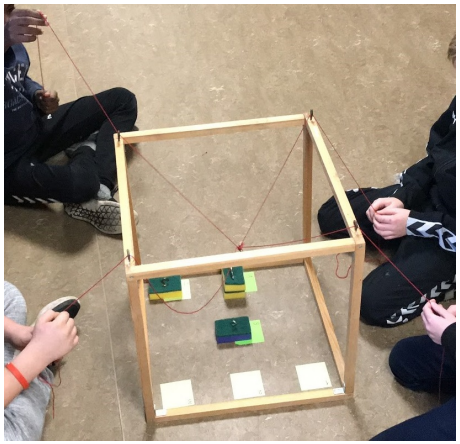

Figure 1: Physical string game in playtest with four children

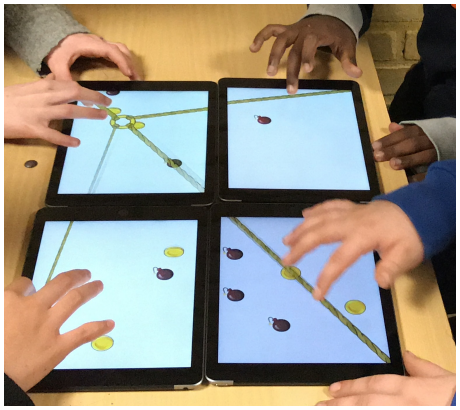

Figure 2: Digital StringForce game in playtest with four children

Using Gameplay Design Patterns to Support Children's Collaborative Interactions for Learning

Gökçe Elif Baykal
Eva Eriksson∗†
Aarhus University ∗
Aarhus, Denmark
elif.baykal@cc.au.dk
evae@cc.au.dk

Staffan Björk
Olof Torgersson
University of Gothenburg and Chalmers University of Technology †
Gothenburg, Sweden
staffan.bjork@cse.gu.se
olof.torgersson@cse.gu.se

ABSTRACT

Co-located games that bring players together have strong potential for supporting children's collaborative competencies. However, there is a challenge how to make results from research work related to this within Child-Computer Interaction (CCI) field easily transferable to future CCI research. Pursuing this challenge, we combined levels of Collaborative Activity (CA) with the design tool gameplay design patterns (GDPs). This combination was used to support comparative play tests of a co-located game with children who have learning difficulties. We report our observations on using our approach, arguing that the possibility of making patterns based on CA concepts such as *Reflective Communication* points towards collaborative GDPs. Furthermore, this study presents an exemplar that as a flexible and extensible tool GDPs can be used with different theories and models in the CCI field.

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KEYWORDS
Gameplay design patterns; game research; collaborative games; co-located gaming; CCI.

Levels of Collaborative Activity [2, 7]:

- Co-ordinated Activity: Individuals are gathered together to act upon a common object, but their individual actions are only externally related to each other. They still act as if separate individuals, each according to their individual task.
- Co-operative Activity: Refers to a mode of interaction in which the actors focus on a common object and thus share the objective of the collective activity, instead of each focusing on performing their assigned actions and roles.
- Co-constructive Activity: Interactions in which the actors focus on reconceptualizing their own organization and interaction in relation to their shared objects, as in the form of reflective communication.

INTRODUCTION

Studies on learning suggest that working cooperatively help children learn more effectively [9]. Thus, it is important that designers of collaborative learning applications understand how appropriate gameplay can be employed to support children to engage in collaborative activities. While there are many studies of collaborative games reported within the fields of HCI, in particular CCI, they tend to focus on evaluating or improving a game. As such, the contributions are localized in the sense that contextual aspects such as user group or technology use may limit how easily the contributions can be translated to other contexts e.g. [12, 13] (see [14] for a counter-example of this from the field of game research). Arguing that the CCI research community would be served by a more generalized way of documenting the knowledge generated, we suggest that the design tool gameplay design patterns (GDP), developed by Björk and Holopainen [5], might be one way of achieving this. Originating from Architecture [1], design patterns have been used with HCI (e.g. [11]) but to our knowledge no use of design patterns exist in CCI papers in the ACM digital library.

GDPs have been used to both aid in the design of new games [4] and to evaluate specific aspects of player experiences [6]. Stating that most of the previous GDPs have been identified through analyzing existing games, Lankoski and Björk have proposed harvesting GDPs from theories [10]. While this was argued from the perspective of building a pattern collection, it can also be seen as an argument that GDPs are compatible with many different theoretical lenses.

