Mindergie: A pervasive learning game for pro-environmental behaviour at the workplace

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Mindergie: A pervasive learning game for pro-environmental behaviour at the workplace

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Abstract. This chapter reports about a pervasive learning game to increase the environmental awareness and pro-environmental behaviour at the workplace. Based on a discussion of the theoretical background and related work we introduce the game design and game elements. Results of a formative evaluation study are presented and discussed. Results show that incentive mechanisms are less important than challenging game components that involve employees in proposing solutions for energy conservation at the workplace. Conclusions are drawn for future games and energy conservation activities at the workplace.

Keywords: energy conservation, pro-environmental behaviour, pervasive games, serious games, rewards, open badges

1. Introduction

Several studies have shown the effect of human energy consumption on pollution and climate change (IPCC 2007; United Nations Environment Programme 2012). While in the home context monetary incentives are one of the main motivational aids to save energy, these incentives are not present at the workplace. In a recent study we have conducted we have found that only 25% of employees in an academic organisation are concerned about the financial consequences of their individual consumption for the organization (Börner, Kalz, & Specht, 2012). Therefore, other initiatives are needed to increase pro-environmental awareness and behaviour change at the workplace.

In general, there are only a few studies that have focused on energy conservation at the workplace. A study by Siero, Bakker, Dekker & Van den Burg (1996) showed that the offering of information and learning opportunities about pro-environmental behaviour has the potential to change the attitude and behaviour of employees. A recent study by Lo, Peters, and Kok (2012) revealed that the main differences between the home and work context are that the costs of energy consumption are not monitored nor paid by the employee and that the organisation's structure, size, goals etc. has an influence on individual behaviour. Furthermore the authors stressed the importance to understand the psychosocial determinants of pro-environmental behaviour at the workplace, which differs from the domestic context. Earlier Kollmuss and Agyeman (2002) presented a model of pro-environmental behaviour based on a synthesis of literature that integrates internal factors such as personality traits or environmental consciousness and external factors such as infrastructure or political context. Additionally they investigated and incorporated possible barriers to pro-environmental behaviour. These barriers are attributed to be responsible for the gap between attitude and action, also referred to as engagement gap. Among others the identified barriers were lack of

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environmental consciousness and knowledge, negative or insufficient feedback about behaviour, as well as missing internal and external incentives.

The lack of environmental consciousness, incentives and the lack of feedback was the main motivation behind our study. Our secondary goal was to contribute research that helps to decrease the research gap formulated by Foster, Lawson, Wardman, Blythe and Linehan (2012). The authors identified a "research knowledge gap present in understanding the end-users of energy in the workplace and, therefore, the design of appropriate and achievable workplace energy interventions, particularly those that encompass novel ways of encouraging people to adopt positive energy usage behaviour whilst at work." In this chapter we report about a novel workplace energy intervention in form of a serious learning game called "Mindergie" implemented in a Dutch academic institution.

The chapter is organized as follows. In the next section we discuss related work, especially related game designs focusing on environmental education. Then we present the context and methodology of our research. The game design and game components are introduced. Results of the formative evaluation study are presented and discussed. Last but not least conclusions and implications for future work is drawn.

2. Related work

Games and gamification are emerging topics that gain interest within higher education (Johnson et al., 2013). Games are used successfully as independent tools for training and learning in suitable application domains. Gamification describes the process to apply game elements and game design techniques in non-game contexts (Werbach & Hunter, 2012). While playing games in general is highly motivational, gamification proves to be especially effective to close or overcome engagement gaps.

There is a large amount of games available for environmental education. Reckien and Eisenack (2013) have conducted a review about 52 board- and screen-games about the topic of climate change. Most of the reviewed games are role-play and management-games that combine a global and local level of information. One of these recently developed games is presented by Fennewald and Kievit-Kylar (2013). In their common pool resource game they focus on increasing awareness of climate change and use of resources as a social dilemma. Eisenack (2013) reports about a board game for climate change education that enables players to see the climate change problem from different perspectives and triggers self-reflection and generalization. Lee, Ceyhan and Jordan-Cooley (2013) have developed with GREENIFY an action-based game for environmental education that allows knowledge acquisition in authentic local and social contexts through a desktop-based solution.

Our motivation was to design a game in which learners can collect experiences and reflect in an authentic environment, but our goal was to not focus on the desktop as game framing but to take the office/campus environment as a whole as the gaming and learning environment. A similar approach has been implemented by Bång, Svahn & Gustafsson (2009) in form of a pervasive game

for the household context. Montola (2005) defines pervasive games as games that have "one or more salient features that expand the contractual magic circle of play socially, spatially or temporally". With Mindergie we have developed a pervasive game that is played in the authentic context of the work environment of employees with the focus to evaluate the potential of different game-design components on environmental knowledge, consciousness and last but not least energy consumption behaviour of employees.

