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A Mobile Serious Game for Lifestyle Change:

Conveying nutritional knowledge and motivation through play

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***Abstract*—This paper describes work in progress to create a serious game integrated with an ecosystem of services towards overall project goals of ethically recording, analysing, and motivating adolescent behaviour towards healthier long-term lifestyle. The design outlines an approach that minimises textual and dialogic content in favour of experiential and abstract elements, reflecting existing evidence alongside the need to provide a motivation for users to engage with a wider suite of apps and technologies. Illustrating the use of "freemium" mechanics commonly used to incentivise in-app purchases as a motivator, this paper discusses their use as means towards instead incentivising the use of services to promote a healthier lifestyle. An additional mechanic sources and applies nutritional information from a large database to create a deck of food "cards", with which the player is challenged to apply their understanding of nutrition to create in-game rewards. Preliminary findings from pre-pilot focus group evaluations with adolescents aged 14-16 (n~10) in Italy and Spain demonstrate enthusiasm for the approach taken to linking real-world behaviour with in-game rewards, as well as potential differences in reception to visual style options between sites and cultures.**

Keywords—serious games; mobile game-based learning; adolescent lifestyle intervention; game design

I. INTRODUCTION

Focusing specifically on the creation of a mobile serious game within the wider ecosystem of the EU-funded project PEGASO (Personalised Guidance Services for Lifestyle in Teenagers through Awareness, Motivation, and Engagement), the background of this paper in Section II describes an approach which seeks to combine services including gaming, nutritional self reporting, wearable sensors, and a persuasive companion, towards behavioural goals. The background also presents the overall design considerations, as well as discussing the specific role of a game in such a context. Such a role focuses on engaging and rewarding adolescents for using other components of the system, whilst to as great a degree as possible conveying knowledge of nutritional information, based on a range of survey metrics shown to correlate to healthier lifestyles [1]. Subsequent design activity, documented in Section III, explores methods of integrating knowledge transfer on nutrition without compromising the "flow" and fun elements of the game, essential for the game to function in its primary role as motivator.

The design explores the use of existing data sources to populate a game rapidly with factually-accurate content, in this case a deck of 1,500 "food cards", sourced from the United States Department for Agriculture (USDA) database. As data directly usable for educational purposes becomes increasingly easy to access from a wide range of sources, such approaches have potential to create deep learning experiences, though also bring challenges in content adaptation and presentation. After presenting the design in a series of European workshops, participants' feedback was gathered and is discussed in Section IV, noting subjectively an initial positive response to the platform and engagement with the use of game mechanics to incentivise behaviour. Future work, primarily centered on player's response to the game illustrated in this paper, will seek to validate the approach through a series of longitudinal field trials discussed in Section V.

II. BACKGROUND

The effects of obesity, and its underlying causal factors such as poor diet and sedentariness, are resulting in increasing demands on healthcare services, particularly in developed countries [2, 3]. In addition to acute conditions brought on by long-term obesity, chronic conditions such as Type-2 diabetes are continuing to rise and affect younger age groups [4]. Addressing this global issue presents a continued challenge with respect to both the design and validation of interventions that seek to impact participants' lifestyles, towards healthier futures. Mobile games present several opportunities when deployed as such interventions [5]: they can utilise location-based services to promote activity; are available to readily message the user; and provide a means to capture lifestyle data "on the go". The PEGASO project seeks to explore and evaluate a range of novel mobile services, including a food diary, wearable sensors, companion messaging, and gamification towards the goal of stimulating lifestyle changes in adolescents aged 14-16, an age range frequently shown as critical in the formation of habits which persist into adult life [6].

The notion of using games to stimulate healthy behaviours has been applied in a wide variety of contexts, ranging from their use to convey dietary knowledge and impact food choices amongst younger children [7], to ensuring treatment adherence in adolescents [8]. Physical activity has also been targeted through games that directly require the player to complete physical movements [9], with commercially-successful examples such as Wii-Fit. However, many evaluations have failed to conclusively demonstrate long-term impact, in part due to the difficulty of measurement, and in part to the challenge of retaining users for a sufficient period of time [10].

