

# Learning via Game Design: From Digital to Card Games and Back Again

Emanuela Marchetti<sup>1</sup> and Andrea Valente<sup>2</sup>

<sup>1</sup>Multimedia and IT, Lillebaelt Academy for Professional Higher Education

<sup>2</sup>Maersk Mc-Kinney Moller Institute, University of Southern Denmark

[emma@eal.dk](mailto:emma@eal.dk)

[anva@mmmi.sdu.dk](mailto:anva@mmmi.sdu.dk)

**Abstract:** In this paper we consider the problem of making design of digital games accessible to primary school children and their teachers, and we argue for the need of digital games that are easy to alter by young learners. We know from previous research projects that digital games do not enable children to express their creativity at full, in contrast with low-fidelity prototypes and non-digital toys (such as card or table top games). Therefore, we propose here a novel approach that serves as a middle ground between digital and traditional table top games, and grants children more freedom to express themselves, articulate their understanding and difficulties both individually and socially. This approach, called card-based model for digital game design, is an alternative to the current trend of associating programming with digital creativity. A preliminary study was conducted by transposing a digital game into a trading card game, to investigate the potential of the approach: as expected, students participating to the study shifted between playing and design thinking. The card-based model introduced in this paper works full circle: it enables learners to go from digital games to cards and back. In fact, the card-centric game architecture that resulted from the study allows a digital game to be reified as trading card-game, so that learners can re-design and digitize it to obtain a new a digital game, without programming. The next step is to involve primary schools in more complete evaluations of our new game development approach.

**Keywords:** Learning, game design, card games, playful play, knowledge transposition, group creativity

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## 1. Introduction

Current research in games based learning shows that learning through the design of digital games elicits a richer experience than learning through play (Kafai 2006). However, enabling children in primary school to design their own digital games has proved to be a challenge, mainly because it requires programming skills. In order to solve this issue, we have looked into traditional forms of play, such as play supported by tangibles, cards, drawing and modelling materials. In previous projects (c-cards, paper turing machine, and MicroCulture) it was noticed that when engaging with these materials children easily express forms of designerly and playful play, in which they create new toys and rules of play for themselves or for their mates (Sutton Smith 1997). In so doing they engage in designerly ways of thinking and learning (Cross 2006), reflecting on their new artefacts and the subject they are supposed to learn.

In particular, results from two case studies, an ongoing project in a school and a project about playful learning in museums (Marchetti and Petersson Brooks 2013) suggest that traditional writing and drawing materials provide richer support for playful play than digital media, which tend to impose the features and gameplay previously decided by the designer, unless players have the required technical skills to change them. This might sound like a paradox since digital devices and media have become more common in all contexts of young people's everyday life, based on the claim that they are more interactive and apt to support learning in different fields. However, the total or partial redefinition of digital media (e.g. altering of digital games) in primary school is hard to achieve because it requires programming skills that pupils and educators do not have. On the contrary, when children play with pen and paper they can easily create new paper-based artefacts and assign them new meanings through social agreement. As a result, with digital games educators and pupils depend on the choices of the digital game designer/programmer has made for them long before the use of the media.

In line with studies on playful and designerly learning, which emphasize the need of individuals to become active learners in charge of their own development, we propose a scenario in which learners and teachers share authorship on the design of new digital learning media. Attempts have been made in order to address this issue, either by teaching children how to program or by providing level editors. Both of these solutions have limitations, the first implies the acquisition of programming skills, which are hard to gain and out of scope

in situation of learning targeting other subjects; editors on the other hand often support limited predefined alterations. Instead, our approach is to seek for a middle ground between traditional tangible games (e.g. card or tabletop games) and digital games, so that the activity of designing a new digital game (or altering an existing one) is re-conceptualized as designing (or altering) a trading-card game (TGC for short). The created TCGs embody the acquired knowledge and understanding of the subject and could be used in several ways: to be played by the pupils afterwards enabling reflections and critique together with the teachers, or by other children enabling possibilities to communicate different understanding on the subject and foster critical reflections on alternative points of views. In this respect such card games serve as mediating means for a playful communication about the subject at hand (Rogoff 1990). Finally, a card game can be used as the basis for defining a new digital game, hence helping pupils and teachers overcome the need for programming.

In order to explore how to achieve this middle ground between card games and digital games, we conducted a pilot study with university students, who are both experts at playing TGCs and members of a group engaged in digital game design.

In the following sections we present the theoretical grounding of our work presenting related work (section 2) and previous studies on which we base our argument (section 3). In section 4 we present our new model and an initial study. Discussions and conclusion can be found in sections 5 and 6.

## **2. Related work**

Psychological studies have explored how play mediated by tangible objects affects the cognitive development of children, notable examples are provided by the theories of Vygotsky (1978) and Dewey (1938). Play mediated by tangible objects, in solitary or social contexts, enables children to detach themselves from their contingent reality, so that they imagine different situations, courses of action they could take and their implications on the reality they imagined (Vygotsky 1978). Through mediated play children start practising conceptual thinking, often in a form of conceptual speculations, analysis, problem solving, and role play in which the children experience as real the situation depicted in their play (Sutton-Smith 1997).

