Digital Game-based Learning can be seen as a subset of e-Learning that is extremely broad, aiming with varying approaches at different target groups with corresponding use-cases. It is a field that integrates at least the three domains of the socio-cultural question of play and games, the design and technological field of how to design play/games as well as what and how learning is and should be. The interconnectedness of these fields in Digital Game-based Learning is what makes it so fascinating but also hard to teach and research, as one must stay up-to-date in all aspects and developments. In this special issue of the Electronic Journal of e-Learning we thus wanted to present selected and extended papers – from the 8th European Conference on Games Based Learning (ECGBL) – to you that exemplarily span this dynamic and ever evolving field.

The first paper “Developing and Testing a Mobile Learning Games Framework” – by Carsten Busch, Sabine Claßnitz, André Selmanagić and Martin Steinicke – opens this eJEL issue with a comparatively rare context for game-based learning research: Private tutoring. Games can be used with varying goals in private tutoring: As a pure motivational or rewarding addition, as a means to foster retention of facts and figures so that the valuable face-to-face time is free to discuss motivational issues and learning strategies, or as deep integrated procedural learning experiences that can be framed and discussed in the private lessons. Each of these three is actually not differing from play-based approaches in schools but especially games targeting the latter two need to be especially good at showing parents that their children learn curriculum related content on the one hand and on the other hand being so engaging that students play these games in their spare time. Based on this use case the authors explain the development and testing of their mobile learning games framework, which consists of a conceptual part that specifies potential core-mechanics for mobile learning games and a technological part which is based on the game engine Unity. The paper describes these parts as well as their design-research oriented iterative development.

The second paper “Learning via Game Design: From Digital to Card Games and Back Again” – by Emanuela Marchetti and Andrea Valente – focuses on the promising field of learning by (re-)designing games. Based on the experience with two game prototypes – one being a settlement simulation that requires the placement of tangible tokens to place infrastructure elements, the other being a maths game – the authors found that children discussed both game and content related questions while teachers easily fell into the “guide on the side” role giving children space to be active social learners. This worked best with low fidelity prototypes that children should and could discuss while high fidelity prototypes obscured the models and rules resulting in discussions about graphical improvements instead. A further problem identified by the authors was that children did not have the technological skills to adapt the prototypes and thus could not really learn by (re-)designing the games. The authors thus tested the transformation of digital games into non-digital card game prototypes that children then could easily adapt. Last but not least the authors propose a round-trip engineering approach, so that the adapted card-based prototypes could finally be re-digitized.

In the third paper – “Scenario Based Education as a Framework for Understanding Students Engagement and Learning in a Project Management Simulation Game” – Morten Misfeldt describes his concept of using a competitive approach to project management simulations. Two groups play the simulation each managing their own project planning for a building site. Additionally each group acts as a disruptive force for the other team’s project plan. Each round students need to make decisions and take actions for their own project. They would then try to find loopholes in the planning of the other group and choose actions to delay the other
groups progress. Repeated over several rounds this clever strategy brings students to analyze both their own as well as the other team plans and decisions thoroughly. Learning to plan ahead and find weaknesses in their own and others plans. Mortens frames this with his view on scenario-based education and an interesting distinction between the simulative and the competitive gaming aspect.

The final paper in this issue is “Dynamic Pervasive Storytelling in Long Lasting Learning Games” by Trygve Pløhn, Sandy Louchart and Trond Aalberg. Montola et al (2009) defined pervasive games as a subset of games that breach the magic circle (Huizinga, 2011; Salen & Zimmerman, 2004) of a game either socially, spatially or temporally. Pløhn et al. focus primarily on breaching the temporal bounds of the game by spanning the game over nine weeks and dynamically interweaving it with real world events to foster in-game awareness. To bridge the sometimes long periods without any play or gaming activities these real world events were integrated into the storyline of their game Nuclear Mayhem and referenced by awareness raising actions – like sending in-character SMS or e-mail to the players. The latter should additionally motivate learning goal related activities without breaking the immersion of players. When integrating unpredictable current news items into a pervasive game one might choose two extreme strategies. Either integrate the news items into the main pre-scripted story-line – potentially breaking the narrative at some future point – or having no pre-scripted narration at all – hoping on the emergence of a story through the current social/political/economic/cultural developments. Pløhn et al. cleverly solve this by using a side-quest like concept that externalises the news items from the pre-scripted main narrative into story arcs that later on can be merged back into the plot.

We hope that you will enjoy the papers in this issue as much as we have and we would love to meet you at the 9th ECGBL 2015 in Steinkjer, Norway – or whenever you are in Berlin.

With best regards from Berlin,
Carsten Busch & Martin Steinicke
Editors

References
Developing and Testing a Mobile Learning Games Framework

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Abstract: In 2010 1.1 million pupils took private lessons in Germany, with 25% of all German children by the age of 17 having attended paid private lessons at some point in their school career (Klemm & Klemm, 2010). The high demand for support for learning curricular content led us to consider an integrated solution that speeds up both the design of mobile learning games as well as their implementation and adaption. This paper describes the iterative development of a game development framework for touch-based mobile learning games. The framework focuses on touch-controlled interaction due to the fact that in 2014 more than 87% of German teenagers possessed a smart phone with touch input (Feierabend, Plankenhorn, Rathgeb, 2014) as well as the possibility to engage in short bursts of learning experiences during their idle time, e.g. when commuting. The framework consists of a conceptual component that specifies five different game modes for casual mobile learning games. The technical part of the framework builds on the Unity game engine and offers an architecture that mirrors the game modes and objects from the conceptual part as well as a layer of service building blocks that cover generic functionality like logging, high score management or social media integration. The development of the framework is iterative and cyclic in that each produced game enriches the framework, which in turn accelerates the prototyping and development of future games. Additionally the games themselves are developed and tested iteratively – both concerning usability/user-experience and transfer, which is described in this paper.

Keywords: mobile learning games, touch interfaces, private lessons, usability, software framework, transfer

1. Introduction

Private tutoring – sometimes referred to as shadow education (Enrich, 2014) – is a huge and growing market. In 2010 1.1 million pupils took private lessons in Germany, with 25% of all German children by the age of 17 having attended paid private lessons at some point in their school career (Klemm & Klemm, 2010). Though Austria shows similar numbers (20%), the amount of paid private lessons varies greatly across Europe. While only 8% of secondary pupils from the UK receive tutoring, surveys in Lithuania showed that 62% of university students had received private supplementary tutoring in their last year of secondary school (Bray, 2011). The reasons for this development are diverse and often viewed in a negative light, in that they foster inequality, performance pressure and a competitive attitude (Klemm & Klemm, 2010; Bray, 2011). Other authors like Enrich (2014) highlight that private tutoring might be beneficial in a social sense, as it could have a neutralizing effect on disadvantaged family backgrounds.

When success in learning is to a large extent coupled with knowing the basics, a vicious cycle is easily set into motion. Failure creates anxiety, thus motivation (Csikszentmihalyi, 2010) and perceived self-efficacy (Bandura, 1977) declines. Negative emotion avoidance strategies (Persons, 2010) are developed, and thus future success in school becomes less and less likely. In today’s performance culture, parents commonly seek professional help even for their well performing children (Klemm & Klemm, 2010). From a motivational standpoint this may actually further foster the decline of pupils’ intrinsic motivation through the perceived parental, thus extrinsic, motivation (Ryan & Deci, 2000:56) and the potential loss of social/peer status.

Digital game-based learning may be used to counter these points. Clearly associative approaches fit into the specific use-case of repetitive training. Pupils need to memorize curriculum-specific content like facts and figures as well as develop a seemingly intuitive grasp of methods and concepts that, like in basic math or language lessons, are often only acquired by such repetitive training. With these approaches facts and figures can be learned in less time compared to systemic or constructivist approaches. Additionally, as the learning content is pretty apparent, parents understand why their children should play these games as a learning aid. And from the child’s perspective, even a game, which is clearly learning-oriented, may be an appealing alternative compared to learning from other sources. Furthermore, such games may be helpful to break the

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above described vicious circle of failure, self-efficacy reduction, avoidance strategies resulting in renewed failure alternately creating moments of success that may foster content-specific self-efficacy.

Compared to such conceptually embedded games (Clark & Gaza, 2012), which embed learning content into existing game mechanics that have a weak or no relation to the learning goals, conceptually integrated games facilitate deep systemic but oftentimes implicit learning. Due to this, the latter do need a teacher or a special game mechanic to support the transfer of the primarily implicit understandings (Clark & Gaza, 2012:280). Thus while the former are ideal for rote learning at home or while commuting as well as relieving the burden of testing by the tutor, the latter engage in deep learning during individual idle time so that the tutoring sessions can be used for discussing concepts, problems and motivational aspects instead. An approach that is rather similar to the concept of the flipped classroom (Tucker, 2012).

2. The Conceptual Component of the Game Framework

With the aim of using mobile learning games in collaboration with private lessons and tutoring, the question arose whether to create an integrated learning experience that teaches multiple school subjects at once or to focus on a palette of games that each teaches a specific subject. Due to the fact that parents commonly only enroll children for one or two courses, we decided to create a game framework that enables both the design and implementation of small games that focus on the latter. In this context “framework” does not denote a pedagogical framework as in (Park, 2011) or a conceptual framework as in (Yusoff, Crowder, Gilbert, & Wills 2009), but rather a software framework, which “is an architecture or infrastructure intended to support and enable the integration and interoperation of software components. The essential idea is that components developed to be compliant and consistent with a framework may be combined, connected, and composed within that framework, and that such compositions may be assembled more readily and with more likelihood of correct operation than would be possible without the framework.” (Petty, Kim, Barbosa, & Pyun, 2014)

The conceptual part of this framework, which provides building blocks for designing touch-based games, will be described below.

2.1 Inspiration

To reach our goal of creating games that support the client’s educational goals while simultaneously being sufficiently entertaining so that students aged 10 to 16 would play them as exercises in their spare time, we started with a market research followed by brainstorming sessions. Although we were well aware of (and for some time even shared) the critical attitude towards learning games that do not integrate the learning content into the games mechanics (see e.g. Egenfeldt-Nielsen, 2007), we came to see that the approach of choice depends primarily on the context and learning goals.

One entertainment game that we identified as promising in our market research is the iOS game Super 7 (No Monkeys, 2010), which inspired the framework described in this paper. The core game mechanic of Super 7 is simple: by drawing paths on the touchscreen, the player has to bring floating digits together until they add up to the number 7. Reaching the summation of 7, scores points. However numbers greater than 7 result in “Game Over”. Super 7 provides a challenging gameplay while teaching basic mathematical concepts like addition and division along the way.

With mathematics being one of the most problematic subjects for many students in our target group (Stiftung Warentest, 2006), our initial idea was to transfer Super 7’s game mechanic to more advanced mathematical problems like fractional arithmetic and percentages. In such a game the goal would be to sum fractions up to 1 (see figure 1). Using color-coding and varying sizes, a game like this should give students a sense of how decimal values and fractions relate to each other and show them how the same value can be represented by multiple fractions. It could also depict how fractions and percentages are related.
Figure 1: Mock-up example of the basic game mechanic with fractional arithmetic.

For our goal to create a number of mobile learning games, we decided to abstract this basic game mechanic, and reconstruct it into a framework consisting of a conceptual as well as technological component. It features a handful of different touch-based input methods in addition to the creation of paths used in Super 7, and a set of different ways in which objects can interact with each other. This framework would serve as a foundation for the game instances, enabling us to mix these game parameters and create similar, but diverse, gaming experiences.

2.2 Core Game Mechanic and Game Objects

In its current state the framework consists of five different game modes, which are loosely based on the same core game mechanic. Game parameters were classified into groups, including variables of game objects and global parameters. Each game mode represents a different combination of these classified parameters (mixture of the global parameter values and game objects that have mixed parameters as well). The game instances, hereinafter called game modules, are implementations of the abstract game modes.

2.2.1 Core Game Mechanic

The playing field is static and two-dimensional. It can be populated by visual objects, which may either float freely or are placed at fixed positions. Depending on their types, the player’s objective is to bring these objects together and combine them, or to keep them apart using touch gestures, for instance by drawing paths for the objects to follow or by swiping them in specific directions. Encounters of the “correct” (contextually associated) objects scores points, whereas collisions of “wrong” objects whether intended or not, drains health points and eventually leads to the end of the game. The player’s objective is to score as many points as possible before all health is depleted.