3. Method and context

Our research is based on the design-based research methodology (Cobb, Confrey, diSessa, Lehrer, & Schauble, 2003). Design-based research addresses complex problems in authentic environments, integrates design principles with technological affordances, and conducts reflective inquiry with the target to refine learning environments and to identify new and emerging design principles. In contrast to predictive research that has the goal to specific and confirm or reject of new hypotheses design-based research is targeting in the constant refinement of problems, solutions, methods and design principles (Reeves, 2006). According to the design-based research collective (2003) the goals of developing theories and designing learning environments are intertwined and these activities constantly inform each other. Another goal of design-based research interventions is to communicate relevant implications to practitioners and other educational designers. In this sense, we see our contribution as an input to other practitioners, institutions and educational designers who want to increase the environmental consciousness and foster conservation at the workplace. This project is embedded into a series of interventions that have been conducted to increase environmental awareness of employees. In earlier studies we have focused on using ambient displays for the increase of awareness about energy consumption at the workplace (Börner, Storm, Kalz, & Specht, 2012a; Börner, Kalz & Specht, 2013) and the use of a sensor network to measure energy consumption on a personal level to provide feedback (Börner, Storm, Kalz, & Specht, 2012b). A full overview about the connection between these interventions is given in a related publication (Börner, Kalz, Ternier, & Specht, 2013). In this study we had the goal to go beyond increasing awareness and providing personalised information and we focused instead on the potential of a pervasive game to increase knowledge, pro-environmental consciousness and last but not least change consumption behaviour.

The context of the research stems from a long-term national agreement on energy efficiency that public institutions have with governmental agencies. In this agreement the Open University of the Netherlands agreed on reducing the energy consumption by 2% each year until 2020 and to raise awareness on this topic among employees. While the awareness-raising was limited mostly to some stickers and posters we saw an opportunity to use mobile, pervasive and ambient technology to reach this goal.

Our research questions for the study have been the following.

- Which aspects of a pervasive game have the most potential for improving energy consumption behaviour at the workplace?

- Which aspects of a pervasive game have the most potential for improving environmental consciousness?
- Do rewards in the form of digital badges and prizes have a positive impact on consumption behaviour and environmental consciousness?

To answer these questions we have integrated and extended different technologies for the study. Participants have been recruited via an intranet news item of the organization. The game was played from November until December 2012 for four consecutive weeks. The only requirement for participation was to have an Android smartphone or tablet available as well as to own a Google account. A limited amount of Android devices was available to borrow.

After registration the participants were invited to participate for the next 4 weeks in the weekly game rounds. The first week started with an introduction to the game and the technologies used to play it. Participation was voluntarily, weekly prices were rewarded in the form of vouchers.

After the Mindergie game a questionnaire has been sent to participants via e-mail. This questionnaire consisted of 21 items which were a combination of multiple choice-items, items with a 7-point Likert scale ranging from 1 (not at all) 7 (completely) or open questions. The questionnaire focused on motivation of participants, overall satisfaction with the game, the potential of game components for changing the environmental awareness and behaviour change and the granularity and amount of information presented during the game.

4. Technologies

The design of the pervasive game has been done with the ARLearn-platform (Ternier, Klemke, Kalz, van Ulzen, & Specht, 2012). ARLearn is a platform for mobile learning games. The platform consists of an authoring interface that enables game-designers to bind a number of content items and task structures to locations and to use game-logic and dependencies to initiate further tasks and activities. The platform has been recently used for several similar pilot studies in the cultural heritage domain, the training of UNHCR employees for hostage-taking incidents in international organizations (Gonsalves, Ternier, De Vries, & Specht, 2012) and resuscitation training for first responders (Kalz et al., 2013; Schmitz, Ternier, Klemke, Specht, & Kalz, 2013). The following motivation guided the decision to use the ARLearn platform to realise the game-based learning intervention:

- The ARLearn platform is multi-user enabled
- The ARLearn platform is location-aware, which allows for realistic game-play settings
- Commonly used smartphones can be used to play ARLearn games, which simplifies game distribution.
- The event-based game model of ARLearn allows to design realistic game processes, which simulate mission critical real-life situations and conditions

- The game-design should be re-usable so that the game can be easily adapted to other locations and contexts

Media items (including multiple-choice questions, video objects, and narrative items) are a central concept in ARLearn. They can be positioned on a map or made available depending on the game logic. A video can thus be bound to a coordinate, it can appear at a certain moment as a message in the player's inbox, or appear or disappear based on actions taken in the game. Within a game, an author defines items, dependencies between items, game score rules and progress rules. A run defines users grouped in teams. While playing, users generate actions (e.g., "read message", "answered question", "scan QR code") and responses. This output is also managed within the realm of a run. Specialisations of Media items allow to ask questions (MultipleChoice) or to include multimedia (Audio- and VideoObjects). Actions can lead (through dependencies) to new available items, increased scores or increased game progress. Items have a simple life-cycle with three states: Initially, an item can be visible or invisible (initial state). Invisible items can become visible (active state). When the item is no longer needed, it can become invisible again (used state). Items can define dependsOn and disappearsOn conditions for the state transitions. A simple dependency mechanism is put in place to support these conditions:

- Action-based dependencies are triggered by specified actions.
- Time based dependencies bind time offsets to other dependencies.
- Boolean dependencies allow combining other dependencies logically.