The emergence of this form of play requires that the children are left free by adults to engage in imaginative explorations (Dewey 1931), in which they challenge familiar objects questioning what they can do and how they could be used differently. Hence children make their own tangible toys as a natural part of their playful experience (Dewey 1931), designing the toys physical qualities in relation to expected functions and rules of play. Sutton-Smith (1997) calls this form of play "playful play", referring more specifically to creative individuals who have fun making toys and rules of play for other children's playful experience. In this way play mediated by tangible objects can be turned into an experiential narrative, in which players shift freely from writers to characters.

Similar claims are proposed by researchers exploring different approaches to games based learning. Kafai (2006) distinguishes two different approaches: the instructionist and the constructionist. The instructionist approach is the most studied and requires to design games that embody lessons and homework for the children. On the other hand the constructionist approach aims at supporting learners by providing them with the opportunity to make their own games as a pedagogical tool. Positive results were gained from a study involving 10 years old children, who were asked to design games about fractions and scientific subjects as part of their learning process, over a period of 6 months. The study shows that when making digital games "the learner is involved in all the design decisions and begins to develop technological fluency," which requires knowing "how to make things of significance with digital tools and most important, develop new ways of thinking based on use of those tools" (Kafai 2006, p. 39). In this way game design "offer an entry point" into games culture promoting children from consumers to producers.

The application of modding in learning design skills shows interesting results with the respect to how playful play enables university students to learn design skills (Engeli 2005). By modding is intended the alteration of the code of a game or of any other software application. According to the mentioned study modding allows to engage in digitally mediated playful play, acquiring deep knowledge on the subject. Similarly to traditional forms of mediated play modding enables the learners to engage in experiential narratives shifting roles from writers and creators to players and readers. However, this study discusses a case about university students

who are developing or already have programming skills, in this respect modding can be seen as too advanced to be applied to primary school pupils, who are our target group.

Both the works of Engeli and Kafai seem to converge towards what Cross (2006) defines as “designerly ways of knowing”, in which design practice functions as a pedagogical tool to foster knowledge and critical reflections on the subject at hand. Through design learners become active and able to express their understanding of the subject by making new artefacts.

The mentioned studies prove the need to explore further design of digital games as a learning tool; however, difficulties are met regarding the need for programming skills. Three main approaches can be found: teaching children how to program or support modding, embedding design practice in sandbox games (or level editors), and defining new programming models which do not require formal knowledge. Visual tools like ScratchJR (Flannery et al. 2013) or Catroid (Wolfgang 2012) were conceptualized to teach children how to program. In this way children should acquire new skills and get the maximum freedom to express themselves and their creativity. However, the adoption of this approach in context of games based learning would make the task of teaching and learning highly complicated, putting children into the additional stress of acquiring programming related concepts before starting to create games and learn their curricular subjects. A variation on the theme of teaching pupils programming to support their creativity is represented by (Burke 2010); in that paper computer programming is used as a tool for children to create stories. The authors discuss about how coding can support deeper understanding of composition. From our point of view, this approach can be seen as a way to turning creative writing into a proxy for programming, where storytelling helps children make sense of programming practice. Our approach tries to use card games and their design as a proxy activity for programming digital games. The second approach can be represented by Minecraft, a sand box game that is easy to alter without involving programming knowledge. Such games afford only customization of configurable parameters, menus and editing tools embedded in the game itself: in fact, Minecraft users cannot define new blocks with new behaviours. A modified version of Minecraft was tested in teaching physics to children through the creation of new worlds (Wingrave 2012). The study provided interesting results but significant limitations for the teacher were found since Minecraft does not support the creation of quests or stories.

Based on this evidence our study aims at contributing to the third approach, proposing a new model for programming practice. This third approach is represented by Harel (2008), who proposes a new vision in which programming is re-conceptualized based on multimodal interfaces and AI, and Wegner (1997) who claims that interaction should be seen as a better grounding to define complex systems.

### **3. Motivation and background**

The approach proposed in this paper is based on evidence gathered from two empirical case studies: a doctoral study aimed at enriching museum guided tours (Marchetti and Petersson Brooks 2013), and the design of a digital game about prime numbers for pupils at their final years of primary school (Valente and Marchetti, 2013). Both projects adopted an instructionist approach, in which we aimed at exploring the transposition of complex processes from a domain into games (Valente and Marchetti 2013). In fact, we transposed knowledge by extracting typical elements involved in the learning content, which were then mapped into the features and rules of the resulting games. Specific objects, characters and actions were identified, for instance in the first study we focused on the kings territorial act of infrastructure placement. In the second study (about factorization) we worked on the operations of division, multiplication, and on the visualization of the notions of primality and divisibility.

These two projects involved children around 9 to 13 years of age as informants and as co-designers, in testing and generating ideas for the development of prototypes (Druin 2002). In both studies interesting differences were noticed in the way children interact with low- and high-fidelity prototypes. When the children interact with low-fidelity prototypes and traditional design materials (e.g. construction blocks, play dough, paper and pencils) they naturally engaged in forms of playful play often associated with role play. On the contrary when interacting with high-fidelity prototypes, the children tend to accept what is embedded in the prototype and limit the expression of their creativity to their social interaction. In this respect, we found that digital games do not enable children to express their creativity at full, in contrast with non-digital toys and low-fidelity prototypes.