For example: In a game, in which the player’s objective is to associate countries with their respective continent, bringing “Denmark” and “Europe” together would score points, whereas matching “China” and “Africa” would drain health.

2.2.2 Game Objects

We classified the possible variables and values for game objects so that every game object could be built upon the same foundation. All types of game objects share the same basic variables, but with varying values. Each game mode (and game module) has a unique gameplay due to its different mix of these factors. The main variables are as followed:
Table 1: Game object variables and their allowed values

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description and possible values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>Game objects can be placed at fixed positions or move freely. Moving objects have a fixed speed and direction, with the exception of objects that the player interacts with, e.g. by providing a path for the objects to follow.</td>
</tr>
<tr>
<td>Limited by playing field boundaries</td>
<td>Objects may be restricted by the boundaries of the playing field. If so, they are deflected by the borders. Otherwise they simply leave the play space.</td>
</tr>
<tr>
<td>Appearance / Spawning</td>
<td>Objects either exist at the beginning of the round or enter the playing field from the outside during the game.</td>
</tr>
<tr>
<td>Player influence</td>
<td>The player may alter the position of objects in various ways.</td>
</tr>
<tr>
<td></td>
<td>Values:</td>
</tr>
<tr>
<td></td>
<td>• None: The player cannot influence the object in any way.</td>
</tr>
<tr>
<td></td>
<td>• Follow path: The player can draw a path on the screen. If the path crosses the object, the object will follow it. (Touch gesture: drag)</td>
</tr>
<tr>
<td></td>
<td>• “Holdable”: The player can hold a moving object (keep it from moving). Once the player lets go, the object begins to move again (Touch gesture: press)</td>
</tr>
<tr>
<td></td>
<td>• Follow path and “holdable”: Mixture of “Follow path” and “Holdable” (Touch gestures: drag, press)</td>
</tr>
<tr>
<td></td>
<td>• Directly controlled: The player can directly change the position of the object by dragging it to a different location. (Touch gesture: press &amp; drag)</td>
</tr>
<tr>
<td></td>
<td>• Deflectable: The player can change the direction of a moving object. (Touch gesture: swipe)</td>
</tr>
<tr>
<td></td>
<td>• Tap action: When the player taps the object, a custom action is executed. (Touch gesture: single tap)</td>
</tr>
<tr>
<td></td>
<td>• Custom action on path encounter: When the player draws a path over the object, a custom action is executed. (Touch gesture: drag)</td>
</tr>
<tr>
<td>Collisions</td>
<td>Depending on the types of two colliding game objects, different results may occur.</td>
</tr>
<tr>
<td></td>
<td>Values:</td>
</tr>
<tr>
<td></td>
<td>• Pass through: No physical interaction. No change in points or health.</td>
</tr>
<tr>
<td></td>
<td>• Deflection: Both game objects bounce off of each other. No change in points or health.</td>
</tr>
<tr>
<td></td>
<td>• Dissolution (both): Both game objects dissolve. Depending on the types of the objects, points may be given or health is drained.</td>
</tr>
<tr>
<td></td>
<td>• Dissolution (one): One of the two game objects dissolves. Depending on the types of the objects points may be given or health drained.</td>
</tr>
<tr>
<td></td>
<td>• Dissolution with creation: Both game objects dissolve, but one or more new game objects are created. Depending on the types of the objects, points may be given or health drained.</td>
</tr>
</tbody>
</table>
2.2.3 Basic Variables of a Game Mode

The game modes themselves also have a set of variables, including the maximum number of paths the player can draw for objects to follow, the maximum number of objects on the same path, in which direction of the path objects are moving (towards the start, the end or the centre) and whether paths are shrinking with time. Another important variable is the number of health points, e.g. the number of mistakes a player can make before the round is lost.

2.3 Game Modes

As stated, all game modes are basically combinations of the different possible values provided by the game objects and the basic variables of a game mode. For the framework five game modes have been specified. Based on these game modes we created concepts for several games (game modules), targeting various subjects from fractional arithmetic to musical history to counting in different languages or numeral systems. Some of these are described with each game mode.

2.3.1 Game Mode: “Categories”

The game mode “Categories” defines two different types of game objects: categories and elements. Categories exist from the beginning of the game, and have fixed positions that cannot be altered by the player. Elements are moving and enter the playing field from the outside. Each element belongs to a specific category. The player’s objective is to guide the elements to their respective categories, but also circumvent unintended encounters of non-associated elements and categories. When a category and an element collide, the element dissolves. The algorithm may replace categories with other categories during the game. The previous example of associating continents and countries is a representative of this game mode with continents being the categories and countries the elements.

The game mode is divided into three different variations (“sub game modes”):

In Variation A, once an element has entered the playing field, it cannot leave the play area. The player can draw paths, which the elements will then follow to the end; however, the player can also hold the elements. With new elements entering the field and old ones unable to leave (unless associated with a category), the players will find themselves under increasing pressure.

Variation B (“Comets”) features elements that enter the screen like comets flying in a random direction. They are not limited by the playing field boundaries and can therefore leave the screen. The player can deflect them by swiping them in the desired direction, e.g. towards a category or out of the playing field. By letting the correct elements leave the screen, the player loses the chance to score points. On the other hand it reduces the risk of false associations if the player is in doubt.

In Variation C (“Boxes”) coincidental collisions of elements and categories do not count as an association of the two. Elements will just bounce off. To bring an element and a category together, the player needs to drag it onto the category. In contrast to the other two variations, where elements and categories can unintentionally collide, the player only loses health if the wrong decision was made.

Game Module: “Continents & Countries”

The educational objective of “Continents & Countries” is to teach the player, in which continent a given country is. The game module is based on the game mode “Categories” variation B (“Comets”). A globe is placed in the center of the screen with the active continent facing the player while individual countries enter the playing field from outside. The player can use swipe gestures to guide the countries in specific directions, either towards or away from the continent. For correctly associating a continent with a country, the player scores points. If the player sends the wrong country to the displayed continent (e.g. “France” to “North America”), the player loses one health point. The game is lost once all health points are depleted. The active continent is repeatedly swapped.

As the game progresses the difficulty increases, which has three consequences. First, with increasing difficulty, the countries will begin to move faster and spawn more often. Secondly, the “wrong” countries are more likely to fly towards the continent, forcing the player to react. Lastly, the set of continents and countries, which
enter the field, are related to the chosen difficulty level, being divided into groups from countries that are most commonly known (e.g. industrial countries and Germany’s neighboring countries) to lesser known countries (e.g. smaller island countries). Lesser known countries score more points, although this can be adapted easily as the sorting of countries into difficulty levels is located in a CSV file. The prototypical implementation of this game module, called “Crazy Robots”, will be described in section 3.4.

**Game Module: “One, Deux, Tres”**

“One, Deux, Tres” uses a similar concept for teaching counting in different languages. Instead of countries, numerals in word-form from varying languages are entering the playing field. Four categories are shown simultaneously in the corners of the screen, representing numbers in the form of western Arabic numerals (symbols). The player’s task is to associate the words with the correct Arabic numerals. The numerals in word-form are color-coded by their respective language (figure 2). The module utilizes sub game modes in Variation A or C (see 2.3.1) depending on the specific implementation of the rule system.

In addition, this module can be enhanced with a mathematical context so that new numeral objects can be created by combining two or more numeral words with mathematical operators such as addition, subtraction, multiplication and division. The result of such a game action is an object that contains the result of the mathematical operation with the two Arabic numerals, which will then disappear from the game field. The languages used in a game session can be chosen individually via options.

![Figure 2: Mock-up example of “One, Deux, Tres”](image)

**2.3.2 Game Mode: “Combination”**

In the game mode “Combination” the player needs to draw paths to combine objects, similar to the gameplay of Super 7.

Objects in this mode are specified as mobile and can hold different types. They enter the game field from outside and keep moving within the dimension of the play area. The player can combine elements by drawing a path between them or can keep items apart by swiping them to change the direction of their motion. A long press on a game object results in “holding” the object – meaning it remains on its current position until released. Once a path was created, it will shrink from both sides, which over time results in a collision of the involved items. Other independently moving objects can collide as well. The specific handling of these events e.g. evaluation within the game context is part of the respective game module implementation.

For the creation of game modules the game mode “Combination” provides two sub variants regarding the basic handling of collisions as well as in the maximum number of objects a path can hold:

In Variation A two colliding game objects merge to a new game object and a path can hold an arbitrary number of elements. This variant is suitable for games like the previously mentioned math game “Super 7”. In “Super 7”, game objects are represented by integer numbers, algebraic signs (+/-) and mathematical operators such as multiplication or division by a specific value. When two or more numbers collide, they merge and sum up their values to a new integer number. Combinations of number objects with algebraic signs or mathematical operators change the current value of the number object and merge with it.

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In Variation B, the colliding items of different types dissolve and a path can hold two objects at maximum. An example would be an application where one-to-one allocations have to be found for example the correct combination of a flag with a country. Two colliding flags will reflect from each other whereas the collision of a country with a flag will result in a merging process.

**Game Module: “Fractional Arithmetic”**

As mentioned previously the “Fractional Arithmetic” game (see figure 1) teaches about the relation of decimal values and fractions and how multiple fractions form the same value. For this, the game mode in Variation A is utilized. Players will combine fractions by drawing paths between them with the goal of forming the value of “1”. On object collisions the values of the involved elements are summed up and the result is the value of a new fraction item (see figure 1). If the new value is 1 the merged fraction object disappears and the player is rewarded with points. If the result exceeds 1 the game is over. Objects with values smaller than 1 remain floating in the playing area. Similar to the gameplay of “Super 7” other elements such as mathematical operators and algebraic signs are available to modify the value of existing fractional items.

### 2.3.3 Game Mode: “Positioning”

The main task of the game mode “Positioning” is to place certain objects in the “correct” position on the playing field. Two types of game objects are specified in this mode: backgrounds and elements. Similar to “category” game objects (see 2.3.1) backgrounds are available from game start and cannot be modified by the player directly. Backgrounds provide the context to which one or more elements relate. Elements can be initially fixed or mobile. The player will move them to a position in the playing area where they are locked. While mobile elements enter the playing area from outside and keep moving within its dimension initially fixed elements are apparent in a specific location from the beginning of a game session. The player’s goal is to drag the elements in the right positions a background provides e.g. placing floating punctuation marks in the correct positions in a displayed sentence.

The game mode offers two variants with respect to object collision and movement settings.

**Variation A** provides elements, which are initially mobile and do bounce on collisions with each other.

In **Variation B** the elements are initially displayed in a fixed location e.g. within a menu where the player can choose from by tapping on an item. Once an element was selected the player can place this item by tapping on a new position in the playing area.

**Game Module: “SURGE Clone”**

Whereas the previous examples use learning by association to teach facts and figures, more constructivist approaches are also imaginable. SURGE II is a learning game that teaches Newtonian mechanics, in which the player needs to navigate a spaceship through a narrow pathway by placing commands (forces, impulses, acceleration, etc.) in the game world, thereby modifying the motion of the spaceship (Clark & Gaza, 2012:282).

![Figure 3: Mock-up example of a “SURGE II” clone.](image-url)
The previously named game mode “Positioning” provides all necessary functionality for placing commands in the world (see figure 3), albeit the specific physical consequences of these commands need to be defined in the game module itself.

2.1.1 Other Game Modes

The other two game modes are constructed in a similar manner. In “Order” the player’s objective is to connect objects in the right sequence, for example combining syllables to make a whole word. In contrast “Separation” requests the player to split up existing objects and form new objects from the pieces. This could be used for teaching subjects like chemistry or engineering.

3. Technical Framework and Game Prototype

Following we will describe the architecture of the technical framework. We strived for an iterative development with a lean base, which could be fleshed out by each produced game module so that – over time – development of new game modules would be accelerated. How this works is described in 3.3 and 3.4 using the example of the “Crazy Robots” game module. A further point in this iterative concept was to use the rapid prototyping approach as in game design, design thinking and design based research (see e.g. Barab & Squire, 2004; Wang & Hannafin, 2005; Pernin et al., 2012) to quickly identify potential issues that need to be addressed. This stands in contrast to the Waterfall or ADDIE (analysis, design, development, implementation & evaluation) approach to software development that focuses on distinct, separated and sequential phases (Kapp, 2012:199). Especially the Waterfall Model is often connected to the low success rate (1995: 16,2%) of ICT projects (Rajlich, 2006). This proved to be a valuable approach as described in 3.5 and 4.