Besides ARLearn we have used a signage solution to display content on existing displays on the campus and recruit participants for the game (see Figure 1).
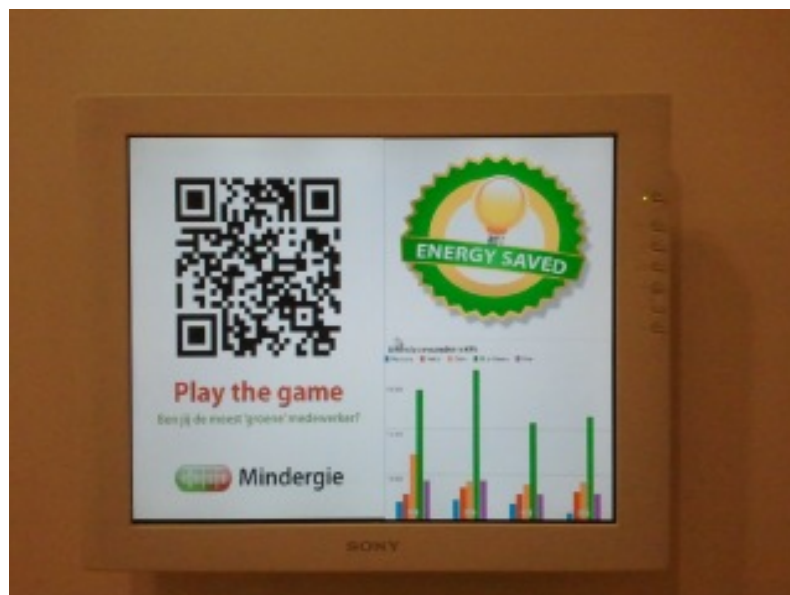

Fig. 1. Signage system in use for content distribution

For the incentive component we have integrated and used the Mozilla Open Badge Infrastructure. The Mozilla Open Badge infrastructure (OBI) has been developed to recognize learning activities in a non-formal context. Several institutions in the US like the NASA, the Walt Disney Company or Intel have

piloted badges as a new approach for rewarding learning and competence development of employees.

A central element for an earner of badges is the "backpack" in which badges are stored. A backpack is solely controlled by its user and after earning a badge the user can decide whether to accept or deny a badge and to make it public or not. So the infrastructure allows users to earn, collect, and share badges. The infrastructure consists of a management interface (i.e. user's badge backpack) as well as a specification to issue and display badges. The badges are then published automatically or uploaded manually to the user's badge backpack where they can be managed and made available to show on other websites via the Displayer API. From the backpack of the badge earner these can be easily shared to social networks like Twitter, Facebook or Google+.

Badges have a long history as incentive and social mechanism for sharing the social status or activities of individuals or groups (Halavais, 2012). A recent study by Abramovich, Schunn & Higashi (2013) has concluded that the benefit of using badges in education depends on the badge type, motivational background and usage context. As an alternative incentive we have used weekly prices to combine digital and non-digital incentives.
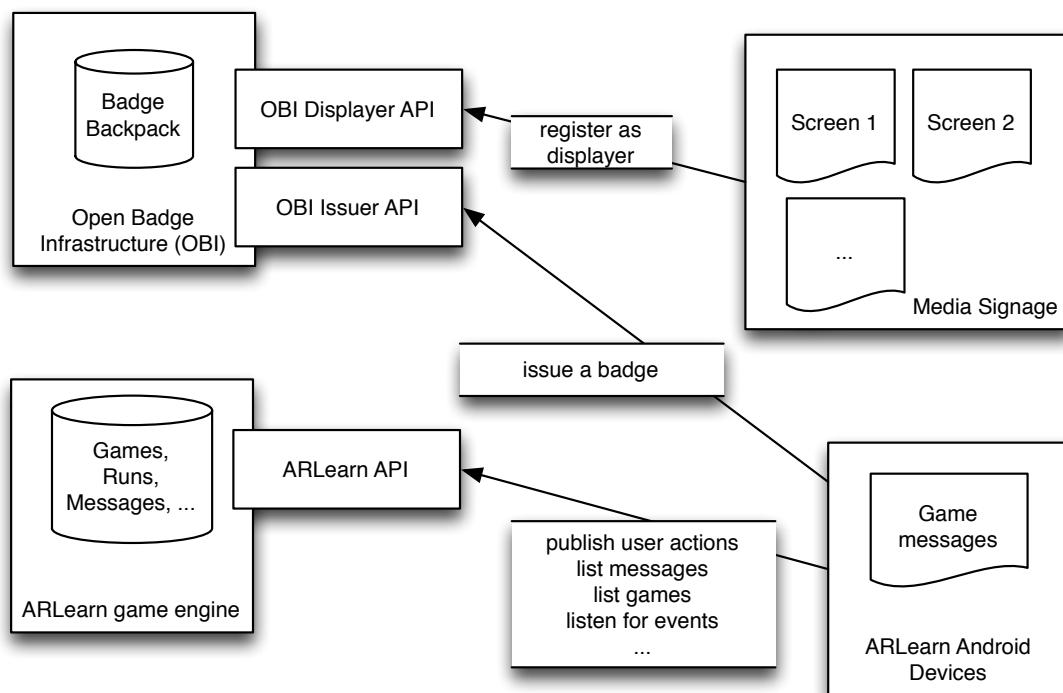

