Collaborative Learning through Cooperative Design using a Multitouch Table

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Abstract. Today, typical classrooms are still equipped with blackboards, chalk and sometimes overhead projectors. Technology-enriched rooms can often only be found in school libraries or computer pools where students can research topics on the WWW or use other specific computer applications. In this paper, we present an educational game called "Parcours", developed for the interactive SMART table. This cooperative design game, installed on a tabletop that is located within a classroom, is intended to teach primary school children collaboration and coordination skills as well as logical thinking.

Keywords: Collaborative Learning, Cooperative Design, Multitouch table

1 Introduction

Today, technology is getting increasingly ubiquitous for children even at younger ages. Many devices such as interactive cell phones (e.g., IPhone), game consoles (such as V-Tech, XBox360, Playstation 3, or Wii) or PCs are widespread and children often use them for a variety of purposes, including gaming. Device manufacturers as well as educational practitioners and researchers have tried to include *educational* games into their portfolio like Nintendo's Dr. Kawashima or V-Tech's V.Smile game series. Regrettably, many existing educational games for these systems can only be played in an unsupervised manner and are rather disconnected from education in schools yet. Also, many educational games such as Dr. Kawashima are not collaborative but either single-user based or competitive. Several studies, however, hve indicated that collaboration can promote children's learning [5, 11].

Interactive tabletops with multi touch input such as the SMART table bear the promise of providing opportunities for collaborative educational games [2]. They have a screen size large enough for several children to interact with it at the same time, thus increasing awareness [7], supporting a more balanced contribution of collaborators [6] and providing intuitive interaction methods [10].

The SMART Company regularly starts application contests in which ideas (and prototypes) for innovative collaborative educational games for tabletop devices are invited. In this paper, we present the design and implementation of the 2010 contest winner, the “Parcours” game. Exploiting the benefits of the table top device, this cooperative and co-constructive game is designed to teach primary school children coordination skills (many actions in the game can only be conducted by the group of players interacting in specific manners) as well as logical thinking skills.

2 State-of-Art: Cooperative Educational Tools on Large Displays

Educational tools that make use of large interactive displays have gained currency in recent years. The NIMIS project was one of the first applications of (single)touch large displays in primary schools. In this project, a special software application supported the acquisition of initial reading and writing skills embedded in a computer-integrated environment for young children [4]. The SIDES system employed multi touch displays to teach collaboration skills to adolescents with Asperger’s Syndrome in a task that involved the joint construction of pathways [8]. Here, the players had to coordinate concerning “how does what” during the pathway construction in order to reach a common goal. Empirical studies with the SIDES system yielded that SIDES provided adolescents with Asperger’s Syndrome with a positive experience through which they could develop effective group work skills and build confidence in social interaction. The StoryTable application [1] enforced co-operation during story-telling activities, and studies conducted with this system showed that cooperative storytelling can increase the level of engagement of less motivated children without affecting the involvement of the more active ones. Harris and colleagues [3] have described a study with the OurSpace application, a groupware tool for solving seat assignment tasks. A result of this study was that multi touch displays reduced group conversations about turn-taking activities and increased task-focused discussions (as compared to single touch interfaces). Recently, also projects that involve the research and development of frameworks (curricular and technological) for using multi touch applications in education have been proposed. This includes the SynergyNet project[1] with an emphasis on pedagogical strategies for designing multi touch applications across multiple stages of formal educations, as well as the work of Schneider and colleagues [9] who present a development framework designed to facilitate the creation of educational multi touch applications. The 2009 winner application of the SMART multi touch contest is an educational game named Laser Lights Challenge. The aim of this game is to direct a laser light through a labyrinth of different walls and obstacles into a goal using mirrors and prisms to direct the laser around corners. The main educational goal of this game is to teach the law of nature of laser lights and their reactions to mirrors and prisms.