3.1 Architecture of the Framework

In its current version, the technological framework (see figure 4) is modelled closely to the hierarchical structure of the conceptual part of the game framework – supplying a class hierarchy for game modes and a base class for game objects that provides the functionality described in section 2.2.2 (Game Objects). The framework builds upon the Unity game engine 4.1.2 (Unity Technologies, 2013).

Figure 4: High level overview of the technical framework
The game modules and components can additionally make use of services like the logging system, which is going to be described in the following section. Services provide commonly used functionality, which is not tied to the core game mechanics and abstract this functionality behind coherent interfaces. Besides the “Logging” service we intend to add other reusable services like “Badges & Achievements”, “Highscore” (local and online leader boards) and “Social Network Integration”.

3.2 Logging & Analytics

In order to enhance our analysis of the possible learning outcomes, logging capabilities were added to the service layer of the technological framework – producing log files that can be analysed using a custom web application.

3.2.1 Logging

The logging system allows the developer to create player sessions (identified by the players name and starting time of the session), log arbitrary events with custom attributes as well as a timestamp in game-time (being the time actively playing - excluding pause and menu time) and save all this session information on the device. This information enables the researcher to reconstruct the complete session of every player.

```xml
<message title="New Round started" timestamp="0.000000" unix_timestamp="1425379850" />  
<message title="Continent Activated" timestamp="2.028221" continent="Africa" />  
<message title="Country Spawned" timestamp="2.110053" country="Ethiopia" oncurrentcontinent="True" />  
<message title="Country Success" timestamp="5.020000" country="Ethiopia" pointschanged="5"      
    currpoints="5" playertouch="False" />  
```

**Figure 5:** Excerpt of a log file from a participant’s session of the “Crazy Robots” game module

The log file is saved as XML (see figure 5) whenever the game is paused or over. This is a compromise between not doing IO while the player is actively playing and saving often enough to prevent losing log data due to unforeseen software crashes. Saving the log data on the device ensures that the test participants do not need to be online while playing, but has the obvious drawback of the researcher needing access to the device after the test was conducted. Optionally sending the log files to a server once a device gets online is a feature for a future version of the logging system.

3.2.2 Analytics

With XML as a standard format, the log data can easily be analysed using existing applications like Microsoft Excel or statistics software like IBM SPSS. Depending on the type of the targeted visualization it may also be feasible to create custom charts using self-written software, for example by using the statistical computing and graphics environment R (The R Foundation, 2015).

To ensure maximum flexibility when analysing the log data of “Crazy Robots” (an implementation of “Continents & Countries”, which will be described in section 3.4), we decided to develop a small web application that does all the necessary computations on the data and generates graphs using the visualization library D3.js (Bostock, 2015) and the reusable chart library C3.js (Tanaka, 2015).
Figure 6: Visualization: participant’s correct, wrong & missed matchings over number of rounds played for Fiji

This web application is currently still strongly tied to the log events produced by “Crazy Robots”, but the idea is to abstract it in a way that it is useful for visualizing the log data of arbitrary game modules that have been created using the framework.

Besides this web application, a command-line utility that converts the XML files into segment.io events, is in the making. Segment.io (Segment, 2015) is a service that provides a unified interface to many different online analytics services. Some of these services like the open source analytics platform Piwik (Piwik, 2015) can be hosted locally, in case privacy is an issue. This will provide researchers with more tools for analysing player sessions and learning outcome.

3.3 How to Create new Games

To implement a new game module, a new class must be derived from a game mode or variant class, which provides most of the necessary game logic. This new class needs to deal with all the functionality that is unique to the game, such as loading the specific necessary data. The visual game objects must be implemented as Unity’s component-based game objects and use the BaseGameObject class, which handles movement, collisions and the like. Unity allows us to expose these game parameters to the user interface of its editor. This way, game parameters like movement speed of the game objects, spawn rate, and difficulty levels can easily be fine-tuned by the game designer. Creating a new game module is mostly a task of adjusting values in the Unity Editor (figure 7) with programming only required for module specific behaviours, which are not already provided by the existing game mode classes.

Figure 7: Properties exposed to Unity’s user interface
3.4 From Game Design to Game Instance: A Quick Tour

As a proof of concept we developed a prototypical version of the game module “Continents & Countries” called “Crazy Robots”, which is built upon the technical framework. The following description of the prototype underlines how the framework enables rapid prototyping and development of new game modules for a given learning goal.

3.4.1 Conceptual Design

Even with a technical framework at hand, the visual appearance and story of a game module must still be crafted. However, once created, arts and animations can be reused for other game modules. With our young target group in mind, we designed a comic-based style that features animated robots (figure 8) in the spirit of WALL-E (Walt Disney Pictures & Pixar Animation Studios, 2008), with the intention of targeting both genders.

Figure 8: Screenshot of the game module “Crazy Robots”

3.4.2 Technical Development

The creation of the game prototype started with an empty Unity scene. All the necessary elements (background, the globe with its continents, the robots) were created as Unity game objects. Some of them, like the globe, were placed in the scene while the robots were saved as prefabs (basically game object templates) that are instantiated dynamically. The robots that represent countries are assembled from different components that handle animations and gameplay (movement, collisions), the latter in form of the BaseGameObject class. We created the new game module’s main class (GM_GeoContinents) as a subclass of the variation GameMode_Categories_Comet.

The game module’s class handles everything specific to “Continents & Countries”: loading of the country-data from a CSV file, rotating the globe, changing the active continent, and setting all parameters related to difficulty and points. The class is also connected with the prefabs of the robots so that it knows what prefab instances to instantiate. With the exception of setting the textual content to be displayed, the creation of the country game objects is handled by the game module’s super classes (GameMode_Categories and GameMode_Categories_Comet).

Having created the necessary game objects and the game module’s main class, we balanced the gameplay by adjusting the game parameters in Unity’s editor. We created a set of difficulty levels with difficulty increasing over given time intervals, for instance robots will move faster and lesser known countries appear more often.

3.5 Transitioning to a more modular framework

The development of the “Crazy Robots” prototype proved that the framework is flexible enough to create game modules that combine the existing game object behaviours in new and interesting ways, but we found that the object oriented class hierarchy makes it harder than necessary to create new game modes that require alternate behaviours, for example means of player-game-object interactions that are currently not provided. In the next version of the framework we thus intend to make greater use of Unity’s component-
based architecture by disentangling the current functionality into even smaller single-purpose components with as little interdependency as possible. These “building blocks” (see figure 4) can then be combined to easily create new game modes, game modules and game objects.

4. Expert and User Tests

We built the “Crazy Robots” game to evaluate the ease of use and potential of both the conceptual and the technical components of the framework. Additionally we carried out heuristic usability and user tests with this prototype to identify further issues that may need to be considered for the development of the framework and the “Crazy Robots” prototype itself.

4.1 Heuristic Usability Tests

We evaluated the prototype with in-house usability and game-based learning experts (heuristic evaluation) in an iterative way to avoid problems with late coming but inevitable changes, which may present serious problems in Waterfall/ADDIE approaches (Kapp, 2012:199). Jeffries and Desurvire (1992) argue that heuristic evaluation is a valuable method, but is no substitute for usability testing with the target group (see 4.2). Nonetheless the “valuable inspection method” (Jeffries & Desurvire, 1992) of heuristic evaluation produced a wealth of information. Following we will highlight three exemplary findings related to the framework and prototype.

The first finding concerns Unity’s realistic simulation of game physics, which is handling movement, deflection and collision detection. Even touch events like drawing paths and deflecting game objects using a swipe gesture act as forces on these objects. Contrary to our expectations the realistic simulation of physical laws harmed the gaming experience. Therefore we adjusted the physics of the game objects to provide a smoother gameplay allowing frictionless and thus steady movement and making colliding objects deflect like billiard balls, despite their real shape. Furthermore, after an expert’s proposal, we decided to give the objects a tiny temporary boost when deflected by the player in order to provide better feedback.

Secondly, instead of the globe, the first version of the game showed only the current continent’s outline, which faded over to the next continent after a period of time. However, the continent’s outline proved to be hardly recognizable. The 3D globe was introduced to provide a better context for the current continent, rotating the globe instead of fading images and having the other continents still visible helped increase recognition and reaction time.

One question that was raised by an expert, but still needs to be evaluated in future user tests, is whether more information could be taught by fine-tuning the feedback’s level of detail. Currently the game only provides feedback as to whether or not a country is located on the given continent. Without altering the game-play, the game could teach more geographical information, e.g. the locations and shapes of countries, by highlighting the outlines of the country on the continent. Furthermore, it might be beneficial to give feedback, where the incorrectly associated countries are actually located.

4.2 User Tests

As Jeffries and Desurvire (1992) argue, testing software with experts is valuable but not enough for a holistic evaluation. This is even truer for learning software, as these additionally need to be tested concerning learning and transfer effects – although this is tricky at best, not only because the concept of “transfer” (Thorndike & Woodworth, 1901, Brown 1994) itself is debated (Schaffer, 2012:403; Anderson, Reder, & Simon, 1996 vs Greeno, 1997) but also because it is questionable whether “gold standard” quantitative science works in educational settings (Squire, 2011:228-234). The latter is especially a problem when using conceptually integrated games (Clark & Gaza, 2012) or applying commercial of the shelf games (Squire, 2011) as well as game-based learning approaches that focus on creating/modding games (Busch, Conrad & Steinicke, 2013) or epistemic learning (Schaffer, 2012). This is due to the fact, that these approaches require extensive time and framing. Squire (2011:229) for example proclaims that one typically needs an eight-week curriculum to find a statistically significant result – which is still burdened with identifying confounders like intra and inter group differences and dynamics, different teachers or to counter this a special moderator, etc (see also Squire, 2011:228-234).
By nature this is a slightly lesser issue with learning games that focus on teaching associations as well as facts and figures by repetition. Here a pre-test/post-test setting with a questionnaire covering the content seems like a low hanging fruit. To test the game we are currently organizing tests with target users. In accordance with (Nielsen & Landauer, 1993) we did not start with a big cohort of testers that all test the same version, but with an iterative approach, which integrates the lessons learned from tests with up to five users into a new version before starting new tests. This approach – although not without its critics – is economically sound as it is expected that especially early versions will contain bugs and issues that can be identified by most users so that using 100 users to find the same problem is a waste of resources especially because the issue might mask further problems that can only become visible after the (first) issue is fixed. Additionally we anticipated that even low hanging fruits might have thorns so we started the first user tests with the main goal not of testing the game but testing the tests and test setting.

To test for learning in a pre-test/post-test setting we used the CSV-file that contains the mapping of continents and countries as well as the attributed difficulty and probability of spawning. As this list contained 254 items (countries, islands, city-states and countries without sovereignty), we decided to reduce this to a number that would fit a somewhat cramped two-page table (110 countries). We first subtracted countries with a very low spawning probability, as these would mostly not be seen or even have a chance to be correctly associated in 30 to 60 minutes game time. Additionally we reduced the number of countries with high priorities as testing for 60 instead of 20 of these would probably not add much value. From the remainder we subtracted countries so that all continents would be presented relatively evenly into a list that was sorted by country name. Additionally we create a page that asked the test participant to name the continents on a world map, to test whether the depiction of continent image and name in the game strengthens this association.

To test the user experience (UX) and usability we decided to try the ISONORM-short (Pataki, Sachse, Prümper & Thüring, 2006) with 21 items and the User-Experience-Questionnaire (Laugwitz, Held & Schrepp, 2008) with 26 items both with a seven point Likert scale. While the latter uses only polar word pairs (e.g. “conservative” <- > “innovative”) and thus fits on one page, the ISONORM questionnaire uses a sentence and its negation instead and thus fills three plus two explanatory pages. The standard UX questionnaires are flanked by a one-page questionnaire that asks for some biographical information, perceived difficulty and likeability as well as some questions for a short semi-structured interview.

Up to now we did two user tests both with the sequence of pre-test, some 25 minutes game play, followed by usability/UX tests and the first post-test. Then two days of free play followed by a second post-test two days after the last play session. Results seem positive as can also be seen on the basis of the selected data in table 2 and the chart from figure 9 that was created by our analytics tool. The chart shows the success/fail events for the country of Samoa, which was answered wrongly in the pre-test, but correctly in the post-test.