### **3.1 A digital and tangible installation about Viking urban development**

The first study resulted in the creation of a tangible and interactive transposition of urban development in the Viking Age (implemented in the MicroCulture installation), which was aimed at turning guided tours into a playful practice (Figure 1). The goal in creating MicroCulture was to create a playful simulation that could enable children to imagine how it could have felt to participate in urban development in the Viking Age. By simulation it is intended here a partial reproduction of a system, which enables users to see dynamics and relationships between the selected elements of the system (Simon 1996). The design of MicroCulture focuses on the foundation of Ribe, which is acknowledged as the oldest town of Denmark and was founded in the Viking Age by King Harald Bluetooth (Jensen 1991). The story of Ribe started with a seasonal settlement, which was transformed into a permanent settlement by King Godfred around 700 (Jensen 1991), who divided the land into lots and rented to the merchants. Since the merchants had to pay in order to sell their goods in Ribe, they developed attachment to their lot and started to live in Ribe on a stable basis. Finally, under the kingdom of Harald Bluetooth around 970 the settlement became larger and a new round fortification was built around it; from that period Ribe became officially the first town in Denmark. The gameplay of MicroCulture specifically focuses on the role of political authority and placement of infrastructures on the territory; these are seen in archaeological literature as two fundamental and intertwined factors in urban development (Jensen 1991). The children are supposed to play as if they were kings or landlords and increase the population of the simulated settlement placing infrastructures. At the same time the gameplay does not impose specific rules or goals, as the children are supposed to explore how to play.



**Figure 1:** MicroCulture during the final test. Children are placing infrastructures on the settlement playing with the given tangibles.

The setup of MicroCulture is composed by a laptop, a flat TV screen oriented horizontally, and a webcam placed above the screen (as visible in Figure 2). The simulation is implemented in Python and ReactIVision, a maker-based system to develop tangible interfaces. A basic set of 4 paper tangibles is provided representing each one Viking Age infrastructure: bridge, wooden paved road, market place lot and round rampart. The simulation shows a territory modelled after the suggestions provided by the museum guides, in order to reproduce Ribe during the Viking Age. MicroCulture also has a simulated population composed of simple agents. These agents have a gender and start their life as children being born in a household, they age as the simulation progresses, and eventually die: the entire cycle has an individual, random duration for each agent, but it always takes just a few minutes of real-time from birth to death. When the infrastructures are placed on the screen, they are detected by ReactIVision through the webcam (Figure 2) and affect the simulated territory and population.



**Figure 2:** Technical setup for MicroCulture. A webcam (looking down at the game board) captures markers on tangibles; the board is in fact a flat television placed horizontally. A laptop runs the game and outputs on the television screen.

So that when a bridge is placed on the screen, a bridge appears after a few seconds and enables the characters to cross the rivers displayed on the territory. Wooden paved roads and market place lots are placed on a forest area cause trees to disappear and new houses to be built (that will spawn agents). Finally, round ramparts prevent agents from accessing specific areas. The infrastructures, however, disappear after circa 1 minute of real-time, and if the players do not insert new ones the population decrease and the woods gradually reconquer the territory. This was decided in order to suggest to the children that urban development requires commitment from the political authorities, who have to keep the infrastructures functioning for a settlement to flourish.

### 3.2 A digital game about number factorization

The second project focused on transposing knowledge about prime numbers and factorization, a challenging topic for primary school children, required for example in simplifying and adding fractions. The gameplay has been designed in order to simulate the actions needed to reduce numbers to their prime factors. Two different mappings have been created in order to explore multiple gameplays and eventually meet the needs of different players, as explained in Valente and Marchetti (2013). The resulting digital game is named Prime Slaughter and it is inspired by classical adventure games (Figure 3): numbers are mapped into the enemies and into the swords that the players use to *slice* the enemies into their prime factors (Valente and Marchetti 2013). The enemies are represented as jello monsters that move around and attack the hero, who has to slice the monsters into their prime factors using appropriate swords. This mapping of numbers as both swords and monsters was decided to make players conscious that numbers are factorized by other numbers. Moreover, we expected that mapping numbers into monsters would have added a light mood to the game, referring to the common perception of maths as a scary subject. Visual clues are provided to support players, for instance the size of the monsters depends on the number of their factors: a 6-monster is larger than a 11-monster, because 6 has 2 prime factors while 11 is prime (so has only itself as a factor), despite the fact that 11 is a larger number than 6. Prime numbers are the smallest monsters, and since 1 is not a prime, the 1-monsters vanish spontaneously shortly after they are created (by slicing a prime with the right sword). When a monster has been sliced into its prime factors, a player can freeze one of the remaining primes and turn it into a new sword that can be used to slice other monsters. These swords have to be collected in order to win and can be gathered in shrines in the initial room (the armoury).

The second mapping is inspired by an exploratory game style, in which the player is supposed to use the prime-swords to prune trees in a special level called Bonsai Graveyard (Figure 3). Numbers are mapped on the number of branches of trees; each tree starts its life as a seed, with an associated number. The player needs to *prune* the seed with the appropriate sword to make it grow branches, otherwise she will lose points: for example a 14-seed can be pruned with a 7-sword or a 2-sword, growing respectively 2 or 7 branches. When a

tree has been completely pruned, each branch will show a single prime leaf, and the tree will start producing number-apples periodically. The operation of picking up number-apples corresponds to freezing monsters and converting them into swords, so that when a player picks an apple she acquires a new sword of the same value. In Prime Slaughter players can easily move from one level to the other and shift in between the two different gameplays as they wish. The goal in both gameplays is either to collect all the swords until 20 or to achieve a score of 400 points by killing monsters or by pruning trees (Valente and Marchetti 2012).