The evaluation of a co-located game for children with learning difficulties called StringForce [3] provided a context to test using GDPs related to collaborative gameplay for CCI research. The levels of Collaborative Activity (CA) inspired by Activity theory [2, 7] was a conceptual framework to adopt as theoretical lens since this was already an inspiration for developing StringForce.

BACKGROUND AND RELATED WORK

GDPs is a tool providing game designers with a collection of semi-formal interconnected descriptions of gameplay features [10]. While work with GDPs do not require an existing collection, a larger collection resides on a gameplay patterns wiki [8] which was primarily developed based on structural analysis of existing games [5]. GDPs are identified in the text through using small caps, e.g. Movement. All but two GDPs are from the pattern wiki (see the discussion section regarding the two new GDPs).

The levels of CA refer to the three modes of interaction to describe the dynamics of inter-subjective collaboration as a basis for developing and designing computer supported cooperative environments [2], see sidebar. In the sidebar, we illustrate the three patterns that meets with the three levels of CA, see Figure 3, which as well address collaborative gaming principles adopted for StringForce [3].

Three Gameplay Design Patterns [8]:

- Mutual Goals: Goals that are shared by two or more agents in a game. Players or agents in games nearly always have goals that they try to reach. When two or more share goals for some reason these goals are Mutual Goals.
- Movement: The action of moving game elements in game worlds. Movement of game elements is a common activity in games that have game worlds or game boards. It allows players to try and move game elements into favorable positions as well as control or explore game areas.
- Togetherness: Based on the premise that games are social, togetherness refers to the socio-emotional aspect of game aesthetics. Since this pattern is still under work in progress we suggest that adopting the dynamics of co-construction mode of interaction defined in CA would help to illuminate the sub-dimensions of this particular pattern.

METHOD

The study of using GDPs for CCI research was done as part of evaluating children's collaborative interactions while playing StringForce. Two different versions of StringForce were tested: a digital one and physical one (see Figure 2 and 1). The reason to apply the two conditions for the same game was twofold: 1) to compare and contrast children's collaborative interactions in two platforms, and 2) to understand children's views and ideas about their experiences in two platforms.

Recruitment and Procedure. All the children and their parents had given informed consent before the children participated in the activities. Eight 4th grade children (3 girls) participated in our study. Six of these children (11 years, diagnosed with ADHD) were enrolled in a special education class at a public school in Denmark. The children were grouped in four in play sessions, where one group had members from mixed developmental conditions. The play tests lasted for about 20 minutes and were held in a counterbalanced order and carried out in three sessions in separate days. The groups were switched to assure children were paired with different team members. Play tests were video recorded.

Gameplay Materials. The physical and digital setup of the game differed. For the physical setup we used a wooden frame, 4 strings connected to each other by a hook, 3 sponges with hooks in different sizes, and three target locations, one for each sponge, see Figure 1. For the digital setup, 4 connected iPads (9.56 inches) were used, see Figure 2. The strings were attached with a ring for collecting coins and avoiding bombs.

In both versions, the aim was to move the connected four strings simultaneously to collect items (see Figure 4). The major difference between the two versions is of course the 3D perspective, but also that you do not have any threats in the physical game (bombs in the digital version).

Data Analysis. GDPs were used in the analysis through matching patterns from the wiki [8] with gameplay concepts mentioned or observed from the data. In this paper we briefly present the structural analysis of the two versions (see Figure 4), and focus on children's collaborative interactions in the playtests. The data from playtests include observational notes, transcriptions of the videos taken during the play sessions and semi-formal post-play interviews with children. Children's collaborative actions were analyzed through the three main GDPs selected for collaborative gaming and evaluated through the key identifying patterns related to these patterns.

PRELIMINARY RESULTS

Here we present the similarities and differences in children's collaborative interactions observed in the physical and digital versions of gameplay sessions. The analytic descriptions were based on GDPs and data was analyzed through the related patterns. Thus, we present results by using GDP

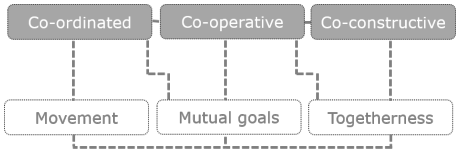

Figure 3: The selected GDPs complementing the modes of collaborative interaction described in CA.

	Play Condition	
	Physical	**Digital**
GDP		
AIM	Capture hooks, relocate sponges	Collect coins, avoid bombs
MOVABLE ITEMS	Strings and sponges	Strings and the ring
ZONE OF CONTROL	Strings	Individual iPads
GAME LEVELS	Changed sizes of hooks	Increased number of bombs and coins

Figure 4: The structural analysis of physical and digital play conditions of StringForce.

terminology and all but one come from [8]. First the similarities were identified, then the differences were described respectively.