<table>
<thead>
<tr>
<th></th>
<th>pre-test correct</th>
<th>post-test 1 correct</th>
<th>post-test 2 correct</th>
<th>play time</th>
<th>saw grade improvement potential</th>
<th>Liked playing</th>
</tr>
</thead>
<tbody>
<tr>
<td>User 1</td>
<td>15 / 110</td>
<td>24 / 110</td>
<td>27 / 110</td>
<td>27m up-to 40m</td>
<td>4/5</td>
<td>4/5</td>
</tr>
<tr>
<td>User 2</td>
<td>74 / 110</td>
<td>80 / 110</td>
<td>94 / 110</td>
<td>3,2h</td>
<td>4/5</td>
<td>4/5</td>
</tr>
</tbody>
</table>

Table 2: first test results of the “Continents & Countries” game “Crazy Robots”
Samoa

Figure 9: Success and fail events for the country of Samoa over time (user 2)

Nonetheless two problems of the transfer evaluation were identified. Firstly as the 110 items are only a subset of the country list in the game, users encountered countries in the game that are not listed in the questionnaire and vice versa. Thus learning gains might very well be higher than measured. This is especially true for the first user as she had a very low level of knowledge and might have had high learning gains for the often-appearing simple countries that have mostly been eliminated from the questionnaire. On the other hand, even the 110 items were found to be exhausting and time consuming thus a further reduction seems to be needed. An additional problem with the list-/table-like presentation might skew results potentially both to the positive and negative. At least with user 2 a negative influence was observed. When she reached the African country “Mauretanian” she saw that the following item would be “Macedonia”, audibly told herself that “Macedonia” would be in Europe and then marked both countries as “in Europe”. A similar error must have occurred for the country of “Tunisia”. Although it was successfully associated to “Africa” most of the playing time (see figure 10), user 2 answered it wrongly in the second post-test. Upon inquiry one week after the test user 2 instantaneously answered correctly.

Both errors seem to be induced by the long list and the visibility of following items. The latter might be countered by an item-by-item approach. Using the mobile device and a questionnaire that presents items sequentially could solve this problem. Thus a further service building block for the mobile learning games framework could prove valuable especially as this could use data from the logging component to tailor the post-test to encountered items, potentially reducing errors that are due to huge number of questionnaire items.

Tunisia

Figure 10: Success and fail events for the country of Tunisia over time

A further issue we identified in the first user test was a potential bug in the logging system. User 1 played some 27 minutes in the first accompanied play session and declared that she played the game for at least 5 minutes on both following days. But the game log-file covered only a playtime of 27 minutes. When asked whether she contrary to the agreement did not play the game in the two days of free play both she and her parents stated that she indeed had played the game. Thus we reworked the logging system and are currently testing for logging leaks.
The ISONORM and User-Experience-Questionnaire results are positive up to very positive but also show some issues. While the former is an inventory that focuses on usability for generic software systems and thus contains questions that both users found inapt – especially IK1-3 – the latter shows a strong tendency of medium values for dimensional labels with complicated adjectives – e.g. “erwartungskonform” which is a very technical term for “conformity with user expectations”. Thus both questionnaires need to be reworked for our target group.

4.3 Future Testing

The iterative small sample testing – even though it clearly does not generate representative data – has proven very valuable and will be continued. Additionally we are preparing a quasi-experimental follow up trail using the “Crazy Robots” prototype in a school setting with 5th and 6th graders from a Berlin elementary school. While the latter is not a perfect match with our original target group of children in private tutoring sessions as well as the contained content of continents and countries which is 7th to 8th grade in the Berlin curriculum (LISUM, 2006:12), we nonetheless hope to gain valuable data concerning usability and learning gains.

5. Conclusion

In this paper we described our approach to developing a mobile learning games framework in an iterative fashion. We first developed the conceptual part of the framework that covers general interaction modes for touch-based games. This enabled us to lay the groundwork for the technical part of the framework that is based on the Unity game engine and additionally enables game instances to reuse existing services, game mechanics and objects. The iterative and cyclic approach thus enriches the framework with each produced game, which in turn accelerates the development of further games – closing the loop. While the framework enables both the creation of conceptually integrated and conceptually embedded games (Clark & Gaza, 2012), we focused on the latter to produce a mobile learning game that fits our current context of private tutoring. The prototype “Crazy Robots” – a geography game that trains the association of countries to continents – was developed in an iterative fashion, too. Experience from both heuristic evaluation by usability experts as well as user testing for usability and transfer lead to the evolution of the game, its tests and in consequence of the framework. Next steps will be a quasi-experimental trial of the game in an elementary school as well as further development of game modules and thus the enrichment of the mobile learning games framework.

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

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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

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.

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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 funded 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 Kind 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 development 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 show 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.
Emanuela Marchetti and Andrea Valente

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 gameplay 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
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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.

![Diagram](image_url)

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 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 turn-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).

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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.
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 redesigned, 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.

References

Scenario Based Education as a Framework for Understanding Students Engagement and Learning in a Project Management Simulation Game

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Abstract: In this paper I describe how students use a project management simulation game based on an attack-defense mechanism where two teams of players compete by challenging each other’s projects. The project management simulation game is intended to be played by pre-service construction workers and engineers. The gameplay has two parts: a planning part, where the player make managerial decisions about his construction site, and a challenge part where the player chooses between typical problems to occur on the opponent’s construction site. Playing the game involves analyzing both your own and your opponent’s building project for weak spots. The intention of the project management simulation game, is to provide students with an increased sensitivity towards the relation between planning and reality in complex construction projects. The project management simulation game can be interpreted both as a competitive game and as a simulation. Both of these views are meaningful and can be seen as supporting learning. Emphasizing the simulation aspect let us explain how students learn by being immersed into a simulated world, where the players identify with specific roles, live out specific situations, and experiment with relevant parameters. Emphasizing the competition game aspect we can see how play and competition allow players to experience intrinsic motivation and engagement, as well as thinking strategically about their choices, and hence put attention towards all the things that can go wrong in construction work. The goal of the paper is to investigate empirically how these two understandings influence game experience and learning outcome. This question is approached by qualitative post-game interviews about the experienced fun, competition and realism. Specific attention is given to how the understandings of the experience (for instance as a game and as a simulation) is entangled when the students describe their experience. Using the concepts frame and domain it is analyzed how the students conceptualize and make meaning of the particular educational scenario manifested by the project management simulation game. We take as an outset that students interpret the situations in the project management simulation game as relating to one or several domains, especially the domains competition and simulation. Results suggest that the views of the scenario as a competition and as a simulation do coexist, and that these views merge in a subtle way. The players consider the game to be both a realistic simulation of construction site work and a fun competition in which they try to beat their opponents and these two views do not seem to create cognitive conflicts. In the discussion it is explored how aspects of the design affords this double conceptualization (e.g. the “manage mode” and “challenge mode”), and finally it is discussed how we can explain why the players experience the challenges that they pose on each other as a natural part of the gameplay, but not as a realistic aspect of the game as a simulation.

Keywords: serious games, simulation, scenario based education, epistemic epistemic games, frame analysis, learning games; simulation and competition

1. Introduction

Games holds an educational promise: games are engaging, allows users to try things out in an artificial environment furthermore games embody the constant strive to become better (Gee, 2003) and finally games allow its users to act as through a simulated practice (Shaffer, 2006).

These strengths of games to support learning do not constitute a coherent pedagogical framework, because games both act as a simulated world to experiment with and experience from and also act as a motivational driver for educational activities.

This paper investigates how an educational game combines a simulation of important situations and a competition against peers into one experience and addresses how such an experience can support learning.

Simulations developed to support learning are often built on a conceptual model designed to correlate with the real world, and hence allow for training and experiential learning (Kolb 1984). Competitions on the contrary motivate a player to perform as good as possible in competition with either peers or the game, in order to win. Hence the underlying conceptual model of a game might very well be designed to be fair and

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transparent, without having any alignment with real world phenomenon. Serious games sometimes occupy an intermediate space, both supporting learning by providing experiences with potential transfer to the real world, and by making use of various gamification mechanisms (points, competitive elements etc) unrelated to any simulation (Hamari et al. 2014). The ambition of this paper is to understand how students make meaning in such an intermediate space.

The discussion of the relation between games and simulations goes back several decades and there have been numerous theoretical contributions aiming at developing analytical clarity on this subject (Klabbers 2009; Zimmerman & Salen 2003). This paper explores empirically how an educational design that taps into learning potentials relating both to simulation and competition, is perceived by students. Using post-game interviews, it is investigated how the experience of using the design stems from players’ immersion in the simulation of the construction site manager praxis or from the strategic reflections that are necessary to play well and win the game, and how these two meaning making mechanisms interacts.

The paper describes the game Benspænd (eng. The Challenge Game), and continue to introduce a theoretical framework for understanding students’ work in open ended educational scenarios. The framework focuses on how students and teachers frame their activity toward different domains of knowledge and praxis, such as school situations and future work situation, but also domains of competing and gaming. After describing the theoretical framework a number of post-game interviews with students of engineering, architecture and various forms of craftsmanship, is described, and finally it is discussed how we can study the way in which the conception of Benspænd as a competition and as a simulation blend in the students framing of their activity.

2. The challenge game-Benspænd

The challenge game www.benspaend.dk is designed to be played by two teams of players. Each team plays the role of manager of a construction project. The gameplay has two main parts: a planning part, in which the construction site manager plans his own activities, allocating resources to various parts of his construction site, and addresses issues that come up, and a challenge part. In this part of the game, the players create problems for the other team of players and thereby make the other players’ game more difficult. Playing the challenge game involves analyzing the competitors’ building site and plans to find weak links to target for maximum effect. When the players return to the planning part of the game, they must react to the challenges imposed upon them by the other team of players. Figure 1 shows the game interface. The Right side shows a Gantt chart of the timeline of the project. The navigation in the game interface is on the vertical bar to the left. Here you have options of visiting the construction site, the Gantt chart, the different actors, and the economy of the game.

Figure 1: The game interface.
The interface in both the planning part and the challenge part of the game consists of a number of views; a Gantt chart, a construction site, and a meeting room with the characters representing all stakeholders involved in the construction project (end users of the house, various construction workers and specialists, the architect, the financial officer, and an engineer). In all these views, players can choose actions (either of a management nature in the planning part or disruptive actions in the challenge part). Furthermore, the interface consists of a view dedicated to the project budget, a newsfeed and a deeper description of the project. The last two views contain overview and information about the construction project and a view, dedicated to prioritizing the chosen actions.

By going through the various views the players are able to discern where the critical and vulnerable parts of the project are and act accordingly by choosing from a set of managerial decisions or challenges. The challenges change the status of the players’ projects and when they receive their project after the challenge part, the players need to revise their managerial decisions. These challenges can affect all levels of the construction site, from receiving unclear directions from the architect over problems with rotting timber to social problems and animosity between the workers at the site. The challenges are presented as very short narratives describing what the challenge entails.

The game has been tested in prototype and final versions in order to learn about how the players experienced the combination of the competition like attack/defense mechanism and simulation like use of the construction site as scenario for actions. In order to develop an understanding of this interplay I will introduce some theory.

3. Scenario based education

Scenario based education is a newly developed framework or approach to understanding educational situations building on scenarios, understood as real or artificial situations that are used to create context, experience of relevance and immersion, in educational situations. Examples of scenarios include inquiry based approaches where students develop projects answering life problems, various uses of commercial games in education (Hanghøj, 2011), role playing scenarios such as epistemic games (Shaffer 2006) and practicum work.

In educational processes involving scenarios the ability to envision various outcomes of situations predict and make hypothesis, about various outcomes of actions is important. Hanghøj, et al (n.d.) with reference to Dewey (1922) has described this as a process of students dramatic rehearsal envisioning, and living out, various possible outcomes of actions in a scenario. We will take four technical terms from scenario based education: frame, translation, scenario and domain. Frame, translation and domain are analytical concepts used to describe how students and teachers conceptualize and make meaning of a particular educational scenario in this case the challenge game, and how knowledge and competence is moved or translated from various domains in society into education. This way of conceptualizing educational situations is inspired by Hanghøj et al. (Hanghøj et al. n.d.).