**Figure 3:** Map of the rooms in Prime Slaughter. On the far left the armoury where the player collects her prime number swords. The lowest room (with sandy background) is the Bonsai Graveyard where the player prunes and grows number trees.

### 3.3 Learning implications

During testing with MicroCulture and Prime Slaughter a rich dialogue emerged among the children and with their educators, promoting peer learning and conceptual reflections. The children asked questions about the features of the prototypes, in order to be able to play. While playing with MicroCulture the children engaged in a conversation about demography, town planning, and archaeology of landscape, exploring what happened to the peasants or to the territory when a specific infrastructure was placed. In this way the children discussed issues related to peasants' mobility, strategic placement of bridges and ramparts, and construction plans on swamps and forest areas. Similarly, Prime Slaughter elicited questions about the nature of prime numbers and how to identify them. In this way the children engaged in forms of mediated interactions (Wertsch, 1991), through thinking aloud and specific questions, so that their thinking became transparent to each other and to the educators, who could support them more adequately than in normal learning conditions. Moreover, the presence of a game affected also the attitude of the educators, who were happy to give the children space to enjoy their play. This in turn caused the children to be granted more independence than in usual lecturing or guided tours activities. Based on previous studies (Rogoff 1990, Wertsch 1991) mediated play, when properly integrated in learning practice, provides grounding for responsibility transfer, enabling children to explore meaning by themselves with the result of progressing more quickly and gaining more confidence in their subject.

These dynamics became even more visible when the children engage with low-fidelity prototypes and design materials. Our case studies suggest that when playing with digital artefacts, the children implicitly accept the available resources and rules, while when engaging with low-fidelity materials they question the essence of the available resources creating new imaginary worlds and social interactions. During evaluations with the low-fidelity prototype of MicroCulture the children asked humorous questions about which animals lived in the Viking Age in Denmark and made provocative objects such as lions and snakes, although they expected them to be inappropriate. While redesigning Prime Slaughter the children proposed to shape the levels as mazes with closed doors that could be opened with particular combinations of prime numbers. In both occasions children pushed the boundaries of the available resources and at the same time opening up the possibility of discussing with their teachers why such objects were not appropriate or explore real-life applications. For instance the suggestions for Prime Slaughter could elicit a discussion about cryptography, where keys are often compositions of primes. Furthermore, these suggestions show that by redesigning the available games the

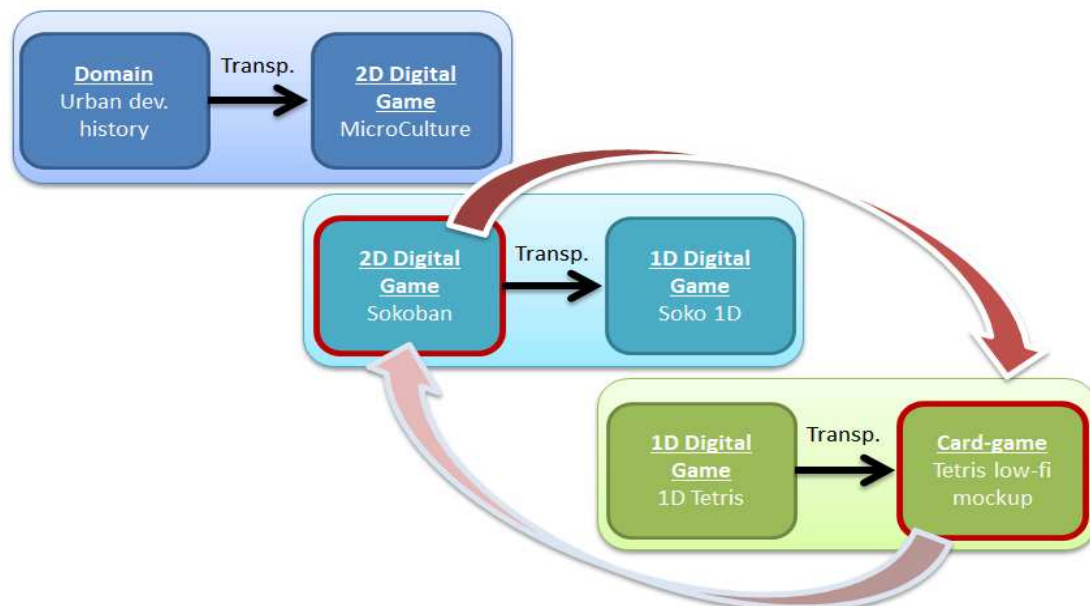
children are going through a process of appropriation of the knowledge and of the learning tools (Rogoff 1990), gaining ownership on their learning process as well as on how the learning material should be.

These aspects are found relevant in different studies about learning in formal and informal contexts (Rogoff 1990), and in participatory design studies aimed at enriching learning experience, through active involvement of potential users in the design of new learning technologies (Druin 2002). In this respect, learning through design of games enables children and their educators to challenge current norms of learning contexts, allowing to set new conditions for play, social interactions, and meaning making. In this way, learning through game design provides a stronger framework for responsibility transfer, which becomes a necessary condition in the moment educators have to encourage the children in making a new game. In this sense, design of learning games would grant children even more freedom to express themselves, articulate their understanding and difficulties individually or socially.