PEGASO explores how an integrative suite of components, able to measure, motivate, and recommend to users healthy challenges and choices, can be applied to impact their long-term lifestyle through shorter-term intervention during adolescence. Within such a context, games are seen as a vital means of stimulating engagement with the overall platform, but themselves require careful design to function in such a role. Simple "Points, Badges and Leaderboards" (PBL) gamification, though generating some limited evidence of success [11], commonly struggles to generate the perceived value in its individual components for long-term behavioural incentivisation or meaning [12, 13]. Points, for example, require consideration of how their value is generated to the user along lines of thought such as *"How hard was it to earn these?"*, *"Do I have more than other people?"*, and *"What's the reward for getting more"*. As can be imagined, complex social and behavioural dynamics quickly emerge and must be designed for to maximise the potential for success of such an approach.

A paradoxical issue with serious games targeting a non-adult market is the risk that the game will be perceived negatively by children or adolescents as a result of its specific target audience. In a 2012 survey of 1,000 UK schoolchildren, the vast majority (>40%) purported that the 18-rated *Call of Duty* was their favourite game, with this outcome consistent even at the youngest age group of 9-10 year olds [14]. That said, the majority also reported being receptive to the idea of serious games, and wanted to see more of them in educational contexts. The straightforward conclusion is that serious game design is best fitted to the context of the classroom or alternate school-based activity, rather than seeking to engage children during their leisure time [15]. However, to meaningfully impact lifestyle, this time outside the confines of a controlled school environment is arguably the most important to address.

Within the wider PEGASO system, therefore, the game is envisioned as encouraging and rewarding actions on a daily basis, rather than facilitating them. For example, if an adolescent completes a daily task such as walking 10,000 steps monitored by wearable sensors, updates their PEGASO food diary, or performs a task assigned by their companion, the game needs to provide sufficient reward to stimulate the activity. A central design challenge, therefore, is in making these rewards sufficiently desired to act as motivators. In the following section, we outline the design of the PEGASO game in terms of its two specific mechanisms seeking to promote engagement and knowledge.

III. Game Design

This section outlines the design adopted against the background considerations provided in Section II. Firstly, it outlines the rationale for the creation of a game which places engagement and entertainment at the forefront, relying on blending with other services and monitoring technologies to monitor and set a users' goals. A current work-in-progress prototype is illustrated with respect to its design around both engagement, and knowledge transfer, demonstrating the incorporation of these factors within an open-world mobile game.

A. Rationale

The primary role of the serious game within PEGASO is to engage and motivate users of the complete platform. As such, the need exists to both provide a solution which engages children outside of a classroom context, and encourages their use of the wide range of PEGASO components. These include a food diary, which allows the user to record and view their daily nutritional intake, wearable sensors, allowing activity to be monitored and fed-back on, and daily goals build around behavioural models intending to nudge and reward the player for positive actions.

A high risk exists in seeking to create a serious game which seeks to engage during leisure time, but also intends to convey a large volume of educational material. A game-player is constantly learning, as is any individual, though their learning is often confined to the mechanics of the game, rather than its content. For example, a player faced with choices may find ways to circumvent learning material by guessing, realising that rapid repetition and luck can provide a more efficient solution than knowledge application. Excessive text-based content is particularly at risk of being overlooked if confined to a manual or reference guide rather than being a central component of the game [14], conversely, attempting to realign this text-based content to serve as a central to the game risks impacting entertainment.

Thematically and aesthetically, another goal is creating a game enjoyable outside of the target age group, with the explicit goal of avoiding creating a game which could risk alienating adolescents, who, as research in Section II demonstrates, primarily play adult games rather than ones specifically targeting their age group. Frequently, ethical constraints prevent the incorporation of elements often used in adult games, such as graphic violence or offensive language; when seeking to provide a wholly positive impact on players, there is little question these elements are best avoided. However, evolution of games into genres through a "survival of the fittest" paradigm demonstrates the frequency and success of narratives which contain antagonists as the foil to the player's hero, and use combat as a means to contextualise their mechanics. This runs largely irrespective of realism: "combat" in the general sense can be described in terms of either the graphic visualisations in *Call of Duty* through to Mario's efforts to jump on foe's heads in *Super Mario World*. The defining factor in whether a game is perceived to be violent is often visual or aesthetic, rather than a mechanical.

