Raising Awareness for Environmental Issues through Mobile Device Based Serious Games

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Abstract. We investigate the design of computer games for mobile phones to raise awareness for environmental issues through targeting the attitude people have towards them. Focusing on people's attitude when investigating their behaviour is an established approach [1] in behavioural psychology. Recent studies claim that the repeated playing of (computer) games can influence the players' behaviour [2]. Computer games have the potential to achieve controlled behavioural change and we investigate a formal basis [3] and identify the requirements [4, 5] for this. We present a prototype for mobile phones.

1 Introduction

This article reports on a resource management game for mobile phones that influences attitudes of children and young adults with respect to environmental issues. The game was conceived and implemented (as a prototype) as a part of a research project aiming at the formal definition and design of serious games for mobile phones to target attitudes and behaviour (cf. [6–9]).

Mobile technologies have started to become an integral part of everyday life. The mobile devices available and extensively used by today's youth is but one indicator for this trend and mobile phones are the most dominant representative of this device type. Today's children are used to carry at least one mobile device with them at all times. In addition to this pervasive nature of the technology such devices are powerful enough to run computationally expensive applications. Most contemporary mobile phones can easily outperform any computer on which the 70's generation played their first games (e.g. Commodore64, Amiga, Atari).

Both, the willingness of the user to carry around mobile devices and play on them, and their increasing computational power allow for rather sophisticated gaming software to be run efficiently on them. This makes them ideal for use as a platform for educational games, or better, serious games.

Games can be used to stimulate complex problem solving, to exercise practical reasoning skills and they have the added benefit of potentially very high
and sustained motivation levels. The main benefits to game-based learning (i.e., which skills are developed and which abilities are promoted), listed briefly below, are identified and elaborated upon extensively in [10]:

- Problem solving skills
- Communication skills
- Analytical skills
- Discovery skills
- Team working skills
- Negotiating skills
- Social and cultural skills
- Logical thinking skills
- Critical thinking skills
- Visualisation skills

Now clearly no game is likely to encompass all of the above to the same extent. A preference over these skills is assumed when designing a game for a specific purpose. The prototype game presented here primarily targets the problem solving skills of the player as well as analytical, logical and critical thinking.

2 Targeting Attitudes of Children

According to [11] stealth learning is “where players learn subliminally or incidentally through rule structures, tasks, and activities within the game”. It is this type of learning the proposed resource management game is aiming to promote. Games are played to experience fun or challenges, not to learn [4]. If learning does take place is either incidental or aimed at becoming a better player.

In the field of psychology the theory of planned behaviour (proposed in 1985 by Ajzen, [1]) provides a model for human behaviour that treats the attitude a person has towards some action as a relevant factor in the decision making process whether to execute this action. Results from behavioural psychology regarding the undesired effect of video games on those that play them (especially with respect to increased automatic aggressiveness through violent computer games [2]) indicate the merit of the model presented below.

As stated in [9], attitude is a hypothetical construct that represents an individual mental predisposition either for or against some concept or idea. We refer to the ‘Theory of Planned Behaviour’ and suggest to target the attitude of students towards some aspect instead of attempting to teach them a desired behaviour directly. There are results that indicate that certain matters which are traditionally difficult to teach (in this case responsible sexual behaviour) were successfully conveyed to students targeting their attitudes towards the subject: “There is a large volume of teaching material on health education which provides factual information. Although facts are important, other factors are also involved in bringing about attitude and behaviour change.”.

According to ToPB and with respect to actions and behaviour, human decision making is guided by three conceptually different considerations and beliefs:

- **Behavioural beliefs**: Ones expectations about the likely outcome of actions, paired with the subjective view on these outcomes.
- **Normative beliefs**: Commonly known as peer pressure, normative beliefs are the opinion of others regarding the outcomes of actions, the personal
intention to adhere to these peer standards as well as the desire of the individual to live up to these expectations of ones peers.

- **Control beliefs**: The confidence towards having control over all relevant factors required to bring about an outcome.

Figure 1 illustrates this model and how the mentioned beliefs and considerations influence ones intentions and subsequently ones behaviour (cf. [9] on how ToPB is applied in games). In accordance with the theory mentioned above we propose to design edutainment games which specifically target the player’s attitude towards some aspect. We suggest to do so by relating the overall performance as well as the actual game play to the citizenship values of the player.

