Development of a Collaborative Learning Game Using External Plastic Cards as an Input Device on an iPad

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***Abstract*—This paper evaluates and describes the usage of plastic cards, coated with conductive paint, as an input device for capacitive touchscreens. By using the developed card prototypes it should be proofed, that usage of this new kind of input device can be handled by primary school pupils in a collaborative learning game. For this reason an educative digital learning game has been developed which can be controlled by the card prototypes. The game asks questions of general knowledge and the answer can be given by putting the proper plastic card on the touchscreen.**

The evaluation of the game by two groups of four children pointed out, that the cards can be easily used to identify a specific user. Although evaluation shows that the card control has weaknesses to reliably detect the correct answer during the game phase. All pupils enjoy to play the game and they additionally state, that they like the usage of the cards.

Beside the problems with a reliable card recognition the evaluation shows that the collaborative concept of the game is promising due to the fact that the pupils are always working together on finding a solution for the answer. Further they support each other in handling and understanding the plastic cards which leads to a deeper understanding of the technical backgrounds.

***Index Terms*—conductive, learning, game, card**

I. INTRODUCTION

A. Game-based learning

Following the actual studies of ESA [3] and JIM [4], the number of computer playing children is still increasing. At the moment over 50% of the children are regularly playing computer games. This development is described by the terms "digital natives" [14] “Net-Generation” [15] or “Generation @” [13] which means that the actual generation of children is used to handle computers from their early childhood on. This fact sustainably changes the way of thinking and knowledge acquisition of our children [7]. As a result of this trend the field of (digital) game based learning tries to examine how learning content can be packed in educative games to match the needs of the actual generation of children. Using games for a learning purpose has the advantage that the maybe the intended learning goal can be hidden from the children. So-called incidental learning occurs when it is unexpected – a kind of byproduct of other activities as for example playing a game [9]. Furthermore other publications pointed out that games can help to increase the motivation of the learners and finally to more joy and fun handling with learning content [2] [17] [7].

B. Gesture control

The presentation of the first generation of iPhones in early 2007 changed the way to interact with mobile devices completely. With the special capabilities of these platforms on the one hand and the restrictions of mobile environments on the other hand, user design principles and mobile usability have to be reconsidered arbitrarily [16] [18]. From this moment on finger/gesture control has become a standard feature for the market of mobile devices.

Having a more detailed look on controlling a mobile device by gestures, it shows that this development has nearly finished and only new kinds of gestures can be developed. However, the concept is still the same: put your finger on the touchscreen and draw some fancy gestures to get what you want to. In the last few months game developers presented a new way to interact with the touchscreen of tablets. They introduced plastic cards or plastic action figures which can be placed and moved on the screen and consequently the application reacts according to this input. This is a very important revolution of the concept of capacitive touchscreens as it changes the possibilities to interact with an application. The development is a novel approach to make new apps more attractive, especially to children.

C. Tablets in class rooms

Actual studies [1] [4] are showing, that children are addicted to use tablets. They easily understand the concept of finger gesture control. Although tablets are a rather new kind of technology, the idea and first deployment of them in classrooms started briefly after their market launch [10]. This is an interesting fact because tablets have not been exclusively designed for an educative purpose. At the moment there exists a great interest to use tablets in class rooms because of the high number of educative games and the undisputable positive effect on collaborative learning [5] [6] [5].

D. Research question

Based on the previous facts this paper tries to answer the research question if *it is possible to develop a collaborative digital learning game, which uses an external input device for gesture recognition*. The input devices are based on the plastic cards introduced by Hasbro's Zapped edition of Monopoly. The paper points out the development of the input plastic cards, which are based on an

environmental harmless conductive paint. Moreover, it should be pointed out if children aged seven to nine can handle the cards and understand how to use them.

For these reasons a digital mobile learning game called "Guess Austria" was developed for the mobile operating system iOS. The game asks questions of general knowledge and offers a way to choose the desired answer by using the card prototypes. The evaluation of the game has been done at the elementary school of Graz-Hirten in Graz, Austria with two groups each consisting of four children.