Unfortunately we find that this rich learning scenario is difficult to achieve with digital games, as their alteration requires technical skills children do not have. This learning scenario could be easily supported by tangible toys and board games, however, digital games provide more convincing representations creating meaningful cause-effect links between the players' actions and the system responses. These characteristics make digital technologies hard to replace. If a human takes control over a game in order to show to the players the consequences of their actions, like a dungeon master in role play games, the whole interaction emerging could seem arbitrary and artificial. Therefore, we argue that there is a need for digital games that could be easy to alter by learners and in this paper we propose a middle ground between digital and table top/card games, aimed at combining lively and rich representation of knowledge with learners' freedom to alter these representations and learning conditions as well.

#### 4. A card-based model for digital game design

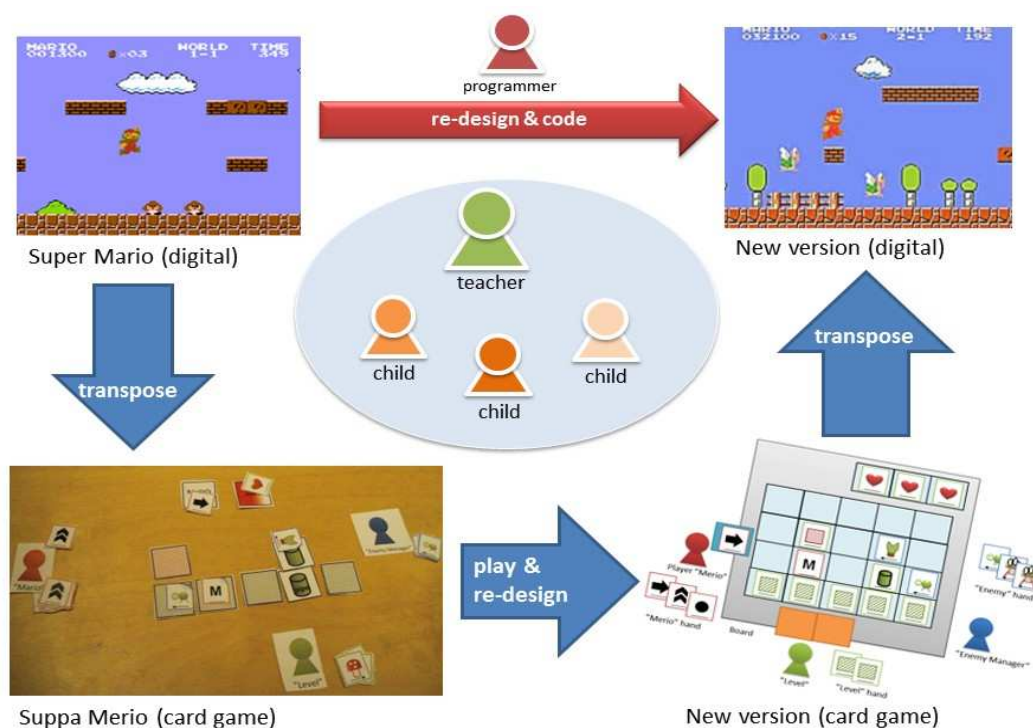
According to what discussed above, digital games provide rich interaction while card games afford (re)design and conceptual thinking. From previous work we know that it is possible to transpose knowledge from a domain into a digital game, for example following the phases suggested by the PlayDT structuralist framework (as discussed in Marchetti (2014)); in fact, PlayDT is a generalization of what we did to create MicroCulture, Prime Slaughter and a few other digital games.



**Figure 4:** We started transposing domain-specific knowledge into digital games, then we experimented with converting 2D digital games into 1D digital games. From there we had the idea of representing 1D games as card games. Finally, we realized we can go directly from 2D digital games to card games and back.

In a separate study we worked with transposition of two dimensional digital games into one dimensional games (Valente and Marchetti 2013); a 1D game is a digital game that uses a single line of colored boxes to visualize the state of the game. Although simpler than classic 2D digital games in many respects, 1D games are fully functional games and can be fun to play (Valente and Marchetti 2013). Moreover, players can easily recognize the original 2D game, from which a specific 1D game was derived, by transposition. This lead us to consider that a 1D game could be a representation of a more complex digital game, while at the same time being a complete game, not just a set of specifications or a diagram (as depicted in Figure 4). A final observation was that the low-fidelity prototype of a 1D game is effectively just a sequence of cards (or sticky notes) and few rules. After this realization we started looking at card games (and TCGs in specific) as a kind of *minimal language* to define more complex games, including digital games (the last step in Figure 4).

Figure 4 also suggests that we could go directly from a digital game (eventually designed by transposing domain knowledge) to a card game, and from card games back up, to a digital game. Hence, we propose here a scenario in which a digital game is transposed it into a TCG, then players are left free to alter it. The altered card game is turned back into a digital game that will be different from the initial digital game.



