# Designing a Mobile Serious Game to Promote Healthy Lifestyles

## Motivating teenagers to adopt healthy habits through play

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*Abstract*—**Behaviours such as diet, sedentariness and how much exercise we do play a major role in influencing health and wellbeing. As a medium, mobile serious games have the potential to educate and foster behaviour change whilst engaging and motivating users. This paper illustrates the user-centred design approach used to develop a mobile serious game to promote healthy lifestyles. In particular, this research, developed in the frame of the PEGASO European project, focuses on teenagers and healthy behaviours linked to the prevention of obesity. In this approach, teenagers from different European countries (Italy, Spain, and United Kingdom) participate to the co-design of the serious game. This activity is still ongoing but first findings show encouraging feedback concerning the generic game mechanics and the designed game**.

*Keywords—Serious game, behaviour change techniques, health and lifestyles, mobile application.*

## I. INTRODUCTION

Making healthy lifestyle choices in terms of diet, physical activity levels and in avoiding unhealthy behaviours such as smoking have the potential to dramatically impact an individual's mental and physical well-being. For this reason, a number of interventions have already been designed and implemented to avoid the wide range of negative outcomes of poor habits and encourage individuals to maintain healthier behaviours. However, one of the main restrictions to the effectiveness of these interventions is a lack of motivation, alongside a lack of time and difficulties in accessing sufficient proportions of the target group [1,2]. These issues, along with a rise in the accessibility of technology, have encouraged the implementation of game-based interventions, which incorporate all the benefits of interventions delivered remotely but with the added advantages of greater enjoyment and in-built intrinsic [3,4].

A number of serious games aimed at improving lifestyle choices in young people have been developed, many of which

have reported significant improvements in behaviour change. While likely to be at least partially due to publication bias against studies reporting non-significant findings, it is still noteworthy that only very few studies report a lack of change following game-based interventions (e.g., [5,6]). This highlights the strong potential for positive outcomes in terms of health-related behaviour change.

The PEGASO European project aims at fostering healthy habits concerning physical activity, sedentariness and healthy nutrition in teenagers through a PEGASO ecosystem, composed of different elements and approaches, among which also a serious game for mobile platforms. In particular, PEGASO focuses its behaviour change approach on specifics target healthy behaviours. Target behaviours are those behaviours, pertaining to nutrition, physical activity, sedentary behaviours and sleeping habits, which have been recognised to have impact on overweight/obesity prevention, and are amenable to be changed. It is important to highlight, that each user of the PEGASO platform will focus on one specific target behaviour at a time.

In the next section, Section 2, we motivate the use of serious games as means for healthy lifestyle interventions presenting the state of the art in this field. In Section 3, we present and schematise the approach that we are following to design the PEGASO serious game. Section 4 discusses the first results that we have achieved testing the game with teenagers in three different countries in Europe (Italy, Spain, United Kingdom). Finally, Section 5 concludes this paper highlighting the future work.

## II. RELATED WORK

One of the main arguments for the use of serious games over more traditional methods or interventions is how ubiquitous and familiar technology is for young people, making game-based delivery a comfortable and potentially enjoyable situation [7]. Learning through play encourages

faster, more implicit learning [8], and digital games in particular have been argued to be especially motivating, encouraging a greater level of engagement than other activities [9]. Digital games are also enjoyed by a large number of young people, and this expectation of enjoyment can be capitalised on in educational contexts; while children may not be interested in participating in traditional interventions, digital games are still seen as a fun activity, and they therefore enter the intervention expecting to enjoy it [10]. As a consequence, in the correct contexts, serious games can prove an ideal medium for the delivery of educational material.

Previous researches into game-based interventions in relation to healthy lifestyle adoption also demonstrates this tool to be largely successful (albeit in relation to different kinds of measures). While the effect sizes tended to be small, they are comparable to other non-game, computer-based interventions (e.g., [11,12]). Moreover, DeSmet et al. [13] argue that coupled with the increased intrinsic motivation inherent serious games compared to other computer based methods, as well as the greater levels of interactivity and visual interest, games may be a better medium. This is in line with other assertions that as long as the games present adequate challenge, participants are willing to spend more time on them than they would on traditional learning methods [14,15].

