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Specifications and high-level design of the Organizational Behaviour Change Framework

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Authors	Ian Dunwell, Pamela Kato (COVUNI), Tsatsakis Konstantinos (HYP), Tsitsanis Anastasios (HYP), Christos Malavazos (GD)
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Description of the related task and the deliverable in the DoA	This task examines workplace incentive dynamics and organizational behaviour theories to generate the design and specifications of a generic organizational behaviour change framework accompanied by a set of gamified tools and user interfaces for the sustained engagement and behaviour change of end-users. Pilot site management is consulted for the behavioural aspects and system administrators regarding the deployment of OrbEEt IT components.				
Comments					

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0.7	2015-10-26	WP leader	Checked and released to the Coordinator for internal QA.
1	2015-10-30	SOL jm	Submission to the EC.

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1. EXECUTIVE SUMMARY

Providing an Organisational Behavioural Change Framework (OBCF) for application within OrbEEt, this deliverable provides a review of behavioural change theories related to both individuals and organisations (S2.1) and the application of workplace incentive dynamics through games and gamification (S2.2). These reviews are combined and reflected upon against the background of the OrbEEt project, which includes a review of pilot site audiences and contexts based on pilot site management consultation in Section 3 alongside the technical framework detailed further in D1.2. The framework itself, outlined in Section 4, identifies the role of the three core interface components of OrbEEt: In office displays, intranet portal, and smartphone gaming. The framework is applied in Section 5 to generate initial design considerations and specifications for these three interfaces under the OBCF, illustrated below in this summary, while Section 6 highlights the design and specifications for the ambient user interfaces.

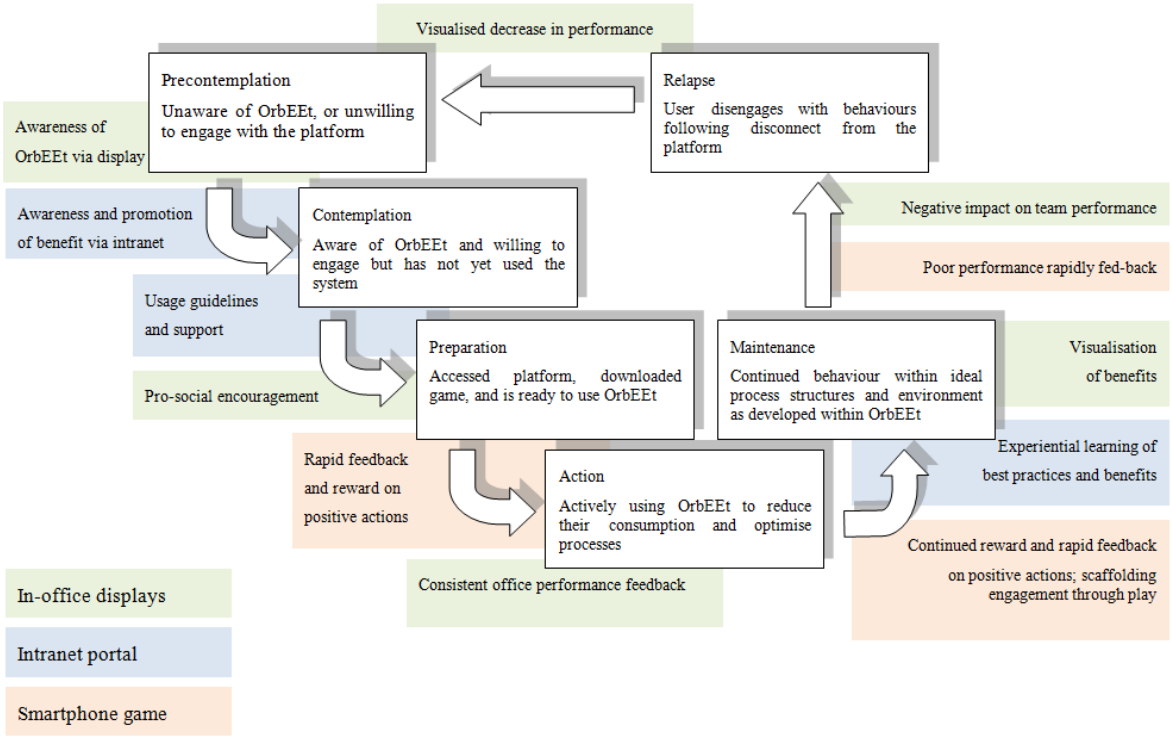

Figure 1. Summary of initial design considerations and specifications for OBCF interfaces

