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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

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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 1: The Three Stage Game Flow Model adopted from [6],[7]

Game flow antecedents	Game flow state	Flow consequences
Challenge to Skill balance	Concentration	Content learning gains
Playability	Sense of control	Exploratory behaviors
Clear Goals	Time distortion	
Gamefulness	Loss of self-consciousness	

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”*

Figure 1. The main screen of the game "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"

Design Principle	Expression in the game
Aligning game & learning goals	LG1- when a character collects 60 minutes it becomes happy and active LG2- There is a variety of animations for varied activities
Content integrated in the game	LG3- activities are categorized according to physical fitness components which have to be combined in order to advance in the game
Relevant context	The background represents a child's everyday route from school home
Challenge to Skill balance	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)
Playability	A short animated tutorial appears at the beginning of the game
Clear Goals	The goals are expressed in the title, the instructions and the tutorial
Gamefulness	Created by the combination of a familiar casual game, graphics and animations

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 siting 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

Flow component	Phase A	Phase C
Challenge to skill balance	68%	94%
Clear goals	91%	100%
playability	66%	88%
concentration	77%	94%
Sense of control	69%	87%
Loss of time and self-consciousness	73%	81%
Learning new content	61%	69%
Deepening knowledge	29%	55%
Change of attitudes	43%	57%

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.
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".*

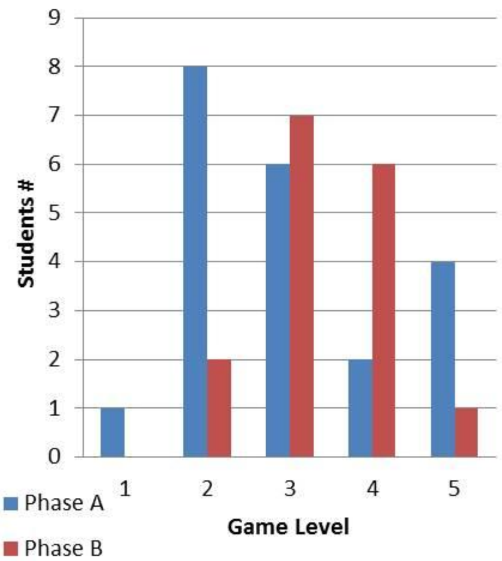

Figure 2. Distribution of students' "success" in the game "Couch Potatoes Defense"

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

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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