Many teaching situations involves a particular environment or situated task that the students work within, in this case it is the challenge game. Following Hanghøj and colleagues (n.d.), I describe such an environment as an educational scenario. The concept frame designates the socio-cognitive structures that make it possible for people to interpret their world and act within that world. In that sense framing is the cognitive mechanism that allows the generation of a “situation” from the many and diverse sensory motor inputs that an individual receive (Goffman, 1974). Hence frames are crucial for making meaning of educational scenarios. But educational scenarios allow framings to be related to different translations between different domains. The scenario can be framed as a teaching situation (with tasks to be accomplished by the students by request from the teacher), it can be framed as a competition (where you can win or lose), and it can be framed as a simulation (that resembles a situation that it is important to master). I assume that different domains are present in the framing of the educational situation by the individual. Domain is an analytical concept that allows us to point to the relevant clusters of practice. The challenge game is about construction site management, and the students framing of the challenge game can be understood with reference to domains of craftsmanship, school situations, management and collaboration, but also with reference to domains of gaming and competing. Different actors will frame activities differently and towards different domains. Using a teaching scenario such as the challenge game always involves reductions or simplifications of non-school knowledge practices. In that sense a practice simulation is never build on a complete and accurate model of practice in one specific domain. And furthermore other domains (of schooling, simulating and gaming) can very well be present in students and teachers framing of the situation.
Figure 2 illustrates how the students relate to the educational scenario through different knowledge domains. Disciplinary domains related to the involved scholarly traditions, (e.g. management and engineering) specialized domains related to the special aspects of the scenario setting (knowledge about the practice that you enact in the scenario), Your everyday knowledge (e.g. about games and gaming) and school related knowledge about educational traditions, mutual teacher students expectations ect.

![Diagram of knowledge domains]

**Disciplinary domains**

**Specialized domain**

**Educational Scenario**

**Scholastic domain**

**Everyday domain**

The concept of frame and scenario is close to Shaffer’s framework of *epistemic frames* and *epistemic games* (Shaffer 2006). Shaffer’s main idea is to copy professional working situations in order to create a new kind of learning where important competencies come into play. Shaffer considers *epistemic frame* as the way he wants the participants to look at the world, when they play his *epistemic games* which are computer supported practice simulating games. The concept *epistemic game* is to a large extend similar to the concept of educational scenario, but the concept of *epistemic frame* is in a sense a combination of a *frame* - a way for the participant to make meaning in a situation, and a *domain* - a collection of practices, narratives about practices, skills and criteria’s and that are known by participants and hence make it possible for them to frame a scenario as a meaningful situation. There is another difference between the frame concept that I apply and epistemic frames. Epistemic frames are learning goals - ways of looking at the world that the student should assimilate to. The frame concept applied in this article is to larger extend an analytical concept, used for understanding how students make meaning in educational situations that points to practices outside school. In the analysis I will focus on how the challenge game is perceived as competition and simulation by focusing on how the students frame the educational scenario towards the two domains *construction site management* and *gaming and competition*, as shown in figure 4.

The domain of construction site management is characterized by enacting managerial decisions in a highly complex situation involving many different groups of employees, investors and users. The domain is relevant to the students playing the game since they all are enrolled in a program targeting a career in the construction sector (Rump et al. 2011).

Games considered as competitions and playful interaction does introduce different domains than school, disciplines and work related domains. Games always communicate the fact that they are games. Playing involves simulating in the sense of using *representations of actions rather than actions*, but playing games also involves competing by making advancing over other players or raising level of points on an artificial scale. Games, in other words, communicate “this is not real - it’s just a game” (Zimmerman & Salen 2003).

**4. Method, data and analysis**

The challenge game was developed in collaboration between experts in construction management, game design professionals and educational experts. The development has followed a design-based research methodology, this means that the data presented here are collected over a period of several years, where we have developed and refined the Challenge Game. The investigation builds on three design based research dogmas by being *iterative*, respects context and being *oriented towards theory* (Barab & Squire 2004; diSessa & Cobb 2004). We have used the challenge game as a prototype, a beta, and as the final version. The game has been used with students of architecture, engineering, construction management, and various types of
The iterative nature of the design process is described in figure 3 where the different prototypes and tests are shown in a timeline diagram.

**Figure 3:** The development process has consisted of iterations of development and test with different stakeholders, and user groups.

Post-game interviews (9 one person interviews and 3 focus groups) were conducted around the experienced realism of the game, the complexity, and the competitive and fun aspects of the game, as well as Human Computer Interaction aspects of the game. These interviews where conducted in relation to the second prototype test.

The interviews evolved around the questions:

- How and to what extend is the game considered realistic?
- What kind of learning do the challenges that students pose to each other’s constructions convey?
- Do the game mechanics promote the acceptance of disruptive behavior at construction sites?

Apart from these interview data, the team has observed many hours of playing the project management simulation game, had a number of debriefing conversations with users of various prototypes, collected teacher statements from teachers using the game, and collected quantitative data about the users experience with using the game. This article is based on the 9 post game interviews, collected in relation to the test of the second prototype.

The analysis is focused on generating empirical understanding of playing the challenge game and how aspects of simulation and competition are present in the student’s conception of playing the game. The domains considered in the analysis are the domain of gaming and competing and the domain of construction site management. In the analysis I investigate how students frame the activities in relation to these domains. The analysis starts with considering the framings and domains related simulation, continues to competition and gaming and ends up discussing how these framings together constitute the students game experience.

5. **Simulation**

In all post-game interviews the issue of realism was addressed in a very direct way; by asking the students whether or not they considered the game experience as “realistic”. In most cases they did, and the question of realism was followed up by a discussion of the nature of the experienced realism, as shown in the following example from an interview with an engineering student (L):

Interviewer (I): Do you think it was a realistic kind of complexity you experienced here?

*Respondent (L): Yes.*

_I: realistic in what sense?_

*L: Well, uh ..._

_I: [I am asking because] the game did not contain all the tasks with which belongs to... [normal construction work]_

*L: no, what can you say? In a small scale, it was very realistic. Obviously missing a lot compared to a real ... [construction site/process]_

_I: So, what was it, that was realistic?_
L: Well it was, the consequences of your choices. Only afterwards you could look at the consequences and say, oh yes, of course.

The transcript shows how this student perceives the complexity of the game. The student obviously realizes that the game is different from the real world, yet he still considers the game experience realistic. “L” describes the game as being realistic “on a small scale” in the sense that the game universe is small, and not as complex as the real world, but the feeling of acting within a complex universe where not all regularities are known a-priori is considered as in line with how real construction work unfolds. This is described by “L” as the consequence of not knowing everything before making a choice but understanding, or at least accepting, the choice afterwards.

A similar view is described by another engineering student, who described the game experience as “simplistic realistic”.

I: Do you think that the complexity in the game was realistic?
Lo: yes ... simplistic, but realistic, yes.
I: ok. What do you mean by simplistic, but realistic?
Lo: uh. So the concepts/curricular items we are working with now in the Construction Management class -
I: yes, yes
Lo: we must think about a lot more than in the game.
I: yes, ok ... so there are more things in reality?
Lo: Yes
I: What is it then that is realistic? Can you explain how it can still be realistic?
Lo: well, quality assurance, for example. It has consequences if we just progress [with low quality] to meet the time schedule, and that might impact your finances and so on.

This quote also shows that the relation between course of action and consequence is considered realistic even though there is a clear indication that the game experience is not the same as the real world. The game experience described by the two students show that realism is not the same as an immersion into a full-fledged simulation or a fictional universe. Both students show an understanding of realism as something that deals with a specific aspect of the game, the experienced complex relation between cause and effect.

Several of the other respondents did consider the game realistic, but did not consider this realism as having to do with a specific aspect of the game as seen in the following quote with a male masonry trainee “K”

K: yes it was a very realistic game, I think.
I: Fine, I'll just ask, did you do something to decode the game? For example if we do that here, then it will probably have this effect on the status or the numbers in the game?
K: yes yes. When we saved money on something, then we spent some money on providing a good piece rate, to get it to be as nice as possible. But still cheap.

This respondent does not understand that the interviewer asks about where the realism in the game ends and more strategic considerations begins. This can of course be due to communicational problems between respondent and interviewer, but it can also be seen as an indication that the respondents do not even question the realism of the game. When asked about whether or not his team was making game strategic reflections within the game, he answer that they did make management related reflections. We saw several examples in the interviews of respondents that considered the game as realistic without reflection on in what respect the game was realistic.

The students all answer positively when asked whether or not the game is realistic. Some, but not all of the students are able to articulate the type of realism they experience. It seems that the realistic aspect of the game has something to do with the relation between course and consequences. This is expressed as “small scale realism” and “simplistic but realistic”. This is a positive result in the sense that the learning objective of
the game exactly deals with understanding the relation between plans and reality, especially in cases where
the plan I challenged by unforeseen incidences.

In the observations of students playing the game as well as in the post game interviews we saw no tendencies
neglect the fiction of the game, and only play against the game mechanics. Data hence support that the
students in general accepts the game as realistic enough to learn with. We need more data to be conclusive in
terms of how the game in general is perceived, but we can see that the students that are able to discriminate
and articulate how the game is considered realistic, all point to the relation between courses and
consequences as the focal aspect of realism in the game.

Most respondent did considered the game realistic, but there was some diversity in how reflective the
students were in describing the specific way in which the game was realistic, as some students considered the
game realistic without being able to discuss in what way. But the students who are able to discriminate
and articulate how the game is considered realistic all point to the relation between courses of consequences and
consequences as the focal aspect of realism in the game.

6. Competition, attack and defense

The post-game interviews were also concerned with understanding how the game was perceived as a
competition based on rules. A construction manager student expressed his experience as follows after the first
proof of concept test:

It was fun, like building a sandcastle, and then once in a while the tide comes in and takes some of it,
and then:

“Oh, s***,” now you are set back a lot. And every time you end a task it was like “Yes! Now we are home
free with this part.”

The competitive element is highlighted as one of the reasons for the game being entertaining, for example
A: it made it more fun – definitely. As soon as there is no competition, then everybody would win, right?
And as soon as you get to choose some challenges you think about where you can hit them as much as
possible, right? So again, it’s just ... having the most fun possible, right? How can we beat them? So, it
definitely made it more fun.

In that sense the competitive aspect and especially the aspect of challenging the other team’s project are
important for the experience of the game as fun. There is no indication that the students frame the actions of
posing challenges towards the domain of construction sites in a direct sense since this would mean that, one
could argue that the players act as saboteurs, damaging the opponents’ construction site. But the process of
posing challenges can support learning in a direct sense. In order to pose the right challenge to the
construction site you are targeting, you need a good understanding of the other team’s project, plan and
available choices. During the tests we observed that participants discussed the other team’s plan in detail, to
pinpoint where the weak points were and how the disruption of one task could delay the entire plan. This is
also expressed by A, who continues the above statement with saying:

A: You start unconsciously searching for their most critical path.
I: hm
A: it is also important in our profession, when we are sitting and doing schedules.
I: but it seems you also know that you look at ... uh ... know when you make it there Obstructions?
A: Well, obviously. This might seem to the inside. Oh ... but where can we hit them very, hardest? Where
will it go really wrong for them if it is ...
I: yes
A: If we play one of these cards? Which card would go most wrong for them? So unconsciously you look
for the most critical path, for them.

In that sense the competitive aspect and especially the aspect of challenging the other team’s project are
important for the experience of it being a fun game.
7. Blending competition and simulation; posing of challenges

The respondents described the process of posing challenges to the other team’s construction site as making the game fun and competitive. But furthermore the tactical considerations necessary for posing challenges relate to realism and support reflection about construction practice. This is clearly described in the statement above where A expresses that you need to “think about the critical path” (a technical term for describing the most fragile parts of a plan), when posing challenges. Some students even describe a synergy between realism and fun when posing challenges. For example the student “L” (from above) suggested that the game is both a collaboration and a competition because

L: I think it is both, the more competition you put into it, the more our group tried to ruin it for the others, and hence competing to win the game, the more complex the game became for the other team.

Another student expresses that posing challenges forced you to think forward in the game. Her argument is that posing challenges requires that you think a plan through, where is the plan weak, and what can go wrong. This conception of posing challenges is also seen in the interview with the bricklayer student K:

I: How was it playing against the others? How did you experience obstructing the others building processes?
K. it was fun in a way. You had to think a little tactical and try to play forward in the game.
I: hm (yes)
K: like so ..
I: Was it like a competition against the other team or was it ...
K: Yes it was ultimately a contest and [the goal was] to get their plans to not come true.

Even though K does consider the game purely a competition he does express the need to think forward in the game in order to beat the others, and this shows that the tactical considerations in posing challenges have the potential of supporting learning, but to building on this potential might require that the topic is addressed by the teacher or facilitator.