In the following sections, we expand on the use of common gaming elements when seeking to provide an entertaining and motivating experience within PEGASO. Whilst the core role of the game is one of engagement, knowledge transfer is also addressed by means of a "research" system, seeking to transfer nutritional knowledge through an experiential learning approach. Hence, whilst the overall design emphasises entertainment, specific affordance is given to the potential to introduce mini-games which convey knowledge shown to impact lifestyle, whilst synergising with the game's overall mechanics.

B. Engagement and Motivation

To address engagement, particular consideration was given to the anticipated contact times and durations required to achieve a lifestyle change within the PEGASO platform. With sedentary screen time a concern, a core objective of the game's central mechanics is to incentivise 10-20 minutes of playtime per day, discourage long single-session play, and encourage return and consistent engagement. This is not dissimilar to the objectives typical to a commercial entertainment mobile game, with this genre increasingly operating under a "freemium" model, whereby the game is free to play with additional content unlocked via "in-app" purchases. Within PEGASO, therefore, several mechanics common to such games are mirrored, though with the key exception of rewards being provided for the completion of healthy tasks using other PEGASO services, rather than directly through purchases.

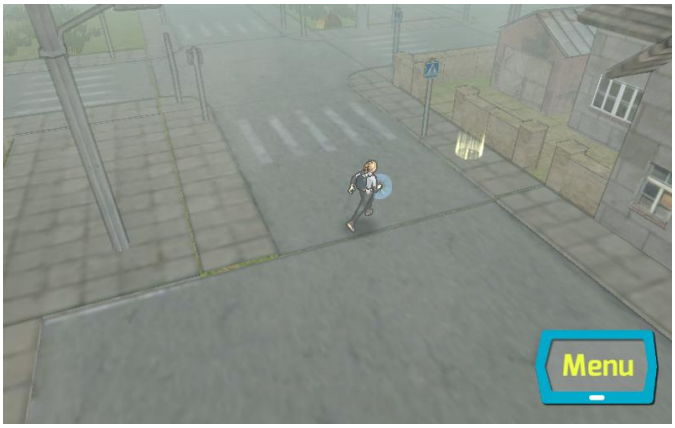

Figure 1: Exploring the game world during the day

"Energy" within the game provides a central system seeking to achieve this. The player consumes energy in-game levelling up and recharging their equipment. Without energy, the player's progression and abilities are unable to advance, hence whilst the player can continue to play and gain nutritional knowledge as described in Section III-C, they need to "recharge" by engaging with the wider ecosystem of PEGASO services. Having a focused, single reward variable at the point-of-integration presents several benefits: it allows game designers to focus on how it benefits the player, rather than requiring individual service providers to devise their own rewards; allows for a technically simplified interface passing a single variable; and simplifies the experience for the user.

An immersive, virtual space is also considered a central component of the PEGASO approach towards engaging the user in gameplay. The overall design of the game, therefore, places the player as a character in a post-apocalyptic world: during the day they must scavenge for food resources, and combine them into abilities which they use to combat waves of creatures that appear during the night. Developed using Unity and deployed primarily to Android, touch-based controls are adopted which allow the user to switch between "shoot" and "run" modes with vertical gestures, with subsequent gestures resulting in actions based on the current mode. In the daytime, as illustrated in Figure 1, simple tap gestures are used to explore the world.

At nightime, the player is faced with increasingly difficult waves of enemies depending on their level. To defeat them, they require new abilities which are "researched" through a nutritional knowledge mini-game described in the next section. Unlocks and upgrades are thus rewarded through a "serious" component of the game, freeing the action itself to focus upon flow and engagement. Figure 2 illustrates the combat at night time. Many mechanics reflect staples of entertainment games in this genre; the player has to manage their health, and gains "combo" multipliers for rapid successful actions, seeking to add to flow.