II. TECHNICAL OVERVIEW

A. Capacitive Touchscreens

The most common capacitive touchscreen technology besides Surface Capacitive Touchscreens is Projected Capacitive Touchscreens (PCT). PCT touchscreens are used in nearly all actual smartphones and tablets. As a matter of fact, there are differences in the production of the panel but the principles are the same. PCT panels are made of two independent layers of conductive material which are organized as a grid. One layer is called drive line, the other one is named sense line. Both layers are normally protected by glass. If a user puts a finger on the glass, the voltage of the sensor line differs from the drive line due to the change of the electrostatic field through the finger. So it is possible to recognize an exact touch on the display. Additionally, PCT offers the possibility to recognize multi touch gestures.

B. Conductive Paint

Conductive paint is nowadays broadly employed for the production of so called "printed electronics" like RFID-Antennas and parts of solar cells, OLED-Panels and touchscreens. The paint can be produced as solution, dispersion or suspension. These attributes make it possible to use such a coating in every state of art printing technology like Inkjet printing, screen printing, low pressure printing, offset printing or flexographic printing. Depending on the viscosity and the desired conductive quality an appropriate printing process can be chosen. Generally, a conductive paint is produced by mixing conductive material with a paint. The following substances can be used as conductive material:

- Nanoparticles of gold or silver: Most conductive material, but problems regarding the environment when used on paper.
- Conductive plastics: less conductive than gold or silver particles, no problems with environment but delicate against oxygen and humidity.
- Carbon or a carbon based modification called Graphen: very conductive and mostly harmless regarding the environment.

III. IMPLEMENTATION

A. Game concept

The target group of "Guess Austria" is determined by elementary school pupils at the age of 8 to 9 years. The game asks questions of general knowledge based on topographical and historical information. The learners have to identify themselves and connect a card color with their usernames during a registration process. In order to register the so-called ID-Card (see Fig. 1) has to be used.

The children can choose an answer by putting a so called Answer-Card (see Fig. 1) on a highlighted scanfield (see Fig. 2) displayed through the game. For a correct answer the players receive as many points as the actual number of finished rounds. This should guarantee a thrill until to the last round.

B. Technical concept

"Guess Austria" is designed and developed for the iOS operating system maintained by Apple Inc. The game can be played on actual iPads exclusively. No other iOS devices like iPhones or iPods are supported. The application only runs in portrait mode and supports up to four players. Due to the release of iOS 7 during the development an automatic port of the source code has been done to prepare the application for the latest version of the operating system. The game is designed to be controlled by a mixture of finger- and card-based gestures. The plastic cards are used to register a player and to submit an answer during the Question-Answer-Round. They can be recognized by a gesture recognizer which has been exclusively developed for this requirement.

C. Plastic cards

To obtain information from the card each of it has to be coated with conductive paint. By painting small dots connected with thin lines on the cards the conductive capacity of the finger is delivered to the touchscreen and can be recognized. To clearly identify a user, cards with two painted touch points are used. These are called ID-Cards. The application can recognize the arrangement of the touch points on the card and can assign them to stored card templates in the application. After the players registered themselves with their names by using one of the four ID-Cards (made of four different color schemes), the cards color will remain as the players color until the end of the game.

An ID-Card can also be used as an Answer-Card. To submit an answer the players choose an Answer-Card with their desired number of touchpoints on it. The number of touchpoints on the card corresponds to the number displayed beside the answer on the game screen.

The idea behind the card production was to avoid an expensive low pressure print procedure. Instead a cheap, easy, environmental harmless, child-friendly production process was demanded. These requirements were met by the conductive paint of Bareconductive[1]. They produce a

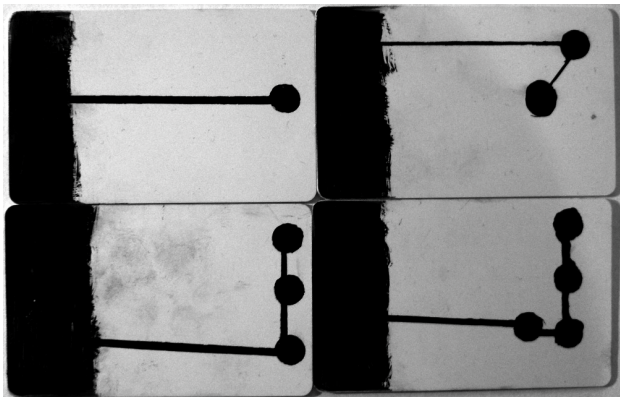

Figure 1. Answer- and ID-Card. ID-Card with two touchpoints.

