A Case Study of a Learning Game about the Internet

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Abstract. This paper describes the design of the learning game *Internet Hero*, in which the player is transported into a fictional world representing the Internet. The game shall convey learning contents about the technical and social basics of using the Internet. We connect game design to learning principles and evaluate the game through gameplay metrics and interviews with children. We show that we were able to build an engaging game while at the same time building on a strong theoretical foundation on digital game-based learning.

Keywords: game based learning, learning principles, case study

1 Introduction

This paper is concerned with the design of a digital game-based learning experience about the Internet for children. 98% of children in Germany aged 6 to 13 use the Internet at home, 21% do so on their own computers or devices without being supervised by their parents. At the same time it is known that children often use the Internet carelessly without enough reflection and conscious awareness of the consequences of their decisions (cf. [1]). Brown and Vaughan [2] say that *Play is exploration, which means that you will be going places where you haven't been before.* What they refer to is a view of games as possibility spaces which allow to explore activities without fearing the consequences. A safe-to-fail game environment can enable children to learn about the Internet and consequences of their actions in this space in a playful and explorative way.

The context for this paper is formed by the project *Play the Net*. The project's goal is to develop a game for children aged 9 to 12, which enables them to playfully experience how the Internet works, how they can surf the net safely and the dangers they might face online. The project was run as a one year long cooperation between the University of Vienna and the Vienna University Children's Office from 2012 to 2013. The result of the project is the game *Internet Hero* (for details see [3]), in which the player has to solve different mini-games correlating to four aspects of Internet use: emails, malicious programs, social networks, and connection types. In order to complete the mini-games players need to understand the basic technical or social aspects of these topics. This paper primarily discusses the the e-mail and malicious programs mini-games which were evaluated through gameplay metrics and interviews. To bridge gameplay and learning our design decisions were guided by the 36 learning principles established by J.P. Gee [4]. We used these principles as inspiration and starting points for the game design process. The core question answered in this paper is, if a game designed following the theory on digital game-based learning also appeals to its players as a game. We further discuss which game-based learning principles are suitable for a learning game around the Internet targeted at children aged 9 to 12. To answer these questions we will first present theory on games and learning, discuss the game design with respect to learning principles [4] and later reflect on the efficiency of these design decisions through an analysis of gameplay metrics and interviews.

2 Related Work

Games can be understood as rule-based systems [5]. Rules in games both act as constraints and affordances. Balancing player freedom with constraints is one of the core challenges in game design. Also abstraction [6] and arbitrary (sometimes even unrealistic) constraints [7] are necessary to make games playable in the first place. Frasca [8] says rules further experimentation more than they limit a player's freedom. Freedom and constraints are not antagonists but together lead to ideal spaces for explorative play. To empower players to explore possible interactions with the game world, the game has to act as a safety net where negative repercussions are removed. Squire and Jenkins [9] state that in an ideal case *the constraints of the game make flaws in the students' thinking visible to both teachers and students, enabling students to learn from the consequences of their actions.* The structure of the game not only defines the conditions of success, but also the nature of the choices that need to be taken to succeed.

Systems thinking has been identified as a core learning concept [10], which sees games as representations of systems formed by dynamic and interactive parts. Systems remain stable through a feedback loop between their parts and variables. Interacting with the game thus means taking part in the feedback loop and thereby triggers meaningful learning. The Internet can be understood as a complex structure of interacting social and technical systems. Therefore a learning game with its rule based representation is suitable to let children explore this space.

Kurt Squire [11] characterized three areas of learning where games play an important role: collaborative learning, learning through failure, personalized learning. Following the initial comments on games as safe-to-fail spaces learning through failure is of particular importance to our project. In Gee [12] three specific areas of learning through games have been defined. These are empowered learners, problem solving and understanding.