In summary, research results both from the education sector and from the field of Human-Computer Interaction indicate that multi touch applications specifically targeted for collaborative learning are not only technically feasible but also potentially valuable, since they combine intuitive interaction concepts with new face-to-face cooperation mechanisms, leading to novel application areas, particularly within classrooms. In this paper, we describe the design and implementation of “Parcours”, a

[1] http://tel.dur.ac.uk/synergynet/

co-constructive application which, compared to the existing research results as discussed in this section, is unique in its combination of target group (primary school), learning goals (coordination and logical thinking) and group activity type (collaborative game).

3 Parcours: Purpose and Design

While many educational games focus on specific cognitive educational objectives like improving mathematical, language or memorizing skills, a discussion with a pedagogue spawned the idea to design a collaborative educational game that focuses on teaching logical thinking and coordination skills. These skills are important for everyday life and child development, yet there is typically no dedicated school subject for them: Physical education classes typically train coordination of one's body parts, but rarely the coordination among children. Mathematics classes, on the other hand, can teach logical thinking, but very often students will stick to their learned "cookbook" formulas and simply apply them to solve problems (without real logical reasoning).

The design goals of Parcours include that the children of the age group 5-10 should be able to intuitively understand the game, coordinate themselves to win, and enjoy the game. In the remainder of this section, we will first introduce the game itself with an overview about its functionalities. Next, the specific design choices (and how they meet the learning targets) will be described.

3.1 Basic Game Concepts

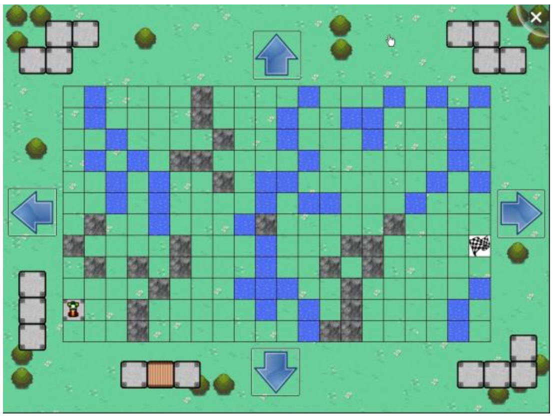


Fig. 1. The Parcours user interface in the "car" theme

Parcours is a bridge builder game. It provides a rasterized gaming area where the players have to build a path from a starting point to a goal point by using certain tiles, located outside the gaming area, in order to help a playing figure across the map. The game comes with several user interface themes (including spaceships, pirates, animals) to motivate pupils with different interest areas. Figure 1, depicting the user interface of the game in the "car" theme (where the goal is to help a car reach the flag position), shows that the game can be operated from all sides of the tabletop display. The tiles are located on the complete border of the screen, and the "arrow" icons for the playing figure movement are also distributed on all edges of the table. There are two main actions that can be done in the game at the same time: building the path and moving the player. The small playing figure (the car visible in the lower left of the figure) can be moved across a built path by touching the arrow buttons, thus maneuvering the figure in the direction the arrows are indicating. The path building process is complicated by different obstacles (visualized depending on the theme, here: rocks and ditches). The players have to build a path either around them or across them using special tiles. There are several tiles with different shapes and different features helping to cross obstacles. For instance, the "bridge" tile can be used to cross ditches by touching its two levers at the same time, lowering the bridge. The ladder tile can be used for crossing rocks. If the playing figure steps onto a ladder, the arrow buttons will change to four identical climb buttons. These buttons must be hit several times to cross the ladder, simulating the effort required to climb up.

All tiles in the game can be added to the gaming area intuitively by touching and dragging them (the game makes motivating, theme-dependent sounds during these movements). They can also be rotated by using at least two fingers, making a rotation movement. All tiles are slightly larger than the raster of the playing field as long as they are still "floating" (i.e., not fixed within the raster yet). The players can drop them into the gaming area with a "minimizing" gesture, using at least two fingers. A dropped tile cannot be removed any more. If the playing figure has reached the goal field, the game will be over and the players win. If the figure does not reach the goal and all tiles are used up, the players have lost.