[1] http://www.bareconductive.com

Figure 2. ID-Card on the scanfield during the registration phase

carbon based conductive paint which is environmental friendly and not poisonous, thus it can be used by children without any problems. In addition, it is a water based colour which means you can wash it away with pure water and a little bit of soap. To make the produced cards more resistant they have been coated with clear vanish. Nevertheless, they rubbed off a little bit during the usage. The cards were produced by creating touchpoint patterns made of a thin plastic film. Such a pattern was laid on to a blank plastic card and painted with this particular conductive material.

D. Game sequence

Basically the game is divided into the so-called "Registration-Phase" and the "Question-Answer-Rounds" (see Fig.°3).

1) Registration-Phase

During this phase each player has to choose a set of cards identified by four different color schemes. During the next step every player starts the registration screen of the game. On this screen the user is asked to type in a player name. After saving the player name the user has to put the ID-Card of the chosen card set in the scanfield displayed on the screen. The application is analyzing the two touch points of the ID-card and if the card has been successfully recognized the registration of the user ends else the user has to put the card in the scanfield again (see Fig.°2).

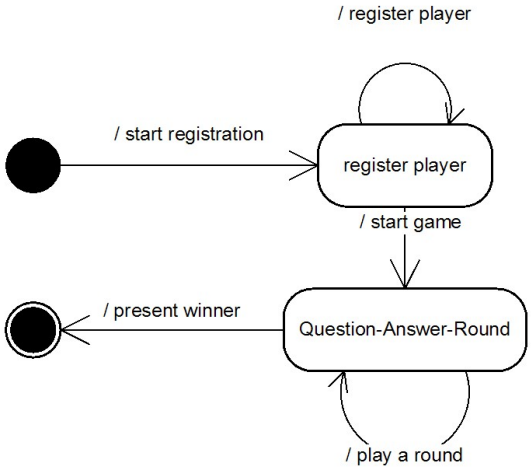

Figure 3. The game sequence as state chart

2) Question-Answer-Rounds

After all players have been registered the real game starts. Every player has his own scanfield area, colored with the same color of the chosen card set, in one of the corners of the display (see Fig.°4).

The game starts to ask questions to the players. Additionally four possible answers are displayed. The players have 10 seconds to read and understand the question and to choose their answer. After 10 seconds the game starts to highlight the scanfields of the players, one after another. The active player has now 10 seconds to put the answer card on the highlighted scanfield to submit the desired answer. After the successful recognition of the card or after running out of the 10 seconds countdown another players scanfield is highlighted.

As soon as all players submitted their answer or missed the 10 seconds countdown to do so, a Question-Answer-Round ends. The game displays the intermediate result to the players. In the evaluated version of the game 8 rounds were played.

IV. FIELD STUDY AND EVALUATION

The field study took place in a primary school in Graz, capital of the state Styria in Austria. The game "Guess Austria" was tested on two groups, each consisting of four children. The study has been done in an extra room to avoid interruptions from other pupils in the class rooms. The children have been introduced by a quizmaster who was leading them through the game and was answering upcoming questions while playing the game.

The pupils were placed around a table considering the position of the iPad in the middle of the table (see Fig.°5).

The field study consists of observation of the pupils while playing the game and a very simplified version of a questionnaire answered by the children after the game. The children had to rate five simple sentences by putting smileys, from laughing to crying, on the sentences. A detailed result can be seen in Table 1. The laughing smiley is interpreted as full acknowledgment and is represented with grade 1 in the result table.

Figure 4. Question-Answer-Round game interface

A. Observations

During the Registration-Phase the pupils had the first contact with the plastic card. Some had problems in putting the card inside the scanfield or holding it correctly. The observations showed that some children did not put their finger on the completely filled area at the bottom of the plastic card which is however necessary to guarantee the conductivity of the touchpoints on the cards. On the other hand, sometimes children put the card in a steep angle on the scanfield which lead to a faulty recognition of the card.