Fig. 2. Architecture for the Mindergie game

The full architecture for the Mindergie game is depicted in Figure 2. At the left side, two cloud-based components are presented:

- The Open Badge Infrastructure manages badges. This infrastructure enables integration with third party systems through an API to submit badges and an API to display badges.

- The ARLearn game engine manages the game. Client devices, such as the ARLearn Android App communicate with the game engine via a web services API.

At the left side of this diagram, components are displayed that consume these services.

- The ARLearn Android app synchronizes game progress with the game engine. A "Mozilla Open Badge" is a special kind of ARLearn message. As this message is made visible, the user can decide to collect the badge. The app awards the badge by making a call to the OBI issuer API that adds the badge to a user's backpack.
- The media signage component registers with the OBI displayer API to display badges that were awarded to Mindergie users.

With this infrastructure we have designed the Mindergie game. The game-design and the formative evaluation study are introduced next.

5. Game Structure and Gameplay

5.1. Game components

Table 1 shows the game components that have been implemented to address problems identified in earlier research.

Environmental Consciousness	Lack of incentives	Lack of feedback
– Information/Knowledge components – Energy statistics	– Digital Badges – Rewards	– Knowledge Tests – Challenges

Table 1: Identified problem areas and game elements

The game design was constructed from the following game elements: information, action, challenge, activity, quiz, and badge.

The *information element (knowledge component)* provided the users with all the important knowledge, e.g. about the game, energy consumption details, conservation possibilities, saving potentials etc. The knowledge components are organized according to the topic of the week and participants are expected to know mean energy consumption for households and individuals and activities that have the biggest saving potential. As a variation of the knowledge element in a text format videos provided the users with simple tips on how to conserve energy. Thereby we made use of available topic-related material. As alternative to the information elements dedicated energy statistics have been provided to the players. An example is shown in Figure 3.
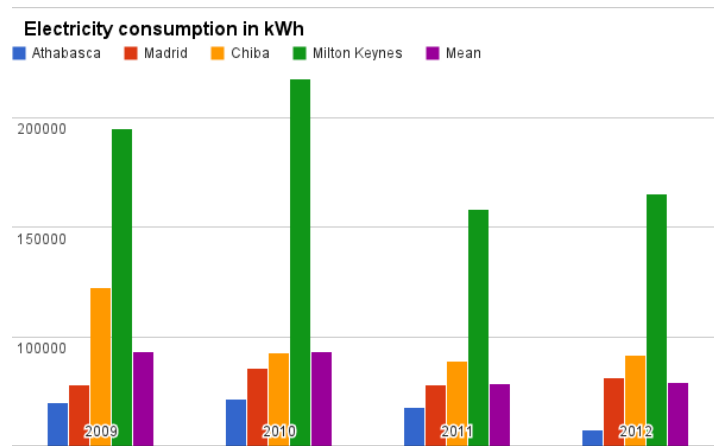
Fig. 3. Mindergie statistics element example

These statistics have been manually collected from the energy control system of the organisation and have then been transferred to simple comparison figures. Examples of the statistics element include electricity consumption (as shown above), the comparison between workday consumption and weekend consumption per building and heating patterns. Mostly these statistic items have been combined with open questions in which the player had to record an audio or video interpretation of the statistic shown.

Action elements were used to get users active and let them do something, e.g. find something out, save some energy, or propose a solution etc. While the activity element was focusing on the collection and registration of concrete energy-saving activities of the participants, the action element triggered activities on the campus. To perform actions they had to leave their workplace and reach different places on the campus, e.g. the game flags we deployed in the centre of the campus. Most of the time actions combined information clues and assignments at the same time. A sample action looked like this: "Athabasca is a rather small building on our campus, which consumed in total 1154 kWh electricity last week and 200 kWh on average per working day. With 256 kWh the highest electricity consumption in Athabasca was on Thursday. Last weekend Athabasca consumed 152 kWh without anyone in the office. Now look for the small QR code attached to the 'Chiba' flag pole and scan it."

Challenges invited the users to elaborate and reflect, e.g. by sharing their opinion and personal experience etc. These items were about the users, their ideas, opinions, and experience about them and their workplace using different kind of media. A sample challenge looked like this: "Visit the website and enter the data about your ecological footprint. Record a video in which you reflect about your ecological foot print and propose future activities to make this footprint smaller".