In their systematization of serious games Michael and Chen [13] also talk about combining fun and learning. They describe that in learning games the serious (learning) content may be like a Trojan horse, hidden in context with fun gameplay. According to Ito et al. [14] three additional important contexts are given: peer-supported learning, which describes everyday exchanges with peers and friends; interest-powered learning, which establishes personal interest; and relevance of learning contents and academically oriented learning, which means that learning benefits from the ability to align learning contents with individual goals. *Internet Hero* primarily tries to raise personal interest through the identification with in-game characters and establishes a social context through play in class and shared leaderboards.

Several studies with respect to unsafe Internet use have been conducted over the years. Among them we would like to mention the recent work of Valcke et al. [15] which also contains many references to other studies on this topic.

With respect to work on games on Internet safety, Nagarajan et al. [16] are discussing the possibilities of game design for cybersecurity training and provide an overview of important training topics, including protection from malware and handling of e-mails from unknown senders or spam. Juhari and Zin [17] developed *Cyberworld Adventure* for children 9-12 years old which uses a similar structure as our game (different levels relating to different Internet safety topics). Also targeting a similar age group as our work, *Net-Detectives* (cf. [18]) is a supervised online role play activity where children take on the role of a detective and receive help from human experts. *Anti-Phishing Phil* [19] is an online game to teach people how to protect themselves against phishing attacks. In all three cases, the authors reported a positive impact of the game on children's knowledge of Internet safety. *SimSafety* is an online virtual game environment to foster understanding of Internet safety risks. Its design and technical considerations have been described in Kalaitzis et al. [20]. Results of an evaluation of an early version of the system to assess game usability can be found in Xenos et al. [21].

3 Internet Hero

The story of *Internet Hero* revolves around a young child (the player) who accidentally gets transported into a fictional world representing the Internet and who finds himself in a quest to save this world from evil forces. As the story develops, the player meets the mail-sorting android *Ping* who becomes the players' com-

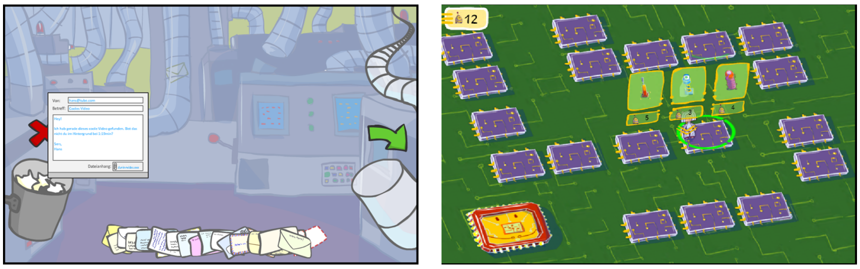

Fig. 1. *E-Mail* (left) and *Malicious Software* (right) mini-games.

panion in the game. *Ping* acts as a tutor for the player who provides explanations of aspects of the Internet and of the mini-games. These mini-games are embedded in the game's narrative meta structure. In the following, two mini-games – which were the subject of our evaluation – are described in more detail.

3.1 E-Mail Mini-Game

Ping works in a mail server and is currently overwhelmed by a wave of spam mails. He needs help separating legitimate emails from spam mails and asks the player to assist him by sorting 20 different mails. Spam mails need to be thrown away while legitimate e-mails need to be forwarded to their recipients. The player's task is to read the incoming e-mails and decide whether they contain any unsolicited advertising or suspicious URLs, senders, or attachments. After the player has read the e-mail and decided if it is a spam mail or a legitimate mail, they can send it forward or destroy it by dragging the e-mail either to the right side of the screen or onto the trash bin on the left side (cf. Figure 1, left). In case players manage to correctly categorize two or more e-mails in a row they get a chain bonus as an extra reward.