3.2 Facing the Learning Goals

Parcours is a bridge builder game. As already mentioned, Parcours faces learning goals related to logical thinking and coordination. The main opportunity to learn coordination skills is connected to the use of the tiles surrounding the gaming area. The players have to cooperate and to agree concerning which tiles to use next in order to jointly design the path, then choose them and pass them to other players around the table, who will then drop them down. Furthermore, they have to coordinate themselves and to cooperate while using the special tiles like the bridge tile. Another feature supporting coordination and cooperation is the movement of the figure because the arrow buttons are split up and distributed around the area. Therefore, the players will have to discuss the next movement steps and work together. If the playing figure reaches a ladder and steps onto it, all players will have to cooperate by hitting the "climb" buttons. The faster they hit, the faster the figure will move up the ladder.

The players are forced to think logically because they have to choose the tiles they will use wisely. If there are no tiles left to finish a path from the starting point to the goal point, they will lose the game. This requires some planning and logical thinking.

4 Implementation

The architecture of Parcours consists of five internal and one external component as seen in Figure 2. These components which will be described in more detail in the following subsections.

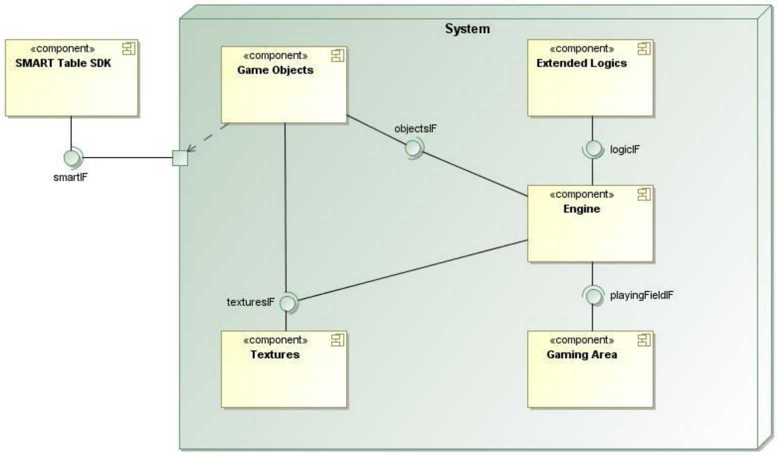


Fig. 2. System architecture

4.1 Smart Table SDK

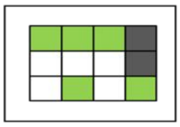
The only external component is the SMART Table Software Development Kit (SDK) which provides a multi touch enabled graphical user interface framework. The SMART Table SDK contains classes and basic functionalities required by developers to realize a multi touch enabled graphical user interface.

As described in section 3, players have to build a path from the starting point to the goal using various tiles. To build the path, players have to drag, rotate, scale and drop tiles. To implement graphical elements supporting these features in a multi touch environment, the SMART Table SDK provides (among other features) a class called `DraggableBorder`.

Developers implementing graphical elements that have to provide the mentioned multi touch features only have to (re-)use the class `DraggableBorder` provided by the SMART Table SDK. No further specific code is required to enable dragging, rotating, scaling and dropping features for graphical elements. Based on this SMART Table SDK, all tiles and functions of the "Parcours" game have been implemented.

4.2 Gaming Area

The Gaming Area component holds an abstract representation of what the players are seeing as an array. The array contains information about the tile type of each square of the gaming area as can be seen in Figure 3. The array is useful in two kinds of manners: First, the array is used for collision detection. The players are not allowed to drop tiles on a build path or on obstacles. The array can be used to check if a tile can be dropped or not. Second, the information in the array is used by the engine to load the corresponding textures from the Texture component for each element in the array (e.g., the number 1 encodes a grass tile). This so-called tile engine is beneficial for system performance because small graphics are reused as textures several times.