The *activity elements* were used to register the conservation activities of participants. The idea was to get an impression of their habits, so they were asked to be honest and only register activities they had really done. Following that codex they were allowed to register as many activities as they liked from a list that was adapted weekly to the theme of the week, e.g.

- switch off appliances instead of leaving them on stand-by

- disconnect power supply units when not in use
- use multiple socket power strips that can be turned off
- switch off lighting when leaving a room
- use appliance built-in energy saving options

For the *incentive component* we have combined digital badges with weekly prizes. In the preparation phase of the game a set of badges for each week has been designed. Examples of these digital badges for the Mindergie game are shown in Figure 4.

Fig. 4. Mindergie badges

A set of badges has been designed for the project. In total four types of badges were used, one for the general gameplay and one for each category. The different types of badges are distinguished by form and colour. Each badge is characterized by a unique symbol illustrating its meaning. Furthermore each badge can have three different states or levels reaching from bronze over silver to gold. As alternative reward to the digital badges we have provided weekly small prizes to participants of the game:

- 1x book voucher for the employee who collected the most information
- 1x activity voucher for the most active employee who performed all the actions
- 1x electronic media voucher for the employee who mastered all the challenges

If there was more than one employee qualified for the prize then the winner was chosen at random. Furthermore there was an overall prize for the best player (aka. the greenest employee), announced and awarded after the game.

The *quiz element* was mainly used to assess the knowledge acquired during the game, e.g. by reading all available information or watching the information videos. Usually this element became available only after accessing all necessary elements. The outcome was taken as basis to issue badges. Finally when users demonstrated a skill or achievement they were usually rewarded with a badge. The respective element then became available and could be used to store the earned badge in the personal backpack.

5.2. Game design

The Mindergie game has been designed in 4 individual sub-games that had all different goals. While the first week was introducing the game and the topic, the second week focused on the topic of "electricity", the third week on "heating" and the last week on the "individual energy footprint" of employees. We followed in the game design general instructional design principles to first build a shared knowledge base and activate prior knowledge of participants via knowledge/information components. Based on this shared knowledge base we provided the participants with contextualized information and real problems of the campus environment for which solutions could be proposed by participants. This should have made the game on the one hand relevant for their direct context and on the other hand authentic and personal.

The game description for the first week's "Introduction" run is illustrated in Figure 5. The game starts with a welcome message that briefly explains the game and the goals and tasks of the week. Arrows indicate dependencies between the single items. So when the welcome message has been read the gameplay message appears in the list etc. There are three different item categories in the game, namely information, action, and challenge. Within these categories the simple text items are represented by the document symbol. Octagons represent single or multiple choice question items, while pentagons pointing downward represent open answer items. Scanning a QR-code, recording an audio statement, taking a picture, or capturing a video can answer the open answer items. Finally each circle symbol represents a badge that can be achieved throughout the game.
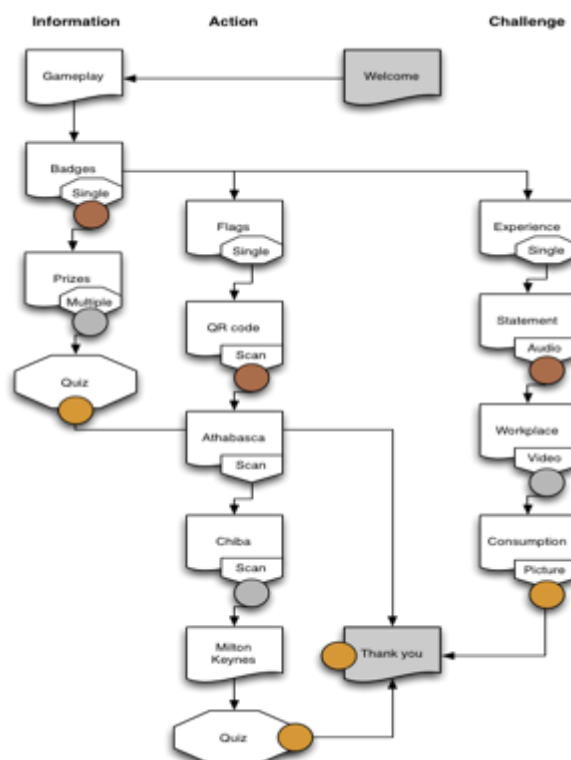
Fig. 5. Mindergie week 1: Introduction