3.2 Malicious Software Mini-Game

After the spam-wave is over *Ping* expresses his gratitude to the player, but soon starts feeling sick because he got infected by a virus. The player accompanies him to the hospital, where an USB-doctor explains a few of the different kinds of malware and how to stop them from weakening *Ping*. The player has to stop the disease from destroying *Ping*'s CPU by playing a tower-defense-like minigame (cf. Figure 1, right). The player can build different types of defense towers on predefined building lots. There are three types of towers to choose from: shooter, scanner, and firewall. The firewall stops various malicious programs (viruses, Trojans, and worms) from getting to the CPU, the scanner identifies Trojans as malware, making them vulnerable to shooters. In order to win the mini-game the player has to survive ten waves of attacks. Each wave enters from one of two sides of the game field. Each time a malicious program is killed it drops *Ping-Points*, the mini-game's virtual currency, which can be reinvested

Fig. 2. Children played and tested the game during the *Children's University* event.

into new towers or upgrades. If an enemy reaches the CPU, *Ping*'s health-bar loses life. Once the CPU is destroyed the mini-game is lost.

4 Methods

The approach of the project can be characterized as explorative. In explorative design [22] knowledge is constructed through interacting with the matter to be explored. In our case we explore learning games and their workings through making them and reflecting back on the process. This approach can also be called design as research [23]. The process of generating research results through game design in particular has also been outlined in Stapleton [24].

The evaluation used a mixed methods approach, including different on-screen questionnaires consisting of open and closed questions and data logging for which purpose the game was instrumented to automatically record different aspects of the player activity. With regard to the former, one questionnaire assessed general demographic characteristics (e.g., age, gender), a questionnaire after each mini-game collected feedback about the mini-game itself, and a last questionnaire at the end of the evaluation collected opinions on the game in general. This way we were able to collect detailed data on the player-game interaction (e.g., for balancing purposes) on the one hand and to obtain subjective opinions on the game on the other hand.

5 Sample

The evaluation was conducted at two workshops during the *Children's University* event which took place at the University of Vienna (cf. Figure 2). During the workshops children were able to play the first two mini-games of *Internet Hero* for approximately 60 minutes. 36 children (50% male, 50% female) between 9 and 13 years ($M = 10.7$, $SD = 1.1$) have participated in the evaluation with the vast majority of them stating to play computer games regularly, ranging from

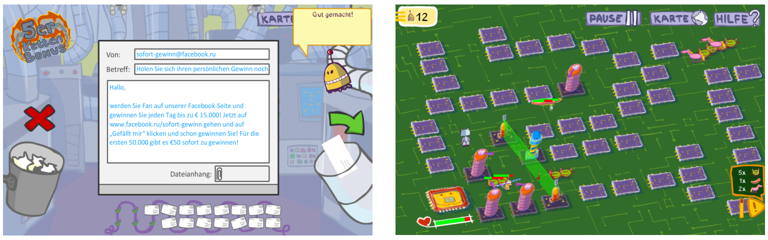

Fig. 3. *E-Mail* (left) and *Malicious Software* (right) mini-games after improvements.

once per month ($n = 10$), to one to four times per week ($n = 20$) or even daily ($n = 4$). Only two of the children reported to never play computer games at all.

6 Results

In general the game was well received by the children. On a four point scale with categories *very good*, *good*, *so-so*, and *bad*, 56% of the children rated the game as *very good* and 40% as *good*. The graphics were rated as *very cool* by 40% of the children and as *well done* by another 56% on a similar four point scale. However, the sound received mixed feedback. While 32% and 28% of the children rated the sound as *very cool* and *well done* respectively, 32% judged the sound as *so-so* and 8% as *bad*. Children indicated, for instance, that they had problems to understand the computerized voice of *Ping* – the player's sidekick.

6.1 E-Mail Mini-Game

One-fifth of the children (21.2%) considered the mini-game to be *very good*, the majority (57.6%) as *good*, 18.2% as *so-so*, and the remaining 3% as *bad*. The responses to the question *What did you not like about the mini-game?* of the post-game questionnaire showed that children most disliked that the phrasing of the emails was sometimes ambiguous (stated by 8 children). Two children also stated that they missed feedback if the mail was categorized correctly or not. However, analysis of the logged data showed that children were able to recognize spam e-mails quite well, getting it right 79.3% (78.3% males, 80.1% females) of the time.