Hence the game is considered realistic by the students that we have interviewed. Furthermore, a small group of the students that we have interviewed considered the game realistic in a more specific sense. These students were definitely aware that they were playing a game and that the game simulation was different from the real world. Nevertheless, they considered the relation between course of action and consequence in a complex construction process to be very realistic.

The interviewed students all considered posing challenges as a fun and competitive. Some of the students related this activity to the game realism both by reflecting on how the process of posing challenges supported their thinking about what can go wrong in construction sites and even more directly, by suggesting that the posing of challenges is a good way of creating a complex and interesting simulation for the opponent team.

The framework of scenario based education can help us understand how the students conceptualize the game experience. The two concerns of realism and competition can be understood as framing the educational scenario involving the challenge game towards the domain of construction sites and towards a domain of attack defense competitions. The challenge game is perceived as a simulation in the educational scenario if this scenario is framed towards construction sites and as a competition if it is framed towards winning an attack defense mechanism game. The data suggests that the challenge game is experienced both as a game and as a simulation in the educational scenarios studied. Furthermore the data suggest that there is a complex interplay between the framings towards the two domains. In order to capture this interplay two types of framings can be introduced; (1) reflection and (2) immersion.

With these concepts the empirical data suggest that the game is considered a realistic simulation since the interviewed students adopt an immersive framing towards the domain of construction site management (they experience doing construction site management), mainly when they perform managerial actions on their own construction site. Furthermore they adopt an immersive framing towards an attack defense mechanism game, mainly when posing challenges (they experience playing a game). The data suggest that some students frame
the posing of challenges, as reflective towards the construction site domain, in the sense that the students reflect on what can go wrong at a construction site, when they are posing challenges against it.

Figure 4 illustrates how the students frame their activities towards the domains of construction and competition in different ways. In the management part they in general adopt an immersive framing towards the domain of construction site, hence accepting the game as a simulation. Simultaneously they adopt a reflective framing towards the domain of competition, being aware that they play a game. In the challenge part the students adopt an immersive framing towards the domain of competition, which makes the challenge game fun and engaging. In the challenge part the game is still framed towards the domain of construction sites, but in a reflective manner. The students are aware of all the things that can go wrong in construction processes without immersing themselves into the role of a construction site manager.

In conclusion, the challenge game was considered fun by the respondents interviewed, and one main reason for the game being “fun” was the process of posing challenges. This was consistently described in the interviews. At the same time students accept the game as realistic. This means that the choices the players make are both framed towards the domain of construction sites as a realistic simulation and as part of a competition where you have to attack your opponent with challenges and defense yourself against the opponent’s aggressive moves.

The gameplay highlights that the same educational scenarios can be framed towards different scenarios by the same individual playing the game. It is documented by previous research that such a situation can create clashes and conflicts for the students (Hanghøj 2011), but this does not seem to be the case in the educational scenarios we have investigated. The data shows no indication that students immerse themselves into a disruptive role. Hence posing challenges is not understood by the students as taking on the role of a “problem creator” as an epistemic frame or set of values in the sense proposed by Shaffer. Rather the role as problem creator for the other construction site creates a competitive gameplay, and acts as an engine to keep students interested in the game. Concerns like “how will my attack work?” And “how will the team we attack react?”, suggest that the students frame the game toward a competition. Furthermore awareness’ like “what will the other team do to our site?” or “how can we prepare the site for their actions?” allows the students to move meaningfully between framings towards competition and simulation.

The two roles, defending and attacking, give two different perspectives on planning. While trying to foresee what can go wrong in order to avoid it and trying to make things go wrong require similar competences in thinking forward, the framing of the situation is, as we have seen, very different. This double framing might give the players a fuller understanding of the relation between plans and reality.

8. Contribution to scenario-based education

Our analysis shows that students enact several types of translations towards the domains of construction site and of games and competition in framing the game scenario. We see how there is a delicate blend of translations making specific actions in the game meaningful both in relation to game/competition and in
relation to construction site. The analysis contributes to our understanding of scenario-based education by distinguishing these different translations and framings towards different domains in the scenario and by showing how framings contains translations towards several domains in a game based learning situation.

We distinguish reflective and immersive translations towards both domains of simulations and of competitions. These translations relates to different approaches to learning.

The reflexive translation from the domain of construction site, or more broadly the domain of simulation, allows the student to think about how he/she relates to the practice of construction site management, and reflect about their own role and ways of engaging in practice. Contrasting to this is the immersive translation which allows the students to frame the scenario as lived experience, and as a way of building competence by training. Where the immersive translation resembles a training metaphor for learning, the reflexive framing allows the active intellectual process of relating the practice of constructive side management to theoretical categories. In that sense we have empirical findings that suggest a relation between game activities and learning resembling the findings of Shön (1983) and Kolb (1984), and how they describe of the relations between learning and practice in work life and education.

The translations towards the domain of game and competition can in a similar a way be seen as having a reflective and an immersive component. This way of looking at the translation resonates with the data we have presented about students experience with the construction site management game. The students experience the game as fun and they engage in the competition on an emotional level. Working with the game is experienced as a playful process. But there is a clear strategic reflection on top of the playful experience. When students talk about the fun, they also mention thinking about how “to hit the others as hard as possible” and in that sense making the reflective translation an integrated aspect of the fun. Neglecting the reflective translation from the domain of game and competition has been described by Zimmerman and Salen (2003) as “the immersive fallacy” where engagement in games is understood solely as a matter of immersing oneself into a game world, taking on different identities ect.

The interviews show that the students consider their experience meaningful even thought they frame it as a blend between translations towards the domains of “gaming and competition” and towards the domain of “construction sites”. The analysis suggests two different reasons for this. The first reason is that the game is divided into a planning part and a challenge part. These two game modes guide the students to frame their activities towards simulation and construction site (in the planning mode) and game and competition (in the challenge mode). Furthermore if the game actions are framed only through translations toward one of the domains (for instance “simulation and construction sites”), they might not be meaningful. Why develop competence in how to obstruct construction sites? The students interviewed, expressed that posing challenges to the other players construction sites was very meaningful because you “had to think a little tactical and try to play forward in the game”, this cane be interpreted as a framing combined of a reflective translation towards the domain of gaming and competition and as well as a combination of an immersive and a reflective translation towards the domain of construction sites because the challenges that the players can pose for the other teams, also represents possible problems in real world practice. And because it raises the awareness of the insecurity and contingency in the relation between planned and conducted construction work.

9. Conclusion

In this article it is documented how students frame their experience in an educational scenarios involving the challenge game. The game allows students to experience a simulation of the process of managing a construction site. Furthermore, we have seen that the mechanism of posing challenges introduces a framing that contains translations towards a domain of gaming and competing, while there is none or at least very little conflict between these two domains. Further research should aim at establishing criteria for when such framings towards multiple domains in general are productive or disruptive for teaching and learning, but in this paper we have seen a proof of concept that such framings containing translations towards several domains can support a meaningful educational experience. Furthermore we have shown have the concepts of scenario, domain, translation and framing can be used to
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Dynamic Pervasive Storytelling in Long Lasting Learning Games

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Abstract: Pervasive gaming is a reality-based gaming genre originating from alternative theatrical forms in which the performance becomes a part of the players’ everyday life. In recent years much research has been done on pervasive gaming and its potential applications towards specific domains. Pervasive games have been effective with regards to advertising, education and social relationship building. In pervasive games that take place over a long period of time, i.e. days or weeks, an important success criterion is to provide features that support in-game awareness and increases the pervasiveness of the game according to the players’ everyday life. This paper presents a Dynamic Pervasive Storytelling (DPS) approach and describes the design of the pervasive game Nuclear Mayhem (NM), a pervasive game designed to support a Web-games development course at the Nord-Trøndelag University College, Norway. NM ran parallel with the course and lasted for nine weeks and needed specific features both to become a part of the players’ everyday life and to remind the players about the ongoing game. DPS, as a model, is oriented towards increasing the pervasiveness of the game and supporting a continuous level of player in-game awareness through the use of real life events (RLE). DPS uses RLE as building blocks both to create the overall game story prior to the start of the game by incorporating elements of current affairs in its design and during the unfolding of the game as a mean to increase the pervasiveness and in-game awareness of the experience. The paper concludes that DPS is a promising approach for creating a game story which increases the pervasiveness of the game and supports in-game awareness.

Keywords: pervasive games, game based learning, in-game awareness, interactive storytelling, media analysis, game mastering

1. Introduction

Pervasive gaming is a gaming genre in which the game is not confined to a virtual world but extend the gaming experience out into the real world (Benford et al. 2005). Many types of games, toys and experiences are labelled as pervasive (Magerkurth et al. 2005) and the boundaries between pervasive games and other types of games are unclear. Researchers have approached the genre from different perspectives which led to multiple definitions of the term pervasive game (Nieuwdorp 2007). This paper follows a technologically independent definition:

A pervasive game is a game that is pervasive relative to the player’s everyday life.

A pervasive game is therefore required to be both spatially and temporally pervasive relative to the player’s everyday life for the whole duration of the game. Given these characteristics, pervasive games can be suited to blend learning into students’ everyday life and thereby bring a pervasive property to learning (Pløhn 2014). However, pervasive games face specific challenges that traditional board games or ordinary digital games do not have. While playing a non-pervasive digital game, the player is aware at all times of the fact that he/she is playing a game. In the case of pervasive games; where the game is a part of the players everyday life and last for days or even weeks (with potentially long periods of times without any game related activities), players can easily forget that they are participating in a game. Pervasive games need features to support in-game awareness:

In-game awareness is the player’s feeling and awareness of participating in an ongoing game.

Given the definition, features that support in-game awareness are everything that helps to remind the player about the ongoing game’s existence.

In this paper we argue that an important success criterion in designing pervasive games is to provide features that 1) support in-game awareness and 2) increases the pervasiveness of the game. Since an important feature
of pervasive games is the use of the real world as a part of the game, it seems natural to use the real world and real world events to support these two properties and the research question is therefore as follows: How can real world events be implemented in a pervasive game to provide support for in-game awareness and to increase the pervasiveness of the game? To address this research question we developed the Dynamic Pervasive Storytelling (DPS) model/approach. DPS was used to design the game story in the game Nuclear Mayhem (NM), a playable prototype of a pervasive game designed to support a university course in the development of Web-games at the Nord-Trøndelag University College, Norway (Pløhn 2013). The duration of the game was nine weeks. Participation in the game was the only mandatory activity during the course and the students had to complete the game to be allowed to attend the exam. The requirement for mandatory participation contradicts one of the most frequently cited definitions of a game offered by Suits (Suits 1978) as “the voluntary attempt to overcome unnecessary obstacles”. New applications of games, such as e.g. Game Based Learning, where participation often is obligatory, suggests that this definition is too narrow and consequently there is a need to revise the definition of “what makes a game” to include the new areas of application in the definition. This discussion is beyond the scope of this paper and we define Nuclear Mayhem as a game according to the six requirements proposed by Juul (Juul 2003), stating that an activity is a game if the following six features are included:

1. A set of fixed rules
2. A variable and quantifiable outcome
3. Valorization of the outcome
4. Player effort
5. Player attached to outcome
6. Negotiable consequences

This definition does not emphasise or include “voluntary participation” for an activity to be defined as a game. All the six features in this model are included in Nuclear Mayhem.

This paper presents the use of DPS as a strategy to create a game story to be used in pervasive games and methods to support both in-game awareness and to increase the pervasiveness of the game. Section 2 provides an overview of the narrative considerations in DPS and section 3 discusses the design requirements for the design of NM. Sections 4 and 5 present our evaluation and results.

2. Narrative considerations in dynamic pervasive storytelling

Storytelling or narrative is commonly used in both digital entertainment and serious games in order to motivate players in first engaging and then keep them engaged. Work by Lazzaro (Lazzaro 2004), Fullerton (Fullerton et al. 2004) and Yee (Yee 2005) all identified storytelling elements as key motivations for players in entertainment games. Storytelling, for similar reasons, is also regarded as a key element for the design of serious games and Lim and Louchart (Lim et al. 2014) identified a schemata (Purpose, Process, Structure) through which narrative serious game mechanics can be identified and described. In the particular context of NM, the story represents an important design factor for player motivation and keeping the player engaged, but also in terms of pervasiveness and its ability to out-reach beyond the remit of in-game awareness. For these reasons, not only does the story need to engage and motivate players like any other digital entertainment/serious game approach, it also needs to be current and timely so as to be part of the player’s world outside the game. Thus gaining relevance within the real-world in which players actually live. Contrary to most gamification approaches where competition is of the essence (Deterding et al. 2011), NM’s interest in blending virtual and real presences is primarily motivated by the desire to achieve narrative immersion and create an omnipresent story-world through which learning outcomes can be put into context and achieved.