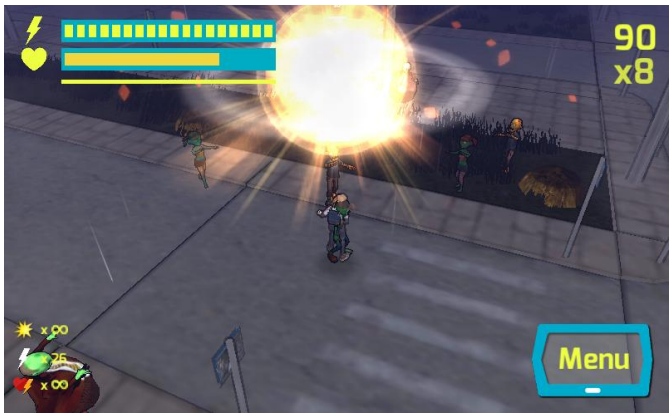

Figure 2: Combat during the night

To address the need for long-term engagement with the game as a component of a lifestyle intervention, the design accommodates increasing player levels through an experience point system. A section of the corresponding graphical user interface content is shown in Figure 3. Included in the figure are the three cards corresponding to the equipped fast, strong, and defensive abilities held by the player, which can be recharged and upgraded through the nutritional minigame. Additional interface components allow the player to track their statistics, including time played, enemies destroyed, and highest scores and hits. Each level, the player can also select an upgrade from 12 potential abilities, improving their characters combat performance, movement speed, health, and similar characteristics. An overall design goal is to create an infinite game which, through the energy mechanic, promotes regular use and goal-achievement within the PEGASO ecosystem, as well as being conducive to short, frequent play rather than long single sessions. As such, integration with cloud components of the PEGASO system allows for both local and server-side storage of game state, whilst the energy mechanic encourages the player to use a daily charge gained by using other PEGASO services.

C. Knowledge Transfer

The research system is designed around a survey of nutritional knowledge, shown to correlate to healthier lifestyle [6]. Whilst caution should be taken regarding correlation equaling causation, for example those intending to live healthier lifestyles may be more intrinsically motivated to develop their knowledge regardless, it provides a basis by which to structure the learning outcomes within the game. The initial prototype of the research system, illustrated in Figure 4, allows the player to upgrade and recharge their in-game

"Research Benefits" (attacks and defensive abilities), by seeking out food items in the world and combining them through a minigame embedded in the user interface. Food items are sought by the player during the day, when no enemies are present. They are equipped with a combination of a map, which marks dynamically their current location and food drops, and a proximity sensor which blinks faster as the player gets closer to a drop.

Figure 3: Character advancement

On finding a container, the player can perform a simple action to add the contents, selected randomly from the deck of 3,000 items, to their inventory. Providing a means to generate a deck of diverse food items and their contents without excessive input from nutritionists posed an immediate challenge. To address this, the USDA nutritional database was queried for all items under relevant food groups (e.g. "fast food", "vegetables", "poultry", etc.), with output stored in XML then converted to in-game content. To optimise performance of the game on mobile, and avoid the requirement of an Internet connection, this was accomplished in Unity using with bespoke editor tools, thus allowing imported content to be fine-tuned to select food groups relevant to learning objectives.

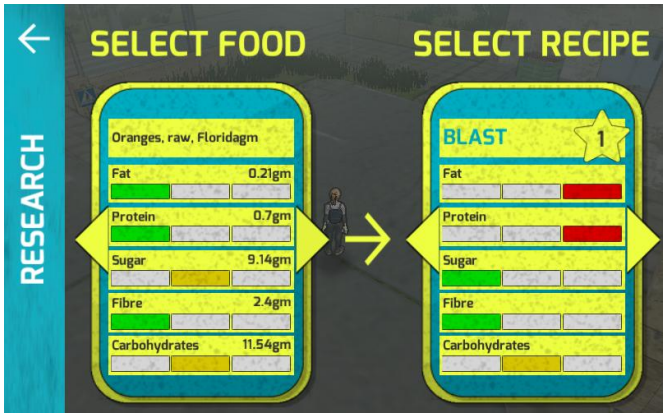

Figure 4: Nutritional knowledge mini-game

The core mechanics of the research mini-game revolve around the player's ability to match nutrients in food, displayed as unique cards for each food item, against recipes for abilities. Recipe requirements are designed to broadly require a certain food group or combination thereof, for example the starter "Blast" ability (Figure 4) requires foods high in fat and protein but low in salt and fibre. Accurate matching by the player is rewarded with five potential ranks, affecting the power of the ability, with correct matching of all five individual nutrients required to unlock the highest rank. Abilities also require recharging and have limited uses, encouraging the player to work within a constant cycle of finding, sorting, understanding, and applying their deck of food cards against the recipes of abilities they want to use the most.