### 3 (Serious) Resource management games

Resource management games are games in which a player is in charge of some coordinated effort in some simulated world. Maybe the most famous example of this genre is SimCity. The overall goal of a RMG is to maximise the outcome of the coordinated effort. In these games the player often has to reach a number of intermediate goals and to do so the player has a limited number of choices to attain these sub-goals while using limited resources. This commonly forces some sort of tradeoff which requires the player to plan ahead for future actions. The 8 principles inherent to most RMGs (as identified in [12]) are:

- Dependence on resources
- Dependence on location
- Dependence on time
- Multiple objectives
- Continuity
- Non-determinism
- Competition
- Need for planning
In [13] we find a detailed account of important aspects of intrinsic motivation in the design of educational computer games. It suggests that intrinsic motivation is created by four individual factors: challenge, fantasy, curiosity and control; as well as three interpersonal factors: cooperation, competition and recognition. Interestingly, these factors also describe what makes a good game, irrespective of its educational qualities. This parallel between what makes a good gaming experience and a good learning experience is also identified by Gee [14] and Tiotuico [15]. We are confident that RMGs can be designed to meet these requirements and are therefore an ideal type of game for our needs because they are: a) challenging due to restricted or limited resources, location and time, the need to plan ahead and the multitude of potentially conflicting objectives; b) stimulating the fantasy by putting the player into an unfamiliar position. Through open games and non-determinism one is also encouraged to use fantasy when conjecturing about unknown elements of the game. Finally, RMGs constantly requiring the player to control issues arising from the continuity of the game and from AI or human competition. Allowing for both cooperation and non-cooperation offers yet another challenge to the player.

Besides aiming to important aspects of intrinsic motivation identified in the previous section the game should aim to include as many as possible of the fundamental principles of good games [14, 16, 17]: By providing a fictional identity a game stimulates the player to embrace a new role and to take on the corresponding responsibilities (Identity). The game generates responses or feedback for the actions of a player (Interaction). By customising a game to the specific interests of a group of players they are directly challenged and interested (Customisation). We enable the players to steer a game through their decisions (Production) and challenge the player by offering not only risk free choices (Risk Taking). Mastery of skills is consolidated through repetition in the game, with sufficient challenge and different variations (Challenge & Consolidation). Furthermore, good computer games have realistically attainable goals that are at the outer edge of the players abilities [18] (Pleasantly frustrating) and encourage the players to think about the effect of their decisions on the game world as a whole (the player becomes concerned with abstract relationships, not just isolated events and facts) (System thinking). Well structured problems encourages the player to abstract and draw on previous experience when solving problems (Well-Order-Problems). Finally, the game gives the players a sense of ownership over their decisions (Agency).

Above we have suggested that by targeting the attitude of a player instead of setting predefined behaviours we can in the long run effect the players behaviour and mentioned the eight principles of resource management games as identified by [12]. We suggest to add another principle: a list of good citizenship values to which the player will have to adhere in order to maximize the available options in the game. The fact that we will not directly advertise these values nor the fact that they exists in the first place is an important aspect of the design. The player has to deduce the right behavioural stance by playing the game and is...
required to infer the relations from that. The other 8 challenges keep the player both interested and distracted from the real learning targets.

The formal language used is propositional logic. There are many textbooks covering classical propositional logic and the reader is referred to [3] or her favorite logic book for further reference. The proposed approach and results have been presented and published in [8, 3] (Image 2 in Figure 2 shows a list of learning targets offered to the moderator). Now we can design a game around the learning targets by making the availability of certain branches in the game tree dependant on the extent to which these targets are met. Algorithms to evaluate which targets are met are standard and can be efficiently implemented. In addition, algorithms to automatically create new learning targets from a set of existing one as well as to verify the consistency of the increased set of targets have been implemented and tested. The latter have been investigated and implemented to assist the teacher or moderator in the task to individually customise the game to suit the needs and expectations of individual players.

In addition to having the game adapt learning targets on the behaviour of one player, the behaviour of other people playing the game can also be taking into consideration on a number of levels. On the one side, the trainer can aggregate information of how players perform in relation to given learning targets, and adapt accordingly. On the other hand, players can exchange information and experience they made while playing the game. The underlying technology can be provided by applying the agent paradigm [19] to the game, adapting it to exchange relevant data points between players.

4 Example: Utility Tycoon

The game is a typical resource management game in which the player is starting with a restricted amount of money and is given a number of options to start a company, situated in the utility sector. All relevant information is made available to the player with the exception of the learning targets. The game can include interaction with the game AI by e.g. engaging in politics in the game.

In Utility Tycoon (cf. [6]) the player assumes the role of the CEO of a company that produces and sells utilities in a fictional country. The player is competing for market shares in different cities, the products sold are water, electricity and gas. Fig. 3 shows some game screens: the player can withdraw cash from the bank, purchasing land and commissioning buildings for construction.