In conceptualising a DPS approach, it is essential to adopt a narrative mechanism in which the story can reflect events, which cannot be pre-determined or planned. From an experiential perspective, the overall main game story should be pre-written and set within the traditional storytelling branching practices seen in most entertainment games (Wei 2011). From a pervasive perspective, however, elements of story related to the depth of the experience require some level of active, on-the-fly interventions in order to bridge or blend
virtual and real worlds. Technically speaking, a DPS experience, requires, for its whole duration to be monitored and authored from the perspective of an active game-master (GM) whose role is to facilitate the integration of story elements and the experience of players (Tychsen et al. 2009). Parts of the story therefore become emergent in nature and require the interventions of an author in real-time so as to maintain a balance or exploit opportunities (Temte and Schoenau-Fog 2012). This approach is common in the designs of modern table-top Role Playing Games (RPGs) such as Dungeons and Dragons (D&D) Series (D&D 2014) and Nordic Live Action Role Play (LARP 2014). In cases (Kanner and Lassila 2012), the game world is set in the real world in which people are oblivious to the game played by participants. The game articulation, in such a context is achieved by the combination of GM interventions and actors whose role is to exploit opportunities arising from the unfolding play or events in the real physical world over which neither the GM nor the actors have any control. NM follows a similar approach in which the GM monitors player actions within the game and the real physical world for opportunities that could be exploited or reported to players via out-of-the-game media such as e-mails, mobile phone texts or social network.

3. Design principles for NM

One of the main challenges for the story in NM was to increase the pervasiveness of the game and provide in-game awareness. The pervasive aspect of the game story is to provide a live information background contributing to player motivation rather than direct the players towards performing specific actions during the game. For instance, the NM scenario features a plot line set in the context of the escalating international diplomatic conflict related to the Iranian nuclear programme. A timely current affair topic at the time of running NM in which there was growing international scepticism on the legitimacy of the Iranian nuclear programme (RT 2009). In this context, computing students play the role of cyber-saboteurs in the wake of the Stuxnet virus attack on Iranian nuclear facilities in 2010 (CNN 2010). In this scenario, Iranian agents are sent from Iran to find and eliminate the saboteurs and as the game unfolds they are gradually getting closer to the players. During the game the “agent story” motivated several SMS messages in which players were informed about the status and whereabouts of the agents. While these messages helped to build and develop this aspect of the story, the main intention was to remind the players about the game (create in-game awareness) and help to increase the pervasiveness of the game (most people will read SMS even if they are occupied with other things) by linking game actions to real news bulletins related to this particularly current topic at the time. To this purpose, a set of specific principles was put together so as to achieve a state of story omnipresence for the duration of NM (Figure 1).

Figure 1: NM story principles

3.1 Create in-game awareness

NM is a 9 weeks long pervasive game and there are necessarily long periods with little or no game related activities. The player needs to develop a kind of information awareness so as to preserve the “feeling” of being in a game whilst not actively participating in any specifically related game activities. We refer to this as in-game awareness in the sense that a player will access or process information from the perspective that it might be related to the game and thus relevant. In-game awareness in pervasive gaming has many similarities
with awareness in computer-supported cooperative work (CSCW). Awareness as an achieved outcome is a critical element of any cooperative work situation (Fitzpatrick 2003). Surveys within the CSCW community have identified up to nineteen different types of awareness information (Cabitza and Simone 2007), but one type of awareness that is special for pervasive games is related to the fact that one is participating in a game (in-game awareness) as opposed to the awareness that one is at work which is the case for CSCW.

The pervasive game *SupaFly* supported in-game awareness by using the players’ geographical proximity to each other to make the players aware of other players in the surrounding geographical area (Jegers and Wiberg 2006). This approach is not relevant in NM since the game play does not put the same emphasis on the players’ physical location towards each other - the main feature in NM to support in-game awareness is the game story itself.

Since pervasive gaming is a new genre, there is still a lot of research needed to find out how in-game awareness can be supported in pervasive gaming. Our techniques to support in-game awareness are identified in Figure 2:

![Figure 2: In-game awareness story techniques](image)

3.2 Integrate the game with the real world

One way to achieve this is to create a game story that incorporates real life events as a part of the game story. Many of the design methods used to support in-game awareness will also contribute towards increasing the pervasiveness of the game and blend the game into the players’ everyday life.

For instance, when the player, in the evening is watching the news on TV and see a news story directly related to the game story, this will remind the player of the game in a non-game related situation (create in-game awareness) but will also help to blend the game story into the players everyday life and thereby increase the pervasiveness of the game. The same properties of the game story that support in-game awareness will therefore also help to increase the pervasiveness of the game, but – to be able to create an overall game story that is based on real life events – the following properties should also be supported in the chosen story (Figure 3):

![Figure 3: Story blending techniques](image)
3.3 An exciting and motivating story

The game story is an important design factor to create player enjoyment and motivation to play the game. Player enjoyment is a crucial factor in successful game designs but little work has been done in the research area of pervasive gaming to address this. The *Pervasive GameFlow Model* (PGM) (Jegers 2007) which is derived from the general *GameFlow Model*, was introduced to develop a better understanding of player enjoyment in pervasive game. PGM does not mention storytelling specifically but outlines the following eight elements as important factors to create player enjoyment in pervasive games:

- Concentration (the game should require concentration and the player should be able to concentrate on the game)
- Challenge (the game should be sufficiently challenging and match the player’s skill level)
- Player skills (the game must support player skill development and mastery)
- Control (players should feel a sense of control over their actions in the game)
- Clear goals (the game should provide the player with clear goals at appropriate times)
- Feedback (players must receive appropriate feedback at appropriate times)
- Immersion (players should experience deep but effortless involvement in the game)
- Social Interaction (the game should support and create opportunities for social interaction)

PGM is not a final and fully comprehensive model but can be regarded as a starting point for further empirical studies on player enjoyment in pervasive games. However, even if the model is not yet complete, it is thus far the most valid model dealing with player enjoyment in pervasive games. Thus, in order to support player enjoyment, we argue that a game story should support, as best as possible, the eight elements in PGM.

3.4 Motivation for the academic tasks

In many games used in game-based learning (GBL), the ludic experience is often suddenly interrupted in order to feature an academic section in which the player must perform some academic. We believe that the “educational part” of the game used in GBL should be an inherent and integrated part of the game and not be perceived as something different or unrelated by the player. To achieve this, the game story must provide clear motivations for the completion of related academic tasks. In NM, this is achieved through the established fact that the academic tasks are the main reason as to why the player is “contacted” and asked to “play the game”.

3.5 Dynamic storytelling

Since we planned to feature relevant real-life events during the game, the game story had to be flexible so as to accommodate those events as an inherent part of the game story. As discussed in section 3.1, this is an important strategy towards in-game awareness and the approach undertaken in NM was to create an overall game story based on previous real life events (as mentioned in chapter 3.2) that form the complete game story (if nothing happens in the real world that can be related to the story) or offer opportunities to explore different aspect of the game topic. If such a case occurs, the technique selected is the classic digital game approach in which the main storyline can be put aside temporarily in order to allow for the development of an arising story line (based on timely real-life events) until the story branches back again to the main overall storyline as shown in the figure below. This is in itself a very common digital game technique in which micro-narratives are inserted within the overall macro-level narrative of the game (Grant and Bizzocchi 2005). In the particular case of NM, the narrative at the macro-level is not per se flexible as its elements are designed to appear in sequence according to the demands of the educational curriculum. The micro-level narrative however can be slotted in as they occur in real-time in the real-world current affairs. The role of the game master (GM) is thus both opportunistic and creative in the sense that it is up to the GM to scrutinize media for relevant news reports and assess the opportunities these could provide with respect to enriching the pervasive game experience.
4. The game story – DPS in practical application

In this chapter we describe the overall game story and examples of the game story to illustrate the DPS approach described in section 3.

Media analyses of the current and former media landscape suggested that Iran’s alleged nuclear weapons program was a relevant candidate as the theme for the game history. At the time, Iran’s alleged nuclear weapons program was often mentioned in the news. There had already been a number of different events that could be used to substantiate the game story, and the issue seemed to be so relevant that there was great probability that one or more events could happen, in the duration of the game, that would be featured in the news media and thereafter could be implemented in the game (Figure 1). On the basis of these considerations the theme chosen for the game story was Iran’s nuclear program.

4.1 The overall game story

The overall game story was constructed from the ability to support the story by referring to real life events that had already happened (reality hack), and the likelihood that there would happen something related to the story that would be referred to by the news media (newspapers, television) and would be possible to implement as a part of the game story or game plot while the game was in progress (Figure 2). Based on the above, the overall game story was constructed as follows:

- Iran has a nuclear weapons program which aims to develop nuclear weapons (RT 2009, Nettavisen 2004, Dagbladet 2010). A group of agents has been asked to delay and sabotage the weapons program so that Iran does not succeed in developing nuclear weapons. We do not know the identity of the members of this saboteur group but they use the identity of a non-existing person, Amir Ahangar, as their contact. The saboteur group has previously managed to delay the nuclear program by liquidating key personnel (AFP 2010), but this is no longer a feasible option.

- In an underground bunker in Iran there is a supercomputer that is currently conducting computations that are absolutely necessary for the Iranian nuclear weapons program. Without these calculations, it will not be possible for Iran to develop nuclear weapons and the saboteur group’s mission is to sabotage the super computer before the calculations are completed.

- To gain access to the supercomputer, the saboteur group has to hack into Iran’s government internal computer network. The group has managed to gain access to an Iranian government office in which there is a computer connected to the internal computer network, but they do not have the codes and passwords necessary to penetrate the network and get access to the supercomputer.
These codes are however known to Shahram Amiri, a former Iranian nuclear physicist, who fled to the United States in a CIA coordinated operation (VG 2010). The saboteur group has to somehow contact Shahram Amiri to get the secret codes to gain access to the supercomputer.

4.2 Integrate location

The probability that the selected theme for the game story unfolds at the same physical location as where the players live their daily lives is most likely very small. A very important part of pervasive games is to use the players’ surroundings, i.e. the city, school/work, home, as an integrated part of the game play; hence there is a need to co-locate the game and the players. The game story must therefore substantiate that the game (i.e. the part of the game where the players has to get involved) happens where the players live their everyday lives, even if most of the game story (what the players can see on national TV, read about in newspapers etc.) unfolds somewhere else in the world. The game was co-located (figure 3) with the players by the following twist in the game story:

The Iranian nuclear physicist, Shahram Amiri, which fled to USA (VG 2010), is regarded as a traitor by the Iranian government. They have sentenced him to death and Iranian agents have been sent out to locate and liquidate him. To protect Shahram Amiri from assassination, he has, in consultation with the Norwegian and American government, in utmost secrecy been placed in Steinkjer with a new and top secret identity as Afghan asylum seeker.

This part of the game story, which is designed on the basis of both real and fictional events, integrates the game with Steinkjer (the city where the Nord-Trøndelag University College and the players are located) and provides the reason for why the players must be involved in the game. The “Amir Ahangar” saboteur group, which is located in Iran, needs help from someone located in Steinkjer.

4.3 Provide motivation for the academic tasks

The game story should provide motivation for the academic tasks that the students have to perform in the duration of the game and integrate the academic tasks in the game in such a way so that the players (figure 1) perceive them as an integrated and natural part of the game. Following the DPS approach the academic tasks in Nuclear Mayhem is integrated in the game (Pløhn 2014) by the following part of the game story:

The former nuclear physicist, Shahram Amiri (VG 2010), who now lives in Steinkjer under a false identity as an Afghan asylum seeker, is willing to help penetrate the Iranian government data network by providing the passwords and codes necessary, but to protect himself, he will not have any direct contact with the “Amir Ahangar” saboteur group. He has instead chosen to hide the codes at different places in Steinkjer, and to prevent them from being discovered and understood by random people, he has hidden the codes included in a technical challenges that not just anyone will understand. Apart from this, Shahram Amiri will not help in any way. He fears, with good reason, for his life and will not do anything that could cause the Iranian authorities to become aware of him.

The codes turn out to be hidden behind, or as part of ActionScript 3.0 programming code and Flash applications.