After the first Question-Answer-Round it was clear that the hard time limit of 10 seconds was too short for the pupils to read and understand the question. The quizmaster paused the game from this moment on to avoid this problem. When the kids were asked - for the first time during the Question-Answer-Round - to put their Answer-Card on the scanfield, they tried to do it simultaneously.

By examining the answers of the children after each round it could be pointed out that some of the given answers has been faulty recognized by the game. Reasons for this behavior are wrong usage of the cards on the one hand and an inaccurate recognition of the cards through the game on the other hand.

One of the children tried to answer a question with a four touch point answer card. As the child slipped over the screen the iOS operating system recognized a four finger gesture which means an application switch in the latest iOS versions.

On the other side the observation clearly pointed out that the children had great fun during the game phase and supported each other in finding the correct answer. Also they gave advices to each other about the correct usage of the game cards.

Figure 5. Evaluation setup

TABLE I.
QUESTIONS OF THE QUESTIONNAIRE

Questions	Group 1	Group 2
The length of the game was optimal.	*5*	*5*
It was fun to use the plastic cards	*2*	*3*
The game was easy to use	*4*	*4*
I learned something new while playing	*3*	*2*
I would like to play again	*1*	*1*

V. DISCUSSION

The evaluation pointed out some weaknesses of the game in regard to the game design, the positioning of the game cards and the production of the game cards. On the other hand the collaborative character of the game could be examined.

A. Production of the plastic cards

The production process of the cards seems to be too inaccurate. This can be verified by the fact that the game's touch recognizer sometimes recognizes both, more or less touchpoints as really painted on the given card. It is quite probable, that a professional production process would decrease the erroneous recognitions.

B. Usage of the cards

The most common usage problem was how to hold the card correctly. During the evaluation this could be solved by explaining it twice by the quzimaster and also the children taught the correct usage to each other. Another common mistake was that the cards were placed on the scanfield with a pretty high angle instead of being completely put on the scanfield (see Fig.°6). All these mistakes led to a faulty recognition of touchpoints.

Nevertheless the evaluation showed that the kids can handle the plastic cards quite fast and that they are interested in using them.

C. Game Design

The counters which were intended to fasten the game were quite a big obstacle for all learners and should be removed. Reading the question and deciding which answer might be the correct one is a challenge difficult enough for pupils of this age. Another problem was the activation of the application switch gesture when putting cards with four touch points on the screen. The only way to prevent this problem is not to use four touch points as the gesture cannot be deactivated on application base.

Another game design problem occurs in connection with the faulty card recognition. During the registration phase an erroneous recognition is no problem as the application asks again for placing the card on the scanfield. A faulty recognition during the Question-Answer-Round is really problematic as it cannot be discovered by the game. The evaluation showed this behavior more than once. As a consequence, the usage of the cards is not optimal to give a satisfying answer. Nevertheless the cards work perfectly

Figure 6. Incorrect usage of the card.

to identify users because this task can be repeated if the recognition was not successful. Resultingly, the concept of the card usage for submitting answers has to be reconsidered.

D. Collaborative FunFactor

The game was intended to enable a collaborative and cooperative learning process for the pupils. The evaluation showed that the children had great fun during the game and that they worked together as a group to answer the questions. This can be verified by the observations and the final questionnaire, which states that the pupils would like to play again and the length of the game was too short.

E. Additional findings

The harmless production of the plastic cards connected with a suitable game concept can be easily used to give children an idea about the technological backgrounds of capacitive touchscreens and how gesture recognition works.

VI. CONCLUSION

The usage of (digital) mobile Game-based learning games during class is a new and promising approach to fit the learning habits of today's children.

The development of the learning game "Guess Austria" aimed to attract the children with a collaborative gaming experience and using plastic cards as input devices. The evaluation of the game clearly showed that the pupils liked to play the game and that they did it in a cooperative and collaborative way. The usage of the plastic cards has been enjoyed by the pupils. Nevertheless faulty recognitions due to the production process and the usage of the cards are problematic for the Questions-Answer-Rounds. Plastic cards as input device should be used in a concept where the application can recognize and react immediately on faulty touch point recognitions.

A big chance for other game concepts is the harmless production process of the plastic cards paired with the simple possibility to store own card templates in an application. This can be used to teach children about the effects of conductivity and the technological background of capacitive touchscreens.

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