's contextualized play and learning practices when playing *Monkey Tales* at home by answering the following, more specific research questions (RQs):

RQ1: How does the game *Monkey Tales* guide player behavior through the use of design strategies?
RQ2: Which (individual and social) user tactics are used to appropriate *Monkey Tales*?
RQ3: How are user tactics related to specific design strategies used in *Monkey Tales*?

When researching how *Monkey Tales* guides player behavior (RQ1), we focus on *design strategies*: the strategies used by designers of interactive technology to embed their view of the users and their goals into the application. Designers create interactive applications with very specific goals in mind (Hassenzahl [30] has called this the 'intended product character'). They use specific strategies to realize their intentions to suggest or even impose specific interactions on the users. An analysis of these design strategies can uncover in detail how the gaming experience is guided by promoting and discouraging specific behavior [38]. From the perspective of multimodal theory, all communication consists of a number of distinct 'modes': "'channel[s]" of representation or communication' (such as writing, image, and sound) that collaborate in communicating messages [34]. In games, modes that contribute to
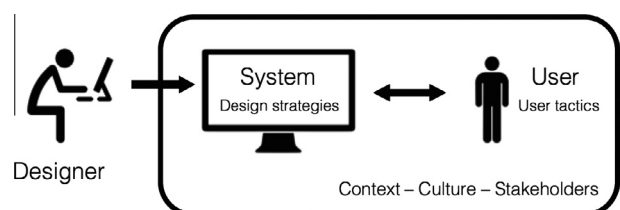

Fig. 1. Interaction between design strategies embedded in interactive technology, and the users' contextualized appropriation tactics.