This means that the “Amir Ahangar” saboteur group has to find someone in Steinkjer, with knowledge of Flash and ActionScript 3.0 programming, which are willing to help the saboteurs by revealing and transmitting the codes to them so they can penetrate the computer network and sabotage the supercomputer before it has completed the calculations.

Via searches on Google and thereafter on www.hint.no, the “Amir Ahangar” saboteur group discovers that there is an ongoing ActionScript 3.0 programming course at the SPO program at Nord-Trøndelag University College in Steinkjer, and they decide to contact the students there to get help to find the codes. The saboteurs group creates a false G-mail account under the name Amir Ahangar (a normal name in Iran) and use this to contact the students. The game has begun.

This part of the game story integrates the educational part with the game by making the academic tasks the only reason why the players are contacted by the saboteur group and asked to help (play the game). Everything else in the game, the riddles, the tasks, the assignments, etc. is only a result of this.
4.4 Awareness and Pervasiveness actions

One criterion for choosing the current theme as the basis for the game story was the likelihood that relevant real-life-events related to the theme and referred to by the news media, would happen in the duration of the game (section 4.1). However, there is no guarantee that such events will occur, and the game story should therefore provide a motivation for pervasiveness and in-game awareness enhancing actions in the duration of the game (figure 2). To meet this requirement the Iranian secret agents (introduced in section 4.2) were included in the game story:

The Iranian government has sentenced Shahram Amiri (VG 2010) to death and has therefore sent secret Iranian agents out in the world to locate Shahram Amiri and kill him. When the game begins the secret Iranian agents are still in Iran but for each week of the game they come nearer and nearer in locating Shahram Amiri and identifying his helpers (the players) and they also come closer and closer to Steinkjer for each week. The last period of the game the Iranian agents are in Steinkjer and at some point, even at the University Campus (YouTube 2014).

In the duration of the game this part of the game story motivated several pervasiveness and in-game awareness enhancing actions by sending emails and SMS to the players informing them about topics such as: “The Iranians have sent two agents to Europe to locate and eliminate Shahram Amiri and anyone who helps him”; “…we now have confirmed information that the Iranian agents are located somewhere in Scandinavia”, “…the agents are now in Norway”, and so on.

4.5 Incorporating occurring real life events

In the duration of the game several real life events occurred that was incorporated in the game story and used to motivate several different game related actions. Due to limited space, only one example is presented in this section.

Some weeks into the game Farzad Farhangian, an Iranian diplomat at the Iranian embassy in Brussel, Belgium, defected to Norway, seeking asylum on the ground that his “life was in danger in Brussels” (BBC 2010). This became a major news story in Norway and was featured in newspapers and national radio and TV. This real life event was incorporated in the game by the following game story:

Farzad Farhangian had been the source to information about the Iranian secret agents and their whereabouts. Farzad was in fact a member of the “Amir Ahangar” saboteur group and acted as a double agent. He had been revealed as a spy by Iranian authorities and had – at the last possible minute – escaped from the embassy in Brussels and fled to Norway to save his life. The disclosure of Farzad as a double agent has led to that the “Amir Ahangar” saboteur group have lost control of the whereabouts of the Iranian agents.

This event was used in many different ways in the game. It was featured in the early morning news on the radio and the game master who rated this as an event with large probability to be featured in the evening news on national TV and from this assessment sent the following SMS to all the players two hours before the newscast on national TV picked this up:

One of our main information sources to Iranian internal Intelligence is Mr. Farzad Farhangian, a diplomat at the Iranian embassy in Brussel. Mr. Farhangian has provided us with Intelligence about all types of Iranian activity in Europe. His connection to us has now been exposed and to save his own life he had to flee from Brussel seeking asylum from Norwegian authorities. More about this at the news broadcast on Norwegian TV tonight.

This SMS had several purposes in the game. The SMS itself helped to increase the pervasiveness of the game and helped to create in-game awareness about the ongoing game. The SMS also functioned as a narrative since it revealed a new part of the game story to the players. The SMS led all the players to watch the evening news on national TV where the event was one of the headlines and received major focus. When the players could watch the game story “unfold” on national TV this clearly helped both to make the game more real/exciting and to increase the pervasiveness and in-game awareness properties of the game. Furthermore, this event was used as a motivation for the players to perform a practical task to ensure that they were not followed or revealed by the secret Iranian agents. This part of the game story and the practical task did not
exist before this real life event occurred and could be incorporated in the game story and game play while it happened due to the DPS approach.

5. Participants, methods and procedure

17 male students were attending the University Course that NM is designed to support and all registered as players in the game. None had any previous experience of pervasive gaming. Amongst registered participants two did not participate in the game and did not attend the lessons or lab-exercises. One completed the game but did not attend the final exam giving a total of 15 who played and completed the game and 14 who attended and passed the final exam.

We gathered four different types of evaluation data (qualitative questionnaires, interviews, log recording, GM observations) during the nine weeks it took to play NM. All participants answered the questionnaire (n=15). While such a small sample will not allow for statistically significant results, the analyses of responses may still provide an indication of the players’ opinion for the design of future pervasive games. Based on the responses, five people were chosen for in depth interview. The five interviewees were chosen based on their attitude towards the game (two positive, two negative, one neutral). The in-depth interviews were conducted after the exam grade was set and mainly dealt with the participants’ general attitude towards their experience of participating in the game NM, the individual game plots, the use the real world as part of the game and what they perceived as motivation or demotivation factors in the duration of the game.

6. Results and discussion

The strategy of using a current news story with the potential that timely and related real-life events could happen and be featured in the news media within the duration of the game proved to be successful. In the nine weeks period during which the game lasted, several real life stories were featured in the news media. These were used in different ways in the game in order to increase the pervasiveness of the game and maintain the players’ in-game awareness.

The quotes in Table 1 illustrate how players perceived the relationship between the game and real-life news stories. They also seem to indicate that the validity of this strategy as a good design choice and an efficient and recognised way to support in-game awareness. Players were, at the time of consuming relevant information, in a non-gaming situation (watching the news or reading the newspaper in the comfort of their own home). They were, however, still aware of the game when reading newspapers or watching TV-news as they developed the expectation that “something was going to happen in the game” when they felt news events would be relevant to the game (see Table 1 (subjects B and E)).

However, many participants were less aware of current affairs and paid very little attention to news broadcasts on TV or newspapers. Thus, these players did not experience the same level of pervasiveness and in-game awareness as those who witness the “game story” being featured in real life news media. Our approach to remedy to this problem was for the game master to send SMS-messages informing participants to watch the evening news when there was a high probability that something was going to be featured in one of the news stories. One example of such an event was the story of an Iranian diplomat at the Iranian embassy in Brussels seeking asylum in Norway (i.e. where NM happened) (BBC 2010). This event was considerable and would almost certainly be featured as a main story to be reported during that evening’s TV news show at 9 p.m. To motivate players a SMS reminding participants to watch the news show was sent to all of participants at 5 p.m.

The intention behind this SMS was to connect the real life event to one of the stories in the game (the secret Iranian agents that are constantly getting closer and closer), to create in-game awareness (the SMS itself) and to increase the pervasiveness of the game by motivating the players to watch the evening news and witness the “game story” being featured as one of the headlines.
Table 1: Quotes from participants about the use of the real world events in the game.

<table>
<thead>
<tr>
<th>Subject</th>
<th>Quote</th>
</tr>
</thead>
<tbody>
<tr>
<td>A (positive)</td>
<td>I was aware of that what I saw in the videos, the news clips etc. used in the game were real life events. I think that the use of real life events as a part of the game makes it all the more realistic ... or more real ... I think that, for my part, that the fact that real life events that occurred while the game was going on – like the Iranian diplomat who defected – was used in the game made it more real ... when you connect it to more realistic stuff so ... it increases the tension as well. I tried to play the game as if it was for real. My main motivation to play the game was the whole “concept” of the game. I think the story was exciting and fun.</td>
</tr>
<tr>
<td>B (negative)</td>
<td>I think the story was a good plot and there was a lot of work put into it. The story matched with a lot of things that was going on at once. There were real things going in the current news that the game linked to. When I received links or tips from the game I paid more attention to the news stories about Iran, and there was a good timing on some of it. I think that the use of real life events in the game was good. It made it the more exciting ... thus ... I am not just negative to the game, I can see the relevance of the game but I don’t like this types of games I saw something about it on the news broadcast on TV and then I knew that things were going to take place in the game also.</td>
</tr>
<tr>
<td>C (negative)</td>
<td>The story was well substantiated, it was well made and the details were good. I am negative to many things in the game but regarding the storytelling in the game, I am positive, The use of real life events in the game story was exiting and it increased the atmosphere of the game.</td>
</tr>
<tr>
<td>D (neutral)</td>
<td>I think the story was relevant. It was very relevant when they hacked the Iranian nuclear facilities with the Stuxnet virus. Then I thought of the game when I saw it in the news. My participation in the game made me become more aware of this type of news. I think that the use of real life events (such as the Iranian embassy employee that fled) was good because it made the story more believable. Being able to read it in the newspapers made it a bit more credible. Real.</td>
</tr>
<tr>
<td>E (positive)</td>
<td>When I saw the story featured in the newspapers I knew that something was going to happen. My participation in the game made me become more aware of news that could be related to the game. The story was exciting. I think the use of real life events as a part of the story might be good ... then it becomes a little more realistic ...</td>
</tr>
</tbody>
</table>
The quotes presented in Table 1 above indicate that the DPS approach was successful in creating a game story that incorporates real life events so as to support in-game awareness and game pervasiveness. All players noticed that real life events were used in NM and viewed this as a positive aspect that made the game more realistic and exciting.

A minority of players expressed a negative attitude towards NM but observations during the game and in-depth interviews showed that dislike was not caused by the game story but by other factors:

- They did not appreciate that participation in the game was obligatory (but so are the alternative which is obligatory assignments)
- The fact that they had to play a game led to them disliking the game
- Some judged that there was not enough “academic learning” in the game (curriculum issue rather than the game design).

Any complaints from the players regarding the academic tasks were, as mentioned in the bulleted list above, related to curriculum issues, and not how the academic tasks where incorporated in the game and game play. None of the players indicated, neither in the duration of the game, in the questionnaire nor the in depth interviews, that the academic tasks felt as an alienated or an unnatural part of the game.

Some players reported that their participation in the game led to increased attention if the story was featured in the media. Higher awareness about the news broadcasts was not an intended goal but it indicates that the use of real life events featured in the news media did increase the pervasiveness of the game and helped to create in-game awareness among the players.

After this experimental run of NM, 46.7% answered they preferred the game to the obligatory assignments, 33.3% still preferred obligatory assignments to the game and 20.0% indicated that they don’t know or that it is not important. The fact that more participants preferred the game is a very good result considering that the “academic challenges” could have been designed in order to reflect on individual skill levels better. NM was a “low budget” experimental game with limitations and could have been better (some of the plots were too similar, there were periods in the game with little activity and too few assignments, game mastering was done manually and player events was sometimes not detected by the game master causing the affected players to fall behind in the game). Academic tasks could have been incorporated better and a more “fancy” and better use of technology towards a fun game-play experience would most likely make a difference too.

7. Conclusion and future work

The main contribution of this paper is the outline of a Dynamic Pervasive Storytelling (DPS) approach which can be used within a story creation process towards dynamic game stories in which real-life events support game pervasiveness and help to create and maintain in-game awareness.

NM demonstrates that we succeeded in selecting a suitable media event/news story to be used in the DPS approach to create a game story with the properties required.

The DPS approach also seemed successful in incorporating the academic tasks in the game in such a manner that the players felt that the academic tasks were a natural and integrated part of the game. Future versions of the game should address how to design good learning tasks that are tailored to the individual players’ knowledge level.

Given NM’s low budget and technological limitations, a discussion should take place as to potential impact of advanced technologies (i.e. Artificial Intelligence, Gaming technologies) on the overall user experience. The emerging domain of Dynamic Pervasive Storytelling for education is, as of today, confined to ad hoc and low technology designs but would certainly benefit from research in synthetic agent actors (Weallans et al. 2012) and advanced digital interactive storytelling systems (Thue et al. 2010). In this context, synthetic agents could be effectively playing autonomous roles within the remit of the storyline and choose to communicate of their own accord with participants, thus facilitating the concept of in-game awareness presented in this article. Such technologies are already available (Keysermann et al. 2012) and could be effectively deployed within the context of this work.
References