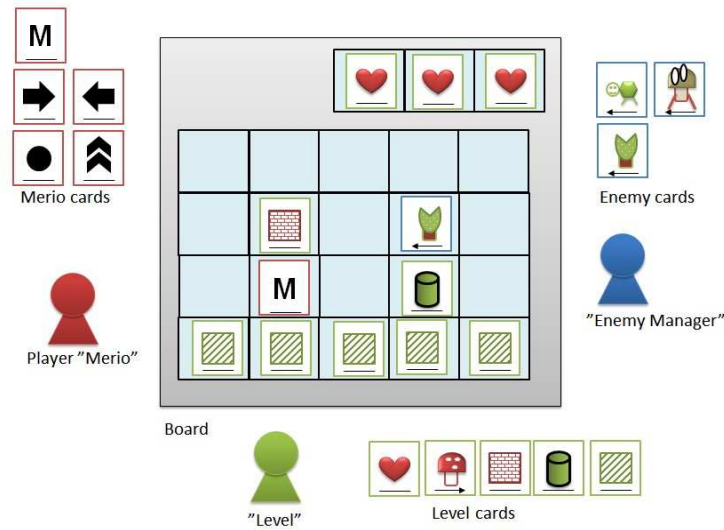
**Figure 5:** The top of the picture shows the traditional programming approach where games are redesigned and implemented by a programmer. Starting from the top left instead we can see how a class can use card games to redesign a digital game according to our approach.

This cycle (visible in Figure 5) can be understood as a novel approach, different from programming and modding, and based instead on TCG, in which players redefine digital games acquiring the same thinking they adopt when engaging in playful play with card-based prototypes, leaving behind the complexity embodied in programming.

As a first experiment we attempted to transpose the Nintendo digital game “Super Mario Bros.” (Nintendo 2015) into a TCG. For us a card game is a multi-player, turn-based simulation that uses cards to represent its state. The computation evolves following rules (similar to matching and rewriting rules found in formal rewriting systems) that alter the cards in the hand of the players with respect to the ones on the table (Figure 5). The original game was analyzed in its main elements: characters and objects with which the characters interact, rules, roles and goals of the player and the AI embedded in the game. This analysis was performed in order to capture the grounding logic of the game and create a card-based version of the same game. Since there is no obvious way to turn a game like Super Mario, which is fast-paced and side scrolling, into a card



game, we expected that this transposition process could provide an interesting challenge enabling us in finding innovative solutions and in assessing the suitability of the found solutions (Figure 6).



**Figure 6:** A view of the table during a game of Suppa Merio, the cards represent the position and state of items in the original Super Mario game.

The resulting card game is called *Suppa Merio* and its design maps the three main functions identified in the original game into roles for human players (Figure 7):

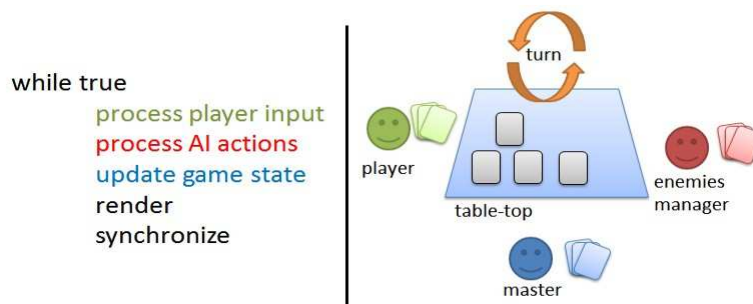
*Player* controlling the behavior of *Merio*

*Enemies manager* that controls all monsters in the level

*Game master* who oversees the state of the game and controls the environment

The resulting game is turned based, as card games are in general, and requires three players in order to control Merio (the main character), the game and the enemies. Finally a rendering step should be included, responsible for the visual representation of the game state, in TCG this is performed by the players who place cards on the table in order to express their intention to others (Figure 7). The rules of the game are applied through the different actions allowed by turning, moving or removing card from the table. The rules themselves are expressed visually a *before-after* notation.

The name *Suppa Merio* was intended as a funny mock-up of the original game’s name. In this way it was easy for us to signal to potential testers that the game was still a work in progress, hoping to collect relevant feedback. In fact, a common issue in participatory innovation is that if the prototypes look finished and professional at very early stages, then the users would take for granted the main features of the prototype and would discuss visual details (Binder et al. 2006).



**Figure 7:** The pseudo-code for the main loop of a game like Super Mario is visible on the left. On the right the 3 roles we identified: player, master and enemies manager, that correspond to card players in the card game.

This transposition technique, from digital game to TCG, should work for turning most digital games (including learning games) into TCG. Moreover, we are currently developing an editor to simplify going back from a TCG to a fully functional digital game, thus closing the cycle in our approach.

#### 4.1 Participatory workshop

To test our ideas and Suppa Merio, an initial study was conducted at our university with students who have programming knowledge and meet regularly to play TCG (Figure 8). Our target group is represented by children in primary school, however, we felt that at the stage we were, we needed to evaluate the validity of our approach with a group of “experts” like these students, and develop a more finished version of our model before we could involve children. Further studies have been planned with local schools, aimed at testing more advanced versions of our card-based model for digital game design and of the Suppa Merio game in specific. The game itself was designed to resemble a low-fidelity prototype made of paper. It includes cards representing characters, objects, explanations for the rules and the players' roles, and blank cards for the players to introduce new elements in the game. All the cards were included in a PDF file that could be easily printed and cut out (similar to the one in Figure 6).