Improvements. Based on these results we made the following changes to the *E-Mail* mini-game (cf. Figure 3, left):

- Rephrased the text of the e-mails where children made the most mistakes.
- Added an indicator to the user interface if and how many of the e-mails were categorized correctly. We suspect that the concerns of some children regarding ambiguous phrasing can be partly attributed to the circumstance that children did not get feedback on the correctness from the game which may have therefore caused them to feel uncertain whether they interpreted the text correctly or not.

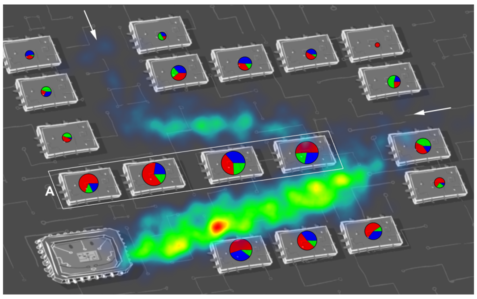

Fig. 4. Heat map where coins have been collected overlaid with pie-charts showing which types of towers (red = shooter, green = scanner, blue = firewall) have been built at the different locations.

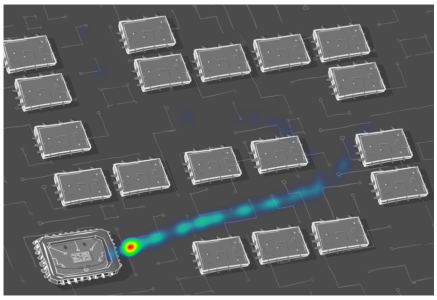

Fig. 5. Heat map depicting locations where *Trojans* have taken damage.

6.2 Malicious Software Mini-Game

Compared to the *E-Mail* mini-game, the *Malicious Software* mini-game was better received by the children, with more than half of them (55.2%) rating the game as *very good*. 31% rated the mini-game as *good*, 10.3% as *so-so*, and 3.5% as *bad*. On average, children played 4.1 rounds (4.2 males, 3.9 females) of *Malicious Software*. However, some of the log files of these rounds were erroneous due to technical problems during the evaluation and were therefore excluded from the following analysis, leaving log-data from 118 rounds.

Figure 4 shows which types of towers have been built at the different locations. The size of a pie chart is proportional to the number of towers built at the certain locations and the colored sections represent the type of the towers (red = shooter, green = scanner, blue = firewall). In general, shooters were built more frequently ($M = 3.43$, $SD = 3.13$) than firewalls ($M = 2.12$, $SD = 1.26$) and scanners ($M = 1.41, SD = 0.85$) across all 118 rounds. This suggests that children were able to successfully defend against *Trojans* without using scanners to expose them. As the heat map in Figure 5 shows, children were rather waiting to attack them until the *Trojans* eventually dropped their disguise in the attempt to assault the CPU.

As evident from Figure 4, towers were preferably built along the horizontally arranged building lots in the center of the map (labeled A). At these locations towers were able to reach viruses in the corridor above and below. In general, defense concentrated on the corridor toward the CPU, since regardless if the viruses entered the map on the top left or right side, enemies eventually have to pass through this corridor. This is also reflected by the heatmap overlaid in Figure 4 which shows where coins have been collected (and therefore indirectly also reflects where enemies have been killed).

To assess if there are differences in behavior between male and female players as well as between players of different age and in order to observe trends in the behavior over multiple rounds we looked at the data of the first and third round.