IV. Preliminary Results

The game concept was presented to small focus groups of adolescents in Italy (n=10) and Spain (n=18). The group activities consisted of a presentation of the aesthetics of the design, along with an overview of planned mechanics, followed by moderated discussion of participant's views and ideas. Goals of this activity were to evaluate the acceptability of a mock-up prototype, collect initial feedback on usability, and evaluate aesthetical options. The outcomes were consolidated by moderators on each site into an agreed set of outcomes; an approach limited with respect to sample and conclusiveness of results, but one which provided some high-level insight into adolescents' reactions to the proposed design.

At the Italian site, participants were reported to respond positively to the idea and novel topic and setting, far abstracted from the real-world objectives of a healthier lifestyle. They engaged with the design in detail, commenting a worry that the searching and combining foods during the day could be tedious when compared to action during the night, prompting adjustments towards shorter daytime cycles and increased daytime content. They confirmed that their perception of the game would be something to play in their "spare time", matching the context required for PEGASO. Avatar customisation and personalisation was a theme which strongly arose for one male, however the majority didn't feel a requirement for the avatar to match their gender. Italian participants also responded positively to the energy bar system, and were enthusiastic about physical activity being rewarded in game, suggesting it could be advantageous in making the game unique in their library.

The Spanish group also described the energy system as a unique and interesting feature. Several participants' initial perceptions suggested a confusion with the game's message, in particular that unhealthy eating resulted in the player becoming a "monster", demonstrating the important of identifying and designing to avoid misconceptions at an early stage. Interestingly they differed from the Italian group when seeking to reach a consensus on the aesthetic - the Italian participants lent towards a cartoon look for the game, and the Spanish participants towards a realistic aesthetic. Inferring meaning from such a finding is difficult given the limitations in scope and context of the studies, though it may be reflective of cultural difference.

Overall, the limited findings from these focus group activities show encouraging responses with respect to the energy mechanism and its use to promote engagement. Participants leaned towards a perception of the system as rewarding rather than punishing behaviours, suggesting initial promise towards the use of such mechanics in serious games.

Across both sites participants were also enthusiastic about the addition of collaborative and competitive online features, though again the limitations of the methodology preclude a clear finding in favour of either. A core goal of future work, therefore, is to advance the prototype illustrated by this paper towards a "hands-on" longitudinal trial, with a larger and more representative sample of participants.

Summary and Conclusions

The work-in-progress presented by this paper builds on previous review work [16] to design a serious game for lifestyle intervention which capitalises on the existing knowledge-base of successful approaches and common issues. In particular, given the role of the game in the wider PEGASO ecosystem, the design presented seeks to engage and motivate the player whilst conveying nutritional knowledge, rather than act as a standalone learning resource. This allows the design, as illustrated, to focus on engagement aspects lacking in games which seek to convey information through large volumes of text or branching multiple correct and incorrect choices. A potential drawback is a shift away from immediate learning outcomes towards a blended and abstract approach which requires adequate scaffolding to promote learning transfer.

Future work will evaluate and seek to validate this design approach. As the concept of a central mechanic with a clear "freemium" analog is transposable to other themes and contexts, potential exists for successes to be transferred to a wide range of behaviour-related game-based interventions. Furthermore, the concept of using entertainment games and replacing the monetary reward with a behavioural measure could allow for the increasing use of games in a serious role, but which themselves eschew complex learning content if it obstructs engagement. Such solutions can thus seek to achieve the meaningful balance of entertainment and education, frequently noted as central to serious games [17], in a holistic fashion, through the integration of the game within a suite of blended systems and services. If validated, this provides an appealing alternative to encapsulating an entire behavioural model within a single game, as such an approach is demanding with respect to the aforementioned balance between enjoyment and education.

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