The study was conducted with two groups, the first consisting of two and the second of three students, the two sessions were filmed and the gathered video material was later analysed through the method of interaction analysis (Jordan and Henderson 1993). We felt it was important to have two groups, one composed of students from early semesters and one with students with more advanced programming knowledge. Moreover, the participants in each group were chosen because they showed high degree of knowledge in TCG games and were all very motivated to contribute to our project. Our interest was in evaluating how people could relate to the transposition of a digital game into a TCG, if the game dynamics and elements of the original game were still recognizable. The students were asked to play for a time of 20 minutes and to participate to an interview of more or less the same time. Both groups played for a long time and easily engaged in playful play, similarly to what was observed in the design sessions we held for MicroCulture and Prime Slaughter. The students interacted in a natural way with each other and did not seem to find our mapping of Super Mario awkward in terms of meaning and playability. Interestingly, the first group was so immersed in the game that by the end they have forgotten that Suppa Merio was supposed to be a new model for game programming and not a game in its own right. Hence, these students proposed suggestions to improve the gameplay in order to make it “more fun” adding weapons and enemies. But they also suggested to provide even “more freedom for the level master and the enemies manager.” Their ideas were inspired by role play games and they referred to the Munchkin card game (Munchkin 2015), as example of the transposition of a role play game into a card game. In general the groups did not have issues in understanding how to deal with our prototype and the second group (Figure 8, bottom) even proposed that the tripartite role structure we gave to Suppa Merio could be *universal*, i.e. valid for transposing any digital game into a TCG.

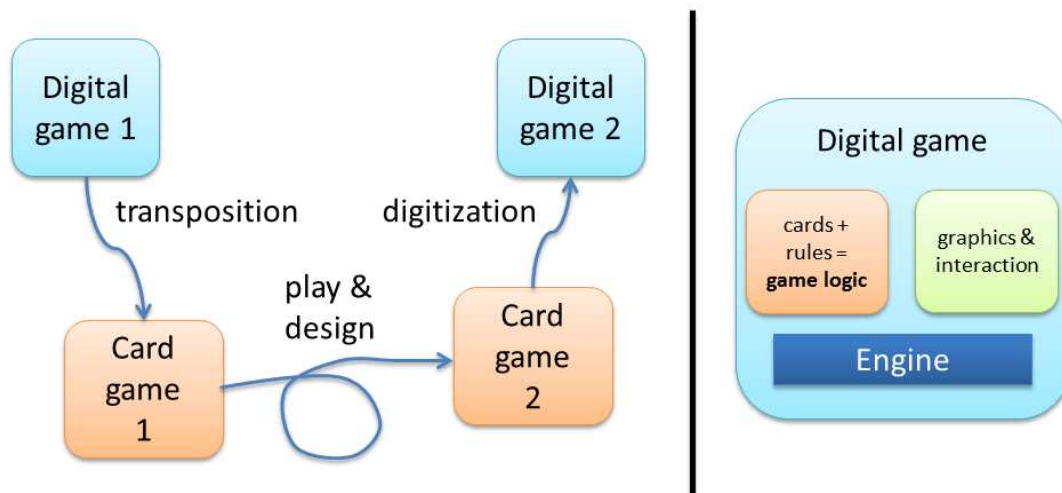




**Figure 8:** The first group of younger students (top of the figure). The second group (at the bottom) discussing while playing Suppa Merio. The emergent interaction style, where play and design behavior are alternated, is a clear sign of playful play.

## 5. Discussion

Results from this study suggest that the notion of altering a digital game through a card-based transposition of the same game could be used to create a new model for programming and modding of existing games. Card game design shares a lot with digital game programming, in terms of defining new game pieces and their behavior. However, as card game design easily emerges when players engage with low-tech games and prototypes, it can be seen as a more approachable activity than programming especially for children. Finally as already mentioned, introduction of the approach we propose to the design of learning games, would enable teachers and pupils to push the boundaries of what is normally accepted in the class, creating conditions for responsibility transfer and eliciting a constructive and reflecting dialogue (Rogoff 1990, Engeli 2005).



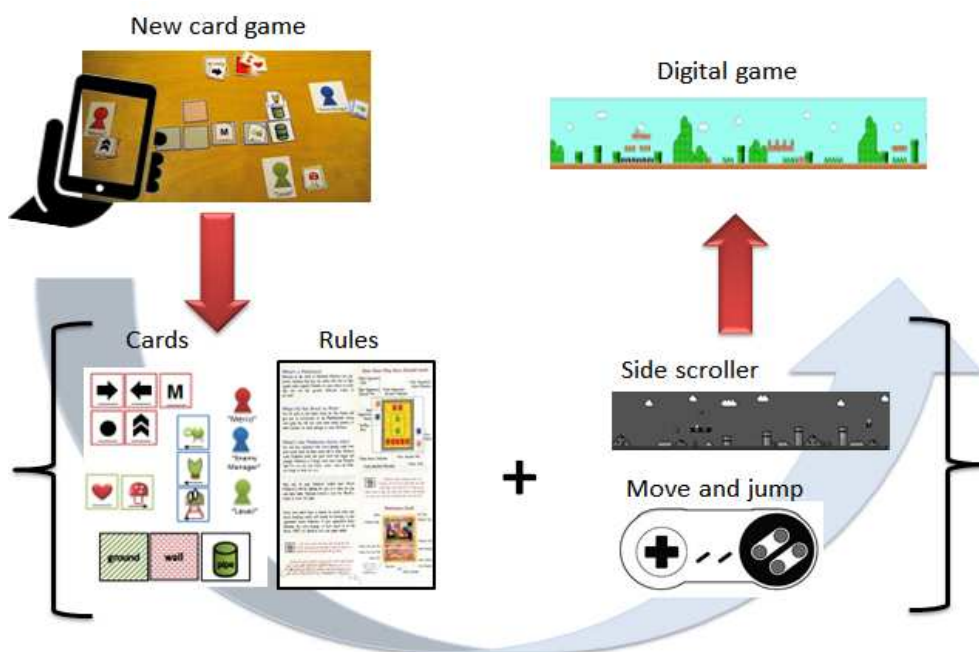
**Figure 9.** On the left the phases needed to go from a digital game to a card game and back to a new digital game. On the right: a digital game is simply a card game extended with digital-like visualization and interaction; a generic engine interprets the rules of the card game and runs the graphics on the specific platform (e.g. mobile or PC).