	Round 1			Round 3		
	male ($N = 17$)		female ($N = 18$)	male ($N = 12$)		female ($N = 15$)
score	478 (386)		296 (323)	1068 (555)	↔	487 (477)
coins	11.8 (14.4)		6.7 (8.7)	30.6 (21.2)	↔	13.4 (14.1)
waves	9.8 (0.7)	↔	8.8 (1.4)	9.9 (0.3)		9.5 (1.1)
shooters	3.2 (2.0)	↔	1.3 (1.3)	6.3 (4.4)	↔	2.7 (2.4)
scanner	1.8 (0.75)	↔	1.2 (1.2)	1.5 (0.5)		1.2 (0.7)
firewalls	2.4 (0.8)		2.3 (1.4)	2.0 (1.7)		2.5 (1.1)

Table 1. Mean values and standard deviations (in brackets) for game-related variables of the *Malicious Software* mini-game. Statistically significant differences ($p < .05$) between males and females are marked with a gray background.

Table 1 lists the mean values and standard deviations of different game-related variables for these two rounds. The effect of gender with respect to these variables was analyzed using Mann-Whitney U tests. The statistical analysis shows that males and females significantly differed with respect to the number of survived waves in the first round ($U = 97$, $p = .02$), with males surviving on average one wave more than females. However, the difference is not significant in the third round anymore, with both males and females surviving almost all 10 waves on average. In general, the mini-game was easily won by the children with males already surviving on average 9.8 waves out of 10 in the first attempt.

Focusing on the type of towers which have been built by males compared to females, females built less scanners than males in the first round ($U = 93.5$, $p = .038$). More interestingly, females also constructed significantly less shooters than males, both in the first ($U = 61$, $p = .002$) as well as in the third ($U = 43$, $p = .02$) round even though shooters are necessary to kill the viruses and to receive coins and score points in turn. A closer inspection of the collected metrics of all 118 rounds revealed that girls sometimes only used firewalls to hold back the enemies until the last wave entered the level and the game counted as won. This strategy was only used by one boy in a single round, whereas six of the girls have pursued it at least once. Females therefore scored on average lower than males as evident from Table 1. This difference is statistically significant in the third round with males achieving more than twice the score ($U = 41, p = .015$) and collecting more than twice as many coins ($U = 45.5, p = .03$) as females. Comparing the scores from the first with the third round, males seem to have been much more concerned to improve their score than females.

No significant differences between the age groups – neither for round one nor for round three – for any of the variables in Table 1 could be observed.

Improvements. In view of these findings we implemented the following major changes (see Figure 3, right):

– To increase the value of scanners, *Trojans* are now immediately disabling firewalls if not exposed by a scanner before. This makes *Trojans* at the same

time more dangerous and should counteract that children wait to attack them until they reach the CPU. As an alternative *Trojans* could, for example, cause more damage to the CPU or could be made more resistant against shooters. However, we think this solution makes more sense in the educational context of the mini-game, that is, teaching children about the dangers of viruses.
- Instead of earning points for killings, points are now awarded for the survived time and for the remaining CPU health. This should make the scoring scheme better suited for different styles of play (whereas the previous one favored offensive play – more frequently employed by males as the above analysis showed). Secondly, this should circumvent that children restrict their defenses to the immediate proximity of the CPU.
- The map itself had been made larger and now includes two corridors leading to the CPU. This should make the game a bit more challenging and varied.

7 Discussion: Connecting *Internet Hero* to Learning Principles

The discussion is structured by several of Gee's [4] learning principles relevant to our game. In the following we first cite a principle and then discuss the gameplay elements relevant to it:

> *Active, Critical Learning Principle: All aspects of the learning environment (including ways in which the semiotic domain is designed and presented) are setup to encourage active and critical, not passive, learning.* [4]

The whole game was set up following this principle as the player acts as part of the game world. The world itself is made out of learning contents, sometimes directly and often in metaphorical sense. Interviews confirmed this decision as players appreciated the game and its visual design.