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[[0, 0, 0, 2 ],
[1 ,1 ,1 ,2 ],
[1, 0, 1, 0 ]]
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Fig. 3. Gaming area represented with an array

4.3 Textures

The Textures component provides all textures needed for the game visualization. The Engine component uses these textures to label all tiles like the grass, rock or ditch tiles (depending on the current theme). The textures are designed to provide the user with an intuitive understanding of which tiles are paths and which are obstacles.

4.4 Game Objects

This component realizes the visual appearance (i.e. the shape) of all usable tiles and the playing figure. Each tile is a 3x3 grid consisting essentially of a set of `DraggableBorder` objects, which are arranged in a way so that the tile has its desired shape. Furthermore, the Game Objects component holds information about the shapes of each tile in an array. Together with the array mentioned in the Gaming Area component, these arrays are useful for collision detection and to determine the needed textures for labeling the tiles. If a tile is rotated by the user, its representing array has to be rotated, too. This way, the tiles will always look correct (and have a correct system-internal representation).

4.5 Extended Logics Component

The Extended Logics component is very important because it implements the correct game behavior and the functionalities which force the players to cooperate.

Each tile is draggable, rotateable and scaleable, as already mentioned. Adding certain event handlers to each tile offers the possibility to increase the functionalities of the tiles, which are required by the special tiles in the game. Special tiles (cf. section 3) are used to enhance the coordination and cooperation among the players. Simple event handlers include, for instance, the counting the amount of touches on one tile or the calculation the distance of two touches.

Further functionalities of this component are collision detection, in order to forbid dropping tiles on paths or obstacles, switching the “arrow” buttons to “climb” buttons and backwards, and the correct movement of the playing figure.

4.6 Engine

The Engine is the main component of Parcours. It uses the other components to instantiate the gaming area, the playing figure and all tiles of the game. Furthermore, the engine connects the visual appearance of the tiles and the playing figure with their corresponding logics from the Extended Logics component and is controlling the game flow. The Engine component arranges the tiles and the arrow buttons always on the border of the gaming area and distributes them to engage the players in cooperation and coordination.

5 Pilot Tests and Teacher’s Feedback

Very recently, the Parcours game has been installed on a SMART table and has been deployed in regular school usage in a primary school in Germany. The first feedback received from this field usage has been very positive: both teachers and pupils like (and use regularly) the tool. However, this field use period has been too short to draw meaningful conclusions. In this paper, we instead report on some tests conducted with a prototype of the system which has been shown to a primary school teacher and has been pilot tested by a group of approx. ten pupils to investigate if teachers and school children accept the educational game.

Fig. 4. Parcours in a primary school

In the pilot tests, after a brief explanation of the game rules, the pupils began playing. An observation of the school children playing confirmed the simple and intuitive handling of the game. As expected, the children were discussing about the next steps they wanted to do and helped each other using the special tiles, which require cooperation and coordination (cf. Figure 4). We also interviewed the primary school teacher who observed the children playing the Parcours game. She was surprised by the good acceptance of the game by the children and stated that she believed that this kind of game can be very useful for multiple school subjects. While the cooperative design game was intended to teach coordination and logical thinking, the teacher also discovered other possible beneficial side effects like language skills (because of the coordination process) and geometry skills (because of the transformable tiles or the estimation of distances). The teacher also stated that she believes that generally, learning with a multitouch screen is very enjoyable and keeps the school children excited and motivated. So far, neither the pupils nor the teacher suggested specific improvements (we expect the field to reveal more in this regard).

In summary, while not constituting solid empirical evidence yet, first tests of Parcours in school suggest that this cooperative design game has the potential to help primary school children learn a set of diverse skills, including logical thinking and coordination. The next steps on our research agenda include an extended field study with the system.

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