Designing Casual Serious Games in Science.
The case of “Couch Potatoes Defense”

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Abstract

Casual-serious games in science are games dealing with science topics that require short playing time and relatively low budget to develop, while based on educational purposes.

The research goal was to investigate the relation between the game design parameters and the learning experience based on the flow model, assuming that by changing game parameters the relation between challenge and skill will be influenced, as expressed by the flow experience, influencing in turn the learning experience.

The framework comprised a series of pilots in a primary school class, in which flow was evaluated using online questionnaires. We found significant changes in flow components between the three phases of the pilot. Students’ responses indicate assimilation of social practices, and understanding of the relation between parameters.

We conclude that careful design of game parameters influences the flow experience as well as the learning experience, understanding of content goals and social values.

Keywords: Serious-games, Educational-games, Flow, Science-learning, Game-based learning, Casual-games.

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1. Introduction

According to OECD data, about 60% of the students in the USA, Canada and many countries in Europe think that school is boring. Moreover, studies show that one of the reasons for low achievements in science is negative attitudes towards science in school [1]. One of the reasons for low motivation in school is that students seldom see the relation of school science to everyday life, especially when the topics are abstract or complicated [2]. Computer games, on the other hand, are one of the favorite activities that teenagers choose to spend their time on. Moreover, while playing commercial digital games youths often seem to be fully engaged in the experience and unaware of their environment as in the flow theory [3] [4].

1.1 Flow and game-based learning in science

The state of flow was defined by [3] [4] as a balance between challenge and skills, or anxiety and boredom. Originally it referred to activities like rock climbing, music composing or dancing, but later the model was extended to other contexts including digital environments. One of the implications of flow experience in digital environments is increased learning [5].

The potential in the influence of digital educational games on motivation, engagement and learning of science content and skills was investigated in several studies (e.g. [6], [7], [8], [9], [10]), that found a positive relation in specific contexts. [9] found that 5th class students who played a digital game in science reported on flow experience and showed significant achievements in content learning. [10] found significant relation between
flow experience and declarative knowledge in a science game.
In a recent report [11] evaluated three aspects of learning:
cognitive, intra-personal and inter-personal in previous
studies of game-based learning, and found that using
games in science learning may improve cognitive
competencies compared to learning in traditional
methods. Another finding shows that the effectiveness of
game influence on learning depends on game design. In a
previous study [12] wrote: “it is one thing to create a fun
and engaging game that students will want to play. It is
another to create one that will also teach them the
intended concepts” (p 49). In this study we investigate
the design process of an educational game that will
combine those two goals.

1.2 Design principles for educational games
in science

An educational game that aims to be both educating and
engaging should incorporate in its design flow principles
as well as educational games design principles. A
framework for flow in computer-mediated environments,
including digital games, was suggested by [6], [7]. He
refers to three stages of flow: Flow antecedents
(comprising the parameters of the game), Flow state
(characteristics of a person experiencing flow) and Flow
consequences (Table 1).

<table>
<thead>
<tr>
<th>Table 1: The Three Stage Game Flow Model</th>
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<tbody>
<tr>
<td>adopted from [6],[7]</td>
</tr>
<tr>
<td>Game flow antecedents</td>
</tr>
<tr>
<td>Challenge to Skill balance</td>
</tr>
<tr>
<td>Playability</td>
</tr>
<tr>
<td>Clear Goals</td>
</tr>
<tr>
<td>Gamefulness</td>
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</tbody>
</table>

The main design principle for educational games was
formulated by [13],[14],[15]: in order to achieve
meaningful learning, game goals must be aligned with
learning goals (in contrast to adding educational content
to a ready game. E.g. a puzzle). This principle is the key
for designing a game that is educational and enjoying at
the same time. When goals are truly aligned the
motivation to learn will be internal and unite with the
motivation to play.