However, it also worth noting that all reviews on the topic of game based interventions and interventions for health-related behaviours agree that the existing literature base is incredibly diverse in terms of target demographics, game formats and outcome measures, making overall conclusions very difficult [16-28]. Furthermore, a lack of information in many of the articles reviewed regarding game characteristics make it difficult to pin-point what elements are especially effective or successful [29].

## III. PEGASO GAME DESIGN

The design of the PEGASO serious game has been structured according to eight different iterative phases of design/development and test. These phases are fundamental steps of a unique iterative process that follows the user-centred design approach. Indeed, in user-centred design, "development proceeds with the user as the centre of focus" [30]. Every phase is performed involving the user many times. The analysis, design and development phases are performed rapidly in order to provide first prototypes to test with actual users in order to understand what is appreciated and what can be improved. Then, the whole process is performed again and again to converge towards the optimal solution. This approach allows responding better to the users' needs and desires in order to increase the acceptance of the final product.

In PEGASO, the test phases involving users are divided in three short time duration pre-pilots (from one day to two weeks) and one final pilot of about six months.

PEGASO Game design – Iterations:
- Phase 0: User requirements
- Phase 1: First design iteration
- Phase 2: Game acceptability and preliminary usability tests (first pre-pilot)
- Phase 3: Serious game first prototype
- Phase 4: Game mechanics and usability II tests (second pre-pilot)
- Phase 5: Design Iteration and Integration in the PEGASO Companion
- Phase 6: Integrated game test (third pre-pilot)
- Phase 7: Pilot version development
- Phase 8: Pilot study

The full process will take 3 and half years. At the time of writing this paper the "pre-pilot 2" phase is still on-going.

### A. Phase 0: User Requirements

The first step before the actual development of the game was aimed at determining the game typologies that are attractive for the target population as long as their knowledge in the domains related to the PEGASO project (healthy habits concerning physical activity, sedentariness and nutrition). Therefore, we conducted a review of the current literature, examining existing game-based interventions to make a list of the evidences that can enable interventions for lifestyle change; a summary of this analysis can be found in [31].

### B. Phase 1: First Design Iteration

Behaviour change interventions have been designed in PEGASO following the COM-B model and the Behaviour Change Wheel (BCW) framework [32]. The COM-B model of behaviour is a powerful model to understand behaviour. This model has the great capability of taking into account the context in which a behaviour is taking place and is particularly valuable for PEGASO because it can be used as a starting point for intervention design. On the other hand, the Behaviour Change Wheel (BCW) is a complementary framework (synthesis of 19 frameworks to classify interventions), based on COM-B, facilitating the design of interventions for behaviour change. BCW is a generic framework and can be adapted to different behaviours: the PEGASO target behaviours. Therefore, the goal of this first phase of design was to conceive key game mechanics starting from the requirements defined by the PEGASO objectives and the preliminary study phase to foster behaviour change through the guidelines of behaviour change models. In addition, the serious game has specific objectives within the PEGASO ecosystem: 1) Convey educational material; 2) Keep teenagers engaged in the whole PEGASO ecosystem; 3) Foster healthy habits.

These elements have brought to the design of several game mechanics. In this paper, we present two core game mechanics that are the most peculiar within the PEGASO project. The first game mechanic is called "research benefits". Since a major learning outcome of PEGASO is to provide teenagers knowledge about food and aliments we designed an *ad hoc* mini-game. In this game, food items found in the game have to be combined in order to benefit the character. However, in order to be effective for the game, the combination should be achieved taking into account the real nutritional parameters of the food item (which are shown to the user). In this way, the user is implicitly learning the composition of the different

aliments. The second mechanic concerns the "energy" bar. Playing the game, the player makes use of and consumes "energy". Without energy some of the character abilities are weakened or disabled. Whilst the user will still be able to continue to play and complete tasks that allow her/him to gain nutritional knowledge. While the character energy is depleted within the game, it is replenished by the behaviours of the user in real world. In particular, more the user behaves close to her/his target behaviour more energy is available to the character in the game. It is important to highlight that the energy game mechanic overcomes the boundaries of the serious games since it needs the integration in the PEGASO ecosystem in order to assess the user activities.