The game logic for the other weeks was mainly enhanced by combining all game items and focus on one of the three topics. The game description for the second week on "electricity consumption" is illustrated in Figure 6. A set of information items and videos about effects of electricity consumption and saving options has been combined with challenges and actions. The completion of tracks in the game included a Quiz item and the delivery of badges. This design has been repeated from week 2 – week 4 with different topics.
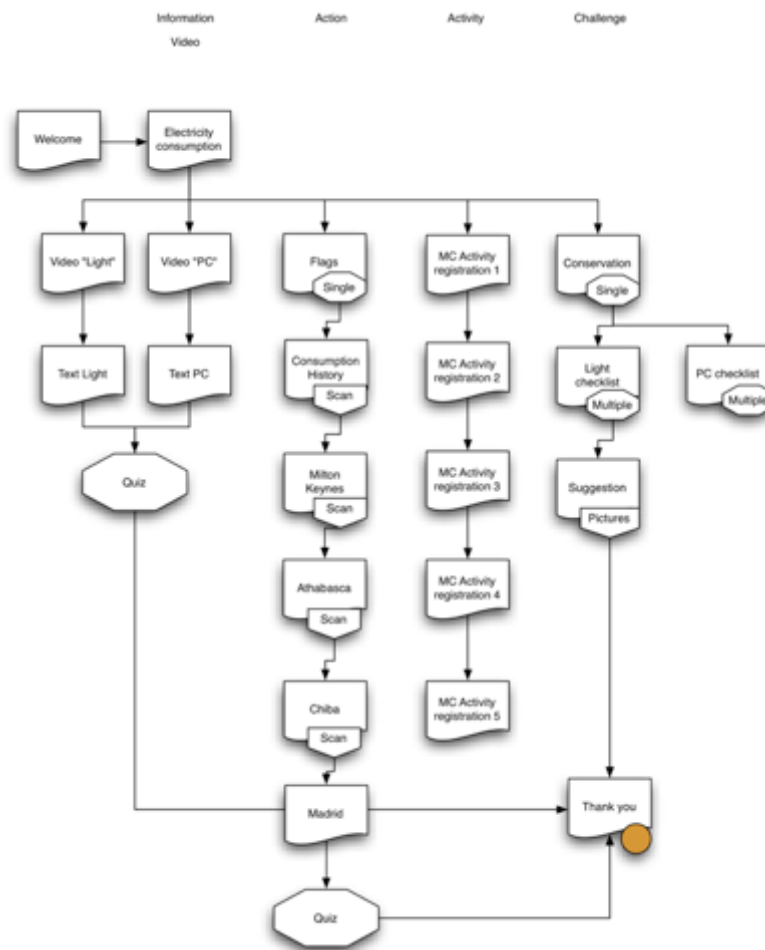
Fig. 6. Mindergie week 2: Electricity consumption

The game components have been integrated in 4 different game-runs of the ARLearn platform. Each week players received a message via mail that a new game is available to them.

5.3. Gameplay

Each week started with an introduction into the topic of the week. After opening the ARLearn app and the Mindergie game participants received this introduction message via a notification on their phones. After accessing the welcome item,

several knowledge/information items have been made available. These knowledge items all depended on each other so that players have followed here a structured approach to build a shared knowledge base about the specific topic of the week. Challenge items asked participants to scan a barcode at a specific location on the campus. This scan triggered again further information items like overview statistics with a reflection task or presented players with a concrete task. In the meantime, players could register energy saving activities whenever they wanted. At the end of the week a quiz was made accessible depending on completion of items during the week. Depending on full completion of activities a badge has been issued. In addition, we have assessed the input by participants via a portfolio page for each game and have decided which player would win one of the weekly prices.
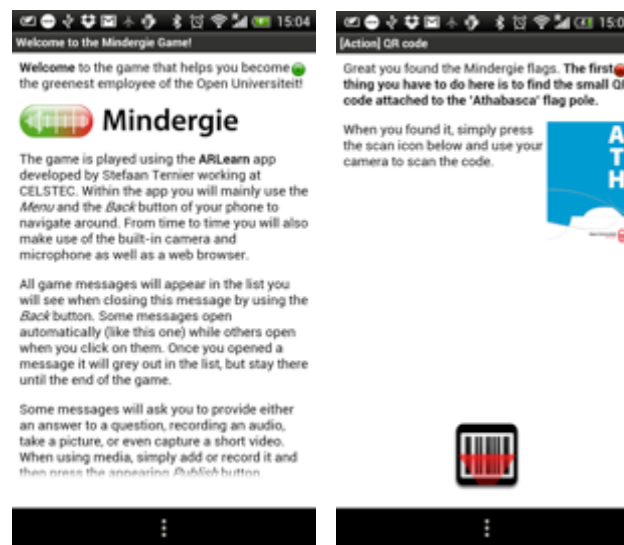

Fig. 7. ARLearn mobile client

Using the ARLearn mobile client (see Figure 7) media items - the main ARLearn elements - appear as messages. Some messages open automatically while others open when users click on them. Messages can comprise different media, e.g. text, audio, or video. Some messages also ask users to provide either an answer to a question, recording an audio, take a picture, or even capture a short video.