Another principle for educational games is integrating the
learning content in the game (in contrast to stopping the
game flow or taking a break in order to teach something).
In a simulation-game, which is a common genre in
science games, the factors in the game must correlate with
a scientific model, and represent the relations between
them. In addition, success in the game cannot be
coincidental, but should depend on knowledge of content
or skills that are relevant to the learning goals. In addition,
the context of the game should be relevant to the target
audience.

2. Methodology

2.1 Game Design

In the following sections we focus on the design and
evaluation process of a casual-serious game in science,
dealing with the subject of “healthy and active lifestyle”,
which is included in the science curriculum for elementary school. A casual-serious game refers to an
educational game which can be defined as a “serious
game” and “casual game” at the same time: Serious
games are usually defined as games with a goal besides
entertainment (for example: PeaceMaker), and recently
many serious games have educational goals. Usually these
games are complicated, expensive, and require extended
playing time. On the other hand, casual games are usually
not identified with educational games. They are
characterized as simple, easy to learn, and easy to play,
and attract a different audience than serious games [16].
But actually, if we aim to integrate digital games in school
learning, isn’t it more realistic to develop casual-serious
games that will be easy for teachers to adopt, will be
possible to play within a lesson time-frame, but at the
same time will be based on educational learning goals?
The game was developed by Snunit center for the
advancement of web-based learning, in cooperation with
the ministry of health, the ministry of education and the
ministry of sport and culture in Israel. The games are part
of a website dealing with health in the kids-governmental
portal. In previous studies [17] we described a model for
integrating learning with enjoyment in digital games. The
games were shown to create positive learning experience
for children playing after school hours. The model
incorporates the games with separate learning units in the
website, in a way that the free-choice learning from the
game is supported by explicit learning in the interactive
units. In formal contexts the mediation may be done by
the teacher using the learning units or any other teaching
strategies.

In the current study we explore the connection between
game parameters and the learning experience in one case
study of a casual-serious game in science. The research
question is: How can we influence the learning experience
through the design of game parameters?

2.2 The game “Couch Potatoes Defense”
Designing Casual Serious Games in Science. The case of “Couch Potatoes Defense”

This game (Figure 1) deals with the significance of physical activity during daily life, as part of a healthy lifestyle. The learning goals include students’ understanding that:

1. They should be active at least 60 minutes a day in order to be healthy and happy. (LG1)

2. These 60 minutes can be easy and fun, and not difficult to accumulate during every day routine. (LG2)

3. There is a large variety of activities you can do, influencing different components of physical fitness. It is recommended to combine those components (LG3)

The game is based on the genre of defence games, and specifically inspired by the long established “Tower Defence” game. The “enemies” are lazy characters (“couch potatoes”) advancing on a conveyor belt, whose aim is to go to sleep as soon as possible, while avoiding physical activity. The player can prevent them from being lazy by placing various activities in specific positions along the conveyor belt. As a lazy character gets to a positioned activity it will have to do it and collect minutes of physical activity. In order to advance to the next level the player has to collect 60 minutes for each of the characters. How are the design principles expressed in the game? The answer is presented in Table 2.

Table 2: Expression of Design principles in the game “Couch Potatoes Defence”

<table>
<thead>
<tr>
<th>Design Principle</th>
<th>Expression in the game</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aligning game &amp; learning goals</td>
<td>LG1 - when a character collects 60 minutes it becomes happy and active</td>
</tr>
<tr>
<td>Content integrated in the game</td>
<td>LG2 - There is a variety of animations for varied activities</td>
</tr>
<tr>
<td>Relevant context</td>
<td>LG3 - activities are categorized according to physical fitness components which have to be combined in order to advance in the game</td>
</tr>
<tr>
<td>Challenge to Skill balance</td>
<td>The background represents a child’s everyday route from school home</td>
</tr>
<tr>
<td>Playability</td>
<td>Parameters influencing the balance include time spans between the appearance of characters, their speed and number. Skill is expressed by the level the player has reached (there are 5 levels)</td>
</tr>
<tr>
<td>Clear Goals</td>
<td>A short animated tutorial appears at the beginning of the game</td>
</tr>
<tr>
<td>Gamefulness</td>
<td>The goals are expressed in the title, the instructions and the tutorial</td>
</tr>
</tbody>
</table>