### C. Phase 2: Game acceptability and preliminary usability tests

This pre-pilot phase has taken place in three countries Italy (Lombardy region), Spain (Catalonia region), and UK (England). The teenagers were provided of fist mock-ups of the game.

Main results (the results of this phase are reported and explained with more details in [33]):

- The teenagers really like the idea of finding reasons to move and to spend energy in real life in order to gain more energy in the game. They suggest that calculating their resting and sleeping hours may be reflected in the energy bar as well.
- The zombie theme is interesting and there are no clear gender differences.
- A cartoonish version is slightly preferred if compared to a realistic one (Spanish teenagers are a little an exception on that).

### D. Phase 3: Serious Game First Prototype

The goal of this phase is to transform the mock-ups in first functioning and playable applications for mobile platform (Android OS) taking into account the remarks of the teenagers obtained during phase 2. Fig. 1 shows some screenshots of the serious game as developed during this phase.

Main outcome: a first, playable prototype of the game available for Android platform. At this phase, the game is a stand-alone application partially integrated in the PEGASO ecosystem.

### E. Phase 4: Game Mechanics and Usability II Test

At the time of the writing of this paper, this phase is currently on-going. Four countries are involved in the participation to this phase: Italy, Spain, England and Scotland. The results presented here below are related to 10 Italian teenagers (5 girls and 5 boys). Main results:

- Teenagers involved in the study suggested that the possibility of interacting with peers for collaborative or competitive purposes would enhance the engagement toward the game.
- Rather than multiple characters, it would be interesting to have the possibility to customise the main character.
- Having a more varied environment will facilitate the use of the application over a long period of time.
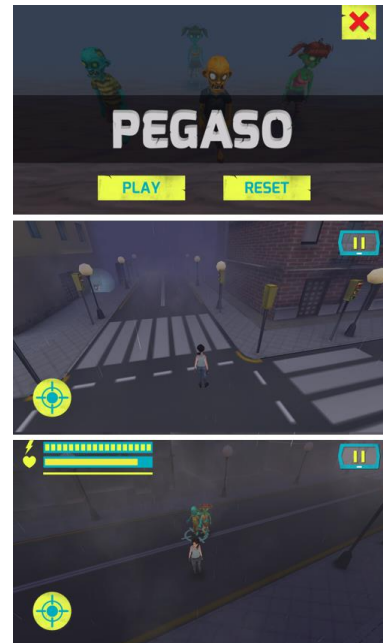


Figure 1. Screenshots from the PEGASO serious game: the startup screen (top); the main character seeing a food item container to be used in the "research" mini-game (middle); during the night the character is attacked by zombies (bottom).
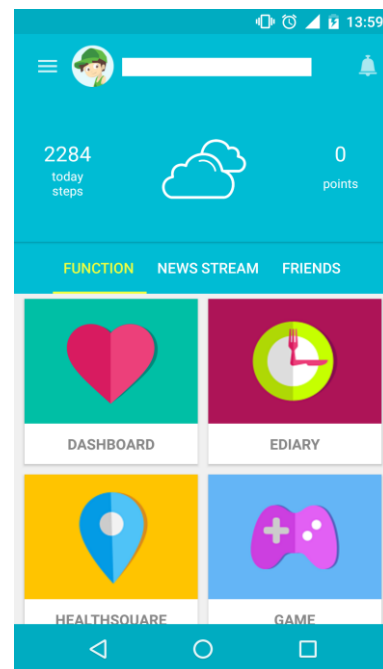


Figure 2. PEGASO Companion UI. From this interface the user can access to the serious game (via the bottom right icon).

## F. Phase 5: Design Iteration and Integration in the PEGASO Companion

The PEGASO Companion [34] is the Android app the will encompass all the PEGASO services (see Fig. 2). The main outcome of this phase will be the integration of the serious game in the PEGASO ecosystem and the PEGASO Companion as well as the integration of the most relevant features demanded by the users in the previous phase. Via this integration it will be possible for the PEGASO user to test the "energy" game mechanic that requires the whole PEGASO ecosystem in order to work.

Expected main outcome: The integration of the serious game within the PEGASO Companion and the related apps. In this way, it will be possible to present to the testers the whole PEGASO ecosystem as a unique and integrated environment and evaluate the user experience in the whole PEGASO.