The educational aim of the game is to change the player’s attitude towards so-called green energy. Underlying the game are formally stated learning targets (cf. [3]). The state of the game is evaluated automatically (cf. [8]) by an evaluation module, the result of the evaluation is used by the game engine to reward the building of solar and water power plants instead of the seemingly more attractive nuclear power plants. This is not immediately obvious to the player for two reasons: The negative effect of building a nuclear power plant is annulled if expensive security measures are in place and the rewarding bonus events do not occur right away: bonus events (see Figure 3) are unlocked only
after meeting a number of targets, making it hard for a player to deduce the causal relations between individual actions and observable changes in the game. One crucial concept is that there is quite a number of learning targets and the player’s actions often affect on more than just one. Through this approach the game can monitor gradual change towards some favoured behaviour or stance and reward the player by offering additional options in the game.

The moderating tools (see Figure 2) are an important feature of the game as they allow the adoption of the learning targets as well as the thresholds for the bonus events during gameplay and for students individually. The teacher is assisted by a module that can automatically generate new learning targets from existing ones and offers them to the teacher for selection. Using the number of current targets met the moderator can easily gain insight into the players approach with respect to the intended learning outcomes. Because of the restricted screen size of the average mobile phones all interfaces are kept simple and their functionality is straightforward. Due to the game’s designed no prior experience with programming is required of the teacher, a strong requirement for games in to be accepted by professionals in the education sector.

The bonus elements in the game and the alternative branches of the game tree are important for our approach; the idea is to make them dependant on the players’ attitude thus providing the incentive for the player to adhere to the learning targets. By making the course of the game itself depend on the attitudes of the player, the feedback is more direct and intense and the player is given many ways to implicitly learn the learning targets. In addition, by withholding the actual attitude score the player has to adopt the overall behavioural stance and can not just meet the learning targets to win the game. By overall we mean the stance described by the set of learning targets in contrast to individual learning
targets. An algorithm to check the consistency of targets is implemented to ensure that as a whole they describe some more general behavioural paradigm.

Resource management game are all about trade offs due to limited resources. Our approach forces the player to make another decision, namely whether to maximise the entertainment value of the game or the game winning actions.

**Implementation and results**

The prototype was implemented using the Eclipse SDK (Version: 3.3.1) and the Java Wireless Toolkit (JWT) 2.5.2 for CLDC with the device configurations set to Connected Limited Device Configuration (CLDC) 1.1 and Mobile Information Device Profile (MIDP) 2.0. In what follows we refer to the length of a target as the number of atomic statements in it. All targets were exclusively constructed as conjunctions using only the AND operator, and such that no atomic statement occurred more than once. This is to ensure that evaluation and satisfiability methods are tested for the worst case scenario. The performance of the prototype was tested in the JWT environment using the above settings. For the evaluation of a targets (complexity increases linear to the length of the targets) we tested for 50 targets of length 10 and 20 and calculated the average over 50 tests, each comprised of 100 runs. The simulated phone averaged 0.019ms (length 10) and 0.025ms (length 20). When testing the targets for satisfiability we used the same
targets but averaged over 50 test comprised of 10 runs each. The prototype was able to check satisfiability for all targets in 439.05ms (length 10) and 431.18ms (length 20). These results are somewhat unexpected as they do not match the relation between the targets of size 10 and 20. This is due to rounding errors, i.e. the fact that the execution was often too fast to register at all. We report these results as they show that even for unrealistic length of learning targets and large size of the set of targets checking for satisfiability will take less than half a second and is thus within acceptable parameters.

5 Conclusion

We reported on a resource management game for mobile phones that aims to influence the attitudes of children and young adults with respect to environmental issues. We confirmed that computer games are increasingly used in the education sector and that there is evidence to support the claim that their use is showing good results. There are parallels between the aspects of a game that make it a successful for gaming and for learning which suggests to focus on games that share as many of the aspects (supporting learning) as possible. Resource management games seem to be very well suited for this task, and the game we suggested is of that type. The presented game aims to influence the attitude people have towards these issues. We argue that focusing on peoples attitude when investigating their behaviour is an established approach [1] in behavioural psychology. Recent studies claim that the repeated playing of (computer) games can indeed influence the players behaviour [2]. This indicates that computer games have the potential to achieve controlled behavioural change and suggests that the investigation of a formal basis [3] as well as the identification of the requirements [4, 5] to do so. We present a prototype running on a mobile phone specifically designed to meet the identified requirements. We have outlined our implementation and presented computational results to support our claims regarding the feasibility of our approach.

References