The answer is presented in Table 2.
2.3 Research Framework

The game was piloted and revised in a primary school class (4th to 6th grade, about 20 students in each class), in a process that lasted about a month. After the first pilot (Phase A) game parameters were calibrated according to the feedback, and then it was piloted again (Phase B) in another class. The pilots were conducted in a computer room, with children sitting in couples or individuals near computers. After a short explanation they were asked to play the game about 20 minutes, and then fill an online questionnaire. Finally there was a general discussion that we recorded.

The game was published (free) online on June 2013, and we continued to collect data through the online questionnaire for several months (Phase C). So far (October 2013) 162 kids aged 8-14 filled the online questionnaires, while data from Google Analytics for the same time period shows 15,566 unique visitors who played the game 6.5 minutes on average.

We used [9] game flow survey to evaluate the flow components, and added some specific questions in order to evaluate the learning experience. Following our previous study [17] we focus on learning social practices and norms. The relevant questions ask students whether they learned something new or deepened their previous knowledge. Another question asks whether their attitude towards physical activity has changed following the game. Students’ answers to some open questions, as well as their responses in the oral discussion were used to corroborate these findings.

3. Findings

The Flow and learning components’ values at the beginning and end of the pilot are compared in Table 3.

Table 3: Flow components in 2 phases of the game "Couch Potatoes Defence" design process

<table>
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<tr>
<th>Flow component</th>
<th>Phase A</th>
<th>Phase C</th>
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<td>Challenge to skill balance</td>
<td>68%</td>
<td>94%</td>
</tr>
<tr>
<td>Clear goals</td>
<td>91%</td>
<td>100%</td>
</tr>
<tr>
<td>Playability</td>
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<tr>
<td>Concentration</td>
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<td>Sense of control</td>
<td>69%</td>
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<td>Loss of time and self-consciousness</td>
<td>73%</td>
<td>81%</td>
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<tr>
<td>Learning new content</td>
<td>61%</td>
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<tr>
<td>Deepening knowledge</td>
<td>29%</td>
<td>55%</td>
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<td>Change of attitudes</td>
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The components that involved a significant change include Challenge to skill balance, Playability and Deepening knowledge. The implication of these results may be that the increase in flow (expressed by challenge to skill balance) is associated with significant learning.

The effect of game parameters’ calibration on students’ flow experience is presented in Figure 2. We compare the number of students who reached each of the five levels of the game. In an ideal game we would expect a normal distribution to account for high level of Gamefulness. The results show an improvement in this aspect in the second and third phases.

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Further evidence for learning can be found in students’ answers to open questions and during the open discussion. Already in the first pilots it was clear that the main message of the game was understood. For example: “After playing this game I know more possibilities of physical activity to do during the day”, “I learned about the importance of doing at least one hour of physical activities every day”.

Figure 2. Distribution of students’ “success” in the game “Couch Potatoes Defense”

4. Summary and conclusions

In this study we examined the relation between game parameters to the learning experience from the game in a game in science dealing with health that can be defined as a casual serious game.

We followed the design principles of educational games, e.g. aligning game goals with learning goals, and calibrated the game parameters to achieve a flow experience. In a series of pilots we found an improvement in the flow experience of primary school students that was associated with evidence for deepening knowledge and change of attitudes. This is a preliminary study that
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requires further research mainly in clarification of learning expectations and outcomes. These findings have implications for integrating digital games in science teaching, which we believe have a great potential for improving science learning experience in schools. Educational games enable positive experience of dealing with complicated concepts, understanding relations between parameters, training problem solving in relevant contexts, and practicing scientific skills and high order thinking skills. Using effective digital games in science teaching may develop students’ internal motivation for learning, and help in clarifying the relevance of science learning to their daily life.

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References