## G. Phase 6: Integrated Game Test

In this phase, the user will test the serious game integrated in the whole PEGASO system. The integration in the PEGASO echo-system will allow the user to test different mechanics that would be impossible to evaluate otherwise. For instance, the users will have the possibility to see how their activities in the real world can affect the game and provide a first feedback about the global motivational mechanisms. Additionally, the expected results will address integrations issues and the usability of the PEGASO platform as a unique entity.

## H. Phase 7: Preparation for the Pilot

This last design and development phase will be mainly centred on the release of the serious game stable version. It means that this phase will focus on creating mechanisms, contents and procedural solutions that should guarantee the game a life span covering the 6 months duration of the final pilot. Such solutions have to motivate the users to come back playing the game and, at the same time, to stay engaged with the whole PEGASO system.

## I. Phase 8: Final Pilot

The final pilot will include about 300 teenagers coming from the same four regions (Italy, Spain, England, and Scotland) for a duration of more than 6 months. Via this pilot, we will estimate the impact of the serious game (and the whole PEGASO ecosystem) on the user behaviours and habits in the medium-long terms.

## IV. PRELIMINARY RESULTS

At the time of the writing of this paper, our work is currently between phases 4 and 5. Currently, the overall design of the game situates the player's character in a modern city (as depicted in Fig. 1), where the player must scavenge for food resources during the day and combine them to obtain abilities which she can use to combat waves of creatures that appear during the night.

The backbone of this idea has been already introduced to teenagers during the first pre-pilot in the Italy (n=10), Spain (n=18) and England (n=16) as mock-ups. The activities



Figure 3. Users testing the serious game during phase 4.

consisted in focus groups during which the main planned game mechanics and aesthetics of the design were discussed. As we detail in [33], the first results positively evaluated the acceptability of a mock-up prototype and aesthetical options. At the same time, we collected valuable feedback about usability and suitable improvements.

On the other hand, during the second pre-pilot, we provided a functioning alpha version of the serious game as standalone mobile application (not integrated with the PEGASO Companion and the other apps in the PEGASO ecosystem). Currently, only the data from Italian pilot site are available (n=10, 5 females and 5 males, all aged 15-17 years old). In particular, the aim of the second pre-pilot iteration about the PEGASO serious game is:

- Testing the core game play mechanics (exploring the virtual world and finding food, fighting, unlocking benefits);
- Evaluating the usability of the first prototype.

Together with a couple of questionnaires (SUS [35] and a custom questionnaire), it was decided to conduct a focus group to find out participants' views and overall impressions about the PEGASO serious game.

About the game play mechanics, teenagers provided valuable feedback highlighting the strengths and making suggestions for possible improvements (e.g., add a tutorial the first time that the mini-game about nutrition is played, or make the fight against the enemies more challenging). Similarly, about the game usability they provided suggestions about improvement in the control system and the feedback to the player. Other suggestions were related to the importance of avatar customisation and the possibility to have a competitive or collaborative game modality with the possibility of playing together with friends. The game needs to be varied if have to keep players engaged.

Although the limited findings from this focus group needs to be validated with the results coming from the other focus groups in the other 3 regions (i.e., Catalonia, England and Scotland), globally, these first results show encouraging feedback concerning the generic game mechanics and the game. In particular, the "energy" game mechanic was highly appreciated. At the same time weak points have been highlighted in order to guide future developments. Comparison with testers in the other countries will also allow highlighting possible cultural differences.

## V. Conclusion and Future Work

This paper presents the iterative approach we are using for designing a serious game in the frame of the on-going PEGASO European project. The goal of this serious game is to convey educational contents, foster healthy habits and keep teenagers engaged in the whole PEGASO ecosystem.

The design process that we adopted is user-centred and consists in 8 phases alternating design/development with tests and evaluations with users. In particular, the design steps involving users consist in three short pre-pilots (from 1 day to 2 weeks) and a six-month pilot study.

Currently, we have realised a first functioning prototype of the serious game and tests are ongoing in Italy, Spain and UK (England and Scotland sites). Whilst now working as standalone app, the future work consists in integrate the serious game inside the PEGASO ecosystem and evaluate its impact as tool for behaviour change. In particular, our research will focus on the effect on motivation and engagement derived from linking user's behaviours in the real world with rewards and features in the game world.

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