ARLearn uses a simple rule-based approach that allows defining actions, time, or location-dependencies for all available items. With dependencies it is possible to implement game structures. This means e.g. that when a game starts, only the first item is visible to a user. Next after the first item has been read, the second item becomes visible etc. Secondly, dependencies enable giving users feedback based on answers that were given. For instance, if a multiple-choice question defines three answers, dependencies allow selecting which item should appear when a user provided a specific answer.

Each item type was noted [in brackets] in front of its title. From time to time users were asked to answer questions, either as part of an item or in the course of quizzes. Usually when answering questions, read information, perform actions, or master challenges new items appeared. Users did not have to do everything at once. They could return at any moment and proceed with the game.

During the game users could earn badges that demonstrate a skill, achievement, or quality. If users successfully answered questions, read information, performed actions, or mastered challenges they received a badge for that. As described we made use of Mozilla's Open Badge Infrastructure for the issuing of badges. The Mozilla infrastructure does not allow systems to issue badges without a user's consent. So whenever users received a badge a browser window opened, they had to sign in with their Mozilla Persona id, and then accept the badge. When they did that, the badge was stored in their badge backpack, which also allowed social sharing (see Figure 8).

Fig. 8. Earned badge shared via Twitter

Since we followed an action-oriented approach it was important to not stress the "knowledge transfer" items too much but to also include participants in improving the local work environment in terms of energy conservation.

For this purpose we have integrated a special kind of action element in which the task was to make suggestions for a specific energy conservation problem at the campus and document this via a media item (photo or video). Figure 9 shows an action item in which players had the task to identify rooms in which the installation of a movement sensor for switching the lights on and off would make sense.

Fig. 9. Action item suggestions

During the game we had installed an email helpdesk to support players in overcoming difficulties during the game.

6. Data analysis & Results

From the 15 participants at the end of the game 12 participants completed the questionnaire and thus provided qualitative feedback on the game. Table 2 presents a overview about questions asked and data collected.

Table 2: Questions and question types

Question	Type
Are you concerned about the amount of energy you are using at your workplace?	Likert scale
What is likely to make you most concerned about the amount of energy you are using at your workplace?	Multiple Choice
Are you concerned with what you can do personally to reduce the energy consumption at the OU?	Likert scale
Are you doing any of the following activities to reduce your energy consumption at your workplace?	Multiple Choice
Why are you not doing more to reduce your energy consumption at your workplace?	Multiple Choice
Are you planning to take more individual actions to reduce your energy consumption at your workplace?	Multiple Choice
To which degree can you estimate how much energy (electricity) you use individually at your workplace?	Likert scale
To which degree can you estimate how much energy (gas) you use individually at your workplace?	Likert scale
Did you actively participate in the game?	Likert scale
Was the gamification appealing to you	Likert scale
Which game round(s) did you like most?	Multiple Choice
Which game element(s) did you like most?	Multiple Choice
Did the game change your energy consumption behaviour?	Likert scale
Which game elements had the most potential to change your energy consumption behaviour?	Multiple Choice
Did the game enhance your environmental consciousness?	Likert scale
Which game elements had the most potential to enhance your environmental consciousness?	Multiple Choice
Was the information presented useful and relevant for you?	Likert scale
Were you satisfied with the amount of information presented?	Likert scale
Were you satisfied with the granularity of the information presented?	Likert scale
How satisfied were you with the game?	Likert scale
Please provide some feedback about the game?	Open question

As expected the results show that participants are highly concerned about the amount of energy they are using at the workplace (M = 5.42), especially regarding the environmental costs, such as higher environmental pollution. They are also highly concerned with what they can do personally to reduce their energy consumption at the workplace (M = 5.75) and performed the suggested energy saving tips. When asked why they are not doing more to reduce their energy consumption at their workplace the participants asked for more information and detailed feedback on their personal consumption. The majority of participants is highly motivated to take more actions to further reduce their energy consumption at the workplace (M = 5.08).

Overall, participants were satisfied with the game (M = 4.25). The amount of information has been evaluated positively (M = 4.67). The granularity of the information presented during the game shows even a higher satisfaction level. (M = 4.83). The gamification of the Mindergie game has also been evaluated positively (M = 4.92). The comparison of the different game rounds has revealed that the second round has been evaluated as the best designed one. For the later rounds participants criticized the similarity of structure.

When asked to evaluate the game the participants stated that the gamification was appealing (M = 4.92). Overall the participants liked "active" game elements, such as action, challenge, and activity most. The "informational" elements, such as information and video were less popular, while badges ranged in between the two. Regarding the expected behaviour change, participants stated that the game in general changed their energy consumption behaviour (M = 4.25), while the information and the activity elements were assigned with the highest potential to do so.

Regarding the environmental consciousness, participants stated that the game enhanced their environmental consciousness (M = 4.67). In this regard the information and video elements were assigned with the highest potential to do so. Participants stated that the "active" game elements had a slighter higher potential to change energy consumption behaviour compared to the "informational" elements and vice versa for enhancing the environmental consciousness. The badge and prizes elements were in general assigned with the lowest potential, while the potential to change the consumption behaviour was higher compared to the potential to enhance environmental consciousness. All results depicting the potentials are compiled in Table 3.