> *Semiotic Principle: Learning about and coming to appreciate interrelations within and across multiple sign systems (images, words, actions, symbols, artifacts, etc.) as a complex system is core to the learning experience.* [4]

The *Malicious Software* mini-game was built to represent the differences in malicious software and to help players understand possible strategies against it. Players had to understand the abstracted game representation as well as introductory text and cutscenes to interact with it. Only the combination of gameplay and instructions establishes enough context to enable a transfer to a real setting.

> *'Psychosocial Moratorium' Principle: Learners can take risks in a space where real-world consequences are lowered.* [4]

The evaluation of the *Malicious Software* mini-game showed that players also explored less successful strategies in fighting back the various pieces of malicious software. Overall real-world consequences are not an issue in *Internet Hero*.

> *Committed Learning Principle: Learners participate in an extended engagement (lots of effort and practice) as an extension of their real-world identities in relation to a virtual identity to which they feel some commitment and a virtual world that they find compelling.* [4]

To enforce this aspect players are given responsibility within the game world. Not only do they have to follow the story and overcome technical and social issues but players also must save their in-game companion to further attachment to the game world.

> *Self-Knowledge Principle: The virtual world is constructed in such a way that learners learn not only about the domain but about themselves and their current and potential capacities.* [4]

While the game world strongly abstracts the technical basics and includes many metaphors it still includes many likenesses to further ease transfer back to the real world. For example the ability to identify simpler types of spam in the game is very related to the ability to identify real email spam.

> *'Regime of Competence' Principle: The learner gets ample opportunity to operate within, but at the outer edge of, his or her resources, so that at those points things are felt as challenging but not 'undoable'.* [4]

The evaluation and metrics of the *Malicious Software* mini-game showed that many difficulty adjustments are necessary to uphold game flow. This principle fully correlates with good game design practice in balancing difficulty in a game so that players are neither overwhelmed nor bored.

> *Multimodal Principle: Meaning and knowledge are built up through various modalities (images, texts, symbols, interactions, abstract design, sound, etc.) not just words.* [4]

The learning contents of the game are conveyed through several channels. The most important always is the gameplay of a particular mini-game itself. Interaction with the matter always forms the core of the learning experience in *Internet Hero*. Additional information is conveyed though the companion *Ping*, instruction texts and cut scenes.

> *Explicit Information On-Demand and Just-in-Time Principle: The learner is given explicit information both on demand and just in time, when the learner needs it or just at the point where the information can be best understood and used in practice.* [4]

The companion was designed to fulfill this particular role. *Ping* plays a role in all of *Internet Hero*'s mini-games and gives timely information. In a game for children this aspect is of particular importance because they should not be overwhelmed with information.

Discovery Principle: Overt telling is kept to a well-thought-out minimum, allowing ample opportunity for the learner to experiment and make discoveries. [4]

From the feedback we noticed that it is still necessary and good to tell some things more overtly than initially planned. At the same time we tried not to spoil experimentation as could be witnessed in the *Malicious Software* mini-game.

8 Conclusions

With Internet Hero we created a game built upon learning principles. The analysis of gameplay and the discussion of individual learning principles primarily illustrated the importance of a game world which is both engaging and at the same time acts as a representation of the learning contents. The evaluation showed that the game was interesting to its target audience. The biggest challenge lies in the right level of abstraction where learning contents are maintained while at the same time designing interesting gameplay. Learning games face the risk to be either fun and worthless, or boring and worthwhile. This can at least partly be attributed to the fact that the notion of *playing a game* is a difficult one in the context of learning. Also, it has proven really hard for a game to be both fun and valuable as a learning tool. This in a way has become the central challenge for learning games: be a game that really is *played*, i.e., used voluntarily, and for fun or recreation. While we have not yet evaluated the transfer of learning contents from *Internet Hero* to the real world, our evaluation so far can confirm that building upon learning principles did still result in an appealing game experience. A future study will address the relation of entertainment to measured learning outcomes.

9 Acknowledgments

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