Similarities between Physical and Digital Setup

Movement. Children co-ordinated their moves to control the Movable Items interdependently, accomplish the Aim and reach their Mutual Goals. They stayed in their Zone of Control throughout the whole play session in both conditions.

Mutual Goals. Children engaged in Social Interaction by communicating to each other about the Aim and how to co-operate and co-ordinate for reaching the shared goal. If a group member did not act co-operatively while executing the task Tension was caused among the members.

Togetherness. Children combined their actions not only to perform together with the help of the co-located interface aspect provided by both setups, but also to reformulate their strategies in relation to their shared goal. Although not apparing at the same level, Reflective Communication between children about their Movement and their Mutual Goals was observed in both versions. Reflective Communication is a new pattern that we suggest based on the co-constructive aspect of CA. We observed this pattern especially in actions requiring tactical planning in the physical version, and in the children's verbal expressions reflecting on the Game Levels in the post-play interviews.

Differences between Physical and Digital Setup

Movement. Children found the interdependent movements in the physical setup more challenging and fun than in the digital version. This led them to take up Game State Editing for instance in figuring out how to bring new rules and strategies to the game (e.g., moving a flipped fallen sponge by using the other sponge rather than using hands or, leaving the sponge out which fell out of the frame). Furthermore, in case of a technical or personal set back, children tended to intervene each other's Zone of Control in the digital version whereas this did not happen in the physical version.

Mutual Goals. Children's Social Interaction while pursuing the goal varied between different phases. In the physical setup they utilized more Stimulated Tactical Planning in their communication about co-operative actions (e.g., for loosening or tightening the strings, or capturing the hooks). However, in the digital version due to need for agility they communicated shorter commands with each other (e.g., "pull", "move", "that one") rather than planning. Besides, the Tension occurred more in body expressions in the digital play sessions whereas it remained more in verbal level when playing with the physical one.

Togetherness. Children employed Reflective communication more explicitly in the physical setup through monitoring the results of their actions (e.g., loosening-tightening interconnected strings),

communicating about the actions to be/being performed and reformulating the strategy. They also tended to discuss and reformulate the game rules together as exemplified in Game State Editing. In the digital version they implicitly involved Reflective communication while providing feedback to each other about a set back, or using game tools. Also, in the post-play interviews they implied a reconceptualization of different obstacles in Game Levels to be adjusted according to the team theme (e.g., if the team sign is waterdrop the challenge would be to move the strings against a stormy rain).

DISCUSSION AND FUTURE WORK

In this paper we argued the knowledge gap in the process of design and development of collaborative games scaffolding children's learning process. To this end, we adopted an approach that brings theory and practice together for observing, analyzing, and evaluating children's collaborative interactions. By doing so, we combined the three levels of interactions described in CA and three GDP related to collaborative gameplay. We used our approach to define the principles of our co-located gameplay, StringForce, and to analyze children's collaborative interactions during the play tests through digital and physical conditions of the game. Observations from both conditions by following this approach allowed us to identify some of the conducive GDPs along with one suggested pattern. The promotive aspects of using GDPs are as follows:

GDPs as scope setting. Mutual Goals, Movement, Togetherness could provide focal points for collaborative interaction based upon a synergy between the theoretical lens and the wiki collection.

GDPs as potential analysis concepts. Aim, Moveable Items, Zone of Control, Game Levels were identified as interesting concepts during initially analyzing the structures of the games and exploring the data. Game State Editing, Social Interaction, Stimulated Tactical Planning were added while analyzing the data for differences and similarities between the two versions of StringForce.

GDPs as knowledge repository. Reflective Communication elicited from CA, Moveable Items derive from the need to specify difference between items that can be moved and those that can't. Concepts such as the latter can be identified by basic observation but the former can be value for those working with GDPs but not familiar with CA.

Seeking CA principles in GDP analysis inspired us to suggest Reflective Communication as a pattern related to collaborative games. In future work, we suggest further investigations in children's co-constructive interactions among each other and the game elements. To distinguish Reflective Communication from communication or negotiation, a discourse analysis would be conducted to extract the data notably focusing children's communications while monitoring and reflecting their own collaborative actions or organizations. This pattern might also promote designing games in which children can take various roles enabling to adapt different team organizations. We believe,

the preliminary findings of this study could inspire designers in taking consideration of a more comprehensive picture of collaboration as a learning objective for game design research and practices.

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