Game Element	Energy Consumption Behaviour (Mean)	Environmental Consciousness (Mean)
Information	5.50	5.67
Video	4.42	4.83
Action	4.33	4.08
Challenge	4.33	4.17
Activity	4.58	4.42
Badge	3.92	3.42
Prizes	3.17	2.83

Table 3: Game element potentials

In addition to the rating of items on a Likert-scale participants have been asked to provide qualitative feedback about the game, the game components and the technology. Here is a selection of these open comments.

- + it was fun + I learned a lot + easy accessible + good use of a mobile device, like the code scanning, making pictures and videos […]
- I really enjoyed the game, nice way of becoming aware of energy consumption […]
- Fun and exiting way to learn more about reducing your ecological footprint
- Game was overall quite fun […] In any case, the main thing is that it was fun and well structured and organized. Without the prizes it would have been as fun as with for me.

In conjunction with some negative points, participants also came up with ideas and suggestions on how to improve the game.

- […] more players on the campus would be nice, probably also team play would be cool
- […] would be even better to be more intrusive about the energy consumption, more live analytics. It would be really nice to get feedback about typical activities like energy costs for making one printout, make a copy, take a coffee etc. so live tracking of energy consumption to compare the single activities and devices. That could

- make a real change as I would try to reduce the top ten energy consumption devices / actions in the office.
- The game was not what I expected it to be. I expected to do more with the app, more a game like app […]
- Found it hard to combine game activities in my daily work […]
- […] After three weeks the structure became repetitive. Also, I expected some more innovation (e.g. In the way the QR codes were used or something) […]

These comments show that the type of game has been appreciated by most participants. Since there was no extra time available for the game some participants reported that they could not continuously participate in activities of the game. This is of course a challenge for gamification, especially when this is applied in a business or work context. Thus an energy conservation game that is played in the work context must be designed in a way that the individual game activities can be played and continued at any time to allow participants also to use small time slots for gaming activities.

7. Discussion & Conclusions

Results of the study show that a pervasive game is a promising approach to involve employees actively in the energy conservation of an organisation. Interestingly, reward mechanisms in form of badges and prizes had the lowest impact on the behaviour and environmental consciousness of participants. Although missing reward mechanisms have been formulated in the literature as one of the barriers for energy conservation at the workplace, the reward mechanisms used did not sufficiently address this problem.

This might have to do with the fact that digital badges are primarily designed for cross-organisation recognition of prior learning and participants of a higher education institution might not see a need for badges that refer to pro-environmental behaviour rather than expertise for a specific topic. In this sense it is also questionable if our usage of badges has produced competition of participants. Abramovich, Schunn & Higashi (2013) report that the effect of digital badges in an educational context depend on the prior knowledge and type of badges used. While we have primarily used participation badges it might have been useful to combine these with skill badges. Another issue of rewards has been described by Kohn as the "risk of rewards" (Kohn, 1994). According to the author behaviour modification programs are problematic since mostly the rewarded behaviour stops when the reward is taken away. Therefore he recommends the investment in what he calls "good values" rather than rewards.

All game elements that have contributed to knowledge building or that have involved participants in problem solving or the development of own ideas (activity, action, challenge) have more influence on pro-environmental consciousness and pro-environmental behaviour according to participants. In future scenarios and designs we should therefor invest more into the exploration of these game components.

The qualitative feedback has further enriched the results with proposals by participants how to improve the involvement of participants and the scaling of the intervention. While the activating game components have been appreciated by the participants they also called for a change in the game design and no repetition of game logic and activities. It has been suggested that teamplay could address this problem. Another suggestion was more personalised feedback about individual energy consumption. We had planned this in one of the first designs, but we did not realize this due to a lack of sensoring devices.

To provide employees with personalised energy consumption feedback as requested in the results a pervasive sensor network would be needed to be able to implement ongoing feedback loops (Goetz, 2011) in which the gap between activities of employees and effects on consumption of the organization could be made visible without delay leading to well-know social trap phenomena (Cross & Guyer, 1980). For this purpose the organisational support of the whole organisation and its management is needed.

The study has several limitations. Due to the decision to use technology which was at the time being only available on the Android platform we could not attract a sufficient amount of participants. For a more summative evaluation study the technological platform needs to be more flexible to attract a larger number of participants. In addition, due to the short duration of the study we cannot make any claims about behaviour change that has actually taken place.

Another limitations of the study might be a potential selection or participation bias of participants. The low value of the rewards and the qualitative feedback suggest that the intrinsic motivation be active for energy conservation at the workplace was already present for most participants. A future study would need to attract not only a larger group but also a more balanced group of participants. To evaluate long-term effects and the increase of pro-environmental behaviour of employees on a larger scale a longitudinal study would be needed that was beyond the timeline of this project.

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