### 5.1 Tools to close the cycle

Before we can close the cycle in Figure 5, we need to find ways in which card games can act as mock-ups of digital games. As depicted in Figure 9 on the left, the two conditions for our scenario to become practical is

that digital games are equipped with a card game output (*transposition* in Figure 9) and an appropriate editing tool to go back from a card game to a new digital game (*digitization* in Figure 9).

For the editing tool we imagine a scenario like the one described in (Harel 2008), supported by a smart mobile phone application with a workflow similar to that of POP (Prototype On Paper 2015): scan drawings of a user interface, then annotate it to create clickable links and simulate navigation. In our scenario of use the editing tool should be similar to POP, but specific to card acquisition and rules specification, so that pupils or educators can easily digitalize their TCG. The other half of the problem is how to transpose a digital game. We have considered automatic generation of a TCG from an existing digital game, but from our experience creating Suppa Merio we feel that it is possibly too early at this stage of development of our new card-based approach, to define an algorithm that could do an acceptable job. Moreover, keeping transposition manual, it is possible to have a single digital game transposed into different TCGs, representing partial yet valid point of views on the original game. For this reason we propose an architecture like the one visible in Figure 9 on the right, where transposition is not automatic, but instead a card game is always present inside each digital game, ready to be printed, converted into cards and rule leaflet. Later the card game can be played and eventually re-designed, then the new card game can simply be acquired (the digitization phase in Figure 9 on the left) with the help of a mobile app, and used to generate a new digital game. The new digital game created needs a few extra specifications: for example graphics style, type of view (e.g. side-scrolling or top-down) and interaction style.



**Figure 10:** A new card game is created and then digitized via a mobile app. To define a complete digital game the authors need to add information about the graphics and interaction styles.

Such information in fact cannot be extrapolated by a card game, and should be expressed by the players/designers. To conclude, in our scenario we consider every digital game as containing the rules and cards of a card game: together these two things define the *logic* of the digital game. In addition, the digital game also specifies how to render the game graphically and how the user-interaction is carried on, either on a PC or on a mobile device. We call the proposed architecture *card-centric*, because with it the development of a new digital game always starts from a card game.

As a concrete example, we can consider the creation of a new digital game similar to Super Mario: we would start from a card game, defined by cards and rules; this card game is digitized using the POP-inspired mobile app. The result is a digital representation of both cards and rules created by the author (or authors). Information about the style of interaction and game graphics is also to be provided, so that the digital game is fully specified. A walkthrough of the entire process is visible in Figure 10.

We are aware that not all digital games allow for a simple re-implementation in our card-centric architecture; however, we expect that our approach should be general enough to cover many genres, in particular puzzle, adventure and platform-style games. Finally, an open question that we are currently investigating is how to best express graphics and interactions styles, in a child-friendly way.

## 6. Conclusions

This paper proposes a two-fold contribution: a new games based learning scenario in which children and their educators engage in game design as part of their lecture, and a proof of concept of an alternative model for game programming in which digital games are re-conceptualized as trading-card games. This model enriches the application of games based learning, promoting children from players to designers: in this respect our card-based model enables children to gain more freedom of self-expression. We observed that while playing with digital games children are more prone to accept what has been already implemented instead of challenging and creatively reconfigure it. The main obstacle to creativity is that freely altering digital games requires programming knowledge, and that in turn might require long time to gain for both children educators; moreover, programming is often out of scope in situation of learning targeting other subjects. To cope with these limitations our model proposes a constructionist approach (Kafai 2006) in which children become game designers. The relevance of coding new digital games is reduced, since game programming is replaced by groups of children tinkering with tangibles, together with their teachers. In fact, our approach is expected to enrich the social interaction emerging between children and teachers, supporting responsibility transfer at early stages, which is considered by Rogoff (1990) as a central factor in children's learning. Giving children better support for creating, playing and reflecting upon their own digital games, the proposed scenario is expected to elicit in them forms of designerly knowing (Cross 2006), through which children develop new ways of thinking through the creation of things of significance centred on the subject at hand (Kafai 2006).

Currently the Suppa Merio game is under further development and agreements with local schools have been made for testing of more refined versions, in order to investigate how to improve learning conditions in class and, on a longer term, define our alternative model for programming. In order to test the card-based approach for digital game design we are working on a KIT, comprising a tutorial, blank cards and special sheets for the rules. Teachers will soon be able to present the concept to their pupils via the tutorial in the KIT and quickly print their own materials. We are cooperating with local schools to validate our claims and collect more general data about the expressive power of TCGs in the class.

An empirical study is also being conducted in a local primary school in cooperation with teachers dealing with classes of autistic children. The school is interested in integrating digital technologies in their teaching activities, in order to make learning more engaging for the children. Moreover, because of their condition, these children have issues imagining abstract concepts by themselves, so that their teachers are constantly looking for new tools that could help them in stimulating the children's imagination and understanding of their curricular subjects.

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