2. INTRODUCTION

2.1 Purpose and target group

The purpose of this deliverable is to provide a high-level model for behavioural change within the OrbEEt platform, which takes into account the core technical aspects of the project. These aspects include energy sensing and monitoring, business process modelling, and games and gamification, all of which are incorporated in this deliverable as the basis for the OrbEEt Behavioural Change Framework (OBCF). This high level model is subsequently used to underpin lower-level architecture designs (D1.4), and drive the design process for the user interfaces, including in-office displays, smartphone gaming, and an intranet portal. Achieving meaningful, long-term change in organisational behaviour is a challenging task, and therefore this deliverable seeks to identify best-practices both in terms of fundamental underlying theory, and existing examples of the application of technologies or theoretical models relevant to OrbEEt. The model itself will be validated by development and piloting within the OrbEEt project, and hence this deliverable and its content has general relevance to designers of interventions with similar objectives as OrbEEt.

2.2 Contributions of partners

This report is led by COVUNI, with the principal contributions of HYPERTECH and GD through their collaboration within the work package and written deliverables to align the technical infrastructure of the OrbEEt platform with the model of behavioural change (OBCF) outlined in this document. Additional support from the consortium beyond that directly stipulated by the DoA is used in this deliverable providing the reports from pilot sites at BHoE, FAU, ARA, and Pernik which are analysed in this document, as well as the outcomes of collaborative work with BOC in aligning business process modelling with the framework.

2.3 Baseline

Coupled with the other outputs of WP1 (D1.1, 1.2, and 1.4) this deliverable contributes to the foundation of the OrbEEt project. Its particular goal is to consolidate and identify relevant theories of behavioural change relevant to the project, and translate these to a specific framework to underpin technical design and implementation. Sections 2 and 3 review and build upon the existing state of the art, reflected in the references of this report in terms of both fundamental theories of behaviour and practical examples of their application. The report also considers games and gamification, a central component of OrbEEt's behavioural change paradigm, and their relevance to the overall behavioural framework.

2.4 Relations to other activities

This deliverable is closely related the business models (D1.1), SEOR modelling (D1.2) and technology framework design and specifications (D1.4), as a component of OrbEEt's WP1. It seeks to provide the basis for design work in D1.4 which is well-grounded in an understanding of behavioural theories and designs, as well as insight into how games and gamification can be meaningfully applied towards behavioural objectives. The framework also reflects on the functional and non-functional requirements of the OrbEEt platform and the constraints and opportunities they present for the behavioural model.

3. REVIEW

The following sections present a review of prominent behaviour change theories that are relevant and consistent with the goals of the OrbEEt project (S2.1) and games/gamification approaches that provide standards and guidelines for developing the interactive engagement platform for OrbEEt (S2.2).

3.1 Behavioural Change Theories

We present behaviour change theories below that can be used to guide the critical on-going interaction requirements with sensor data in the OrbEEt project to promote behaviour change.

At the basis of how we structure the interactions is the assumption that motivation and affect play a key role in behaviour change. Attempts to change behaviour through presentation of information have proven that while knowledge may mediate behaviour change, knowledge is inconsistently related to behaviour change in a number of domains. Gaming interfaces and environments are being increasingly embraced as media to engage and motivate "players" to change behaviours.

3.1.1 Stages of Change Theory or Transtheoretical Model

The success of a behavioural change intervention in the short and long term can depend on people's readiness to change their behaviours. It has been estimated that only a small minority of the population at any time is prepared to take action in changing their behaviours in a meaningful way at any time and we expect that users of the OrbEEt platform will be similar. Thus, most theories that focus on behaviour change fail to be applicable to most people who are not ready to change their behaviours. For this project, we focus on a behaviour change theory that captures different stages of people's readiness to change. It is aptly named the Stages of Change Theory [1]. (Prochaska & DiClemente, 1983; Prochaska, DiClemente, & Norcross, 1992) or the Transtheoretical Model (hereafter TTM).

In addition to addressing readiness to change, the theory also has a number of advantages over other behavioural change theories. Firstly, it addresses behaviour change as a process that builds to lasting behaviour change over time rather as a single event (e.g., quitting smoking). For example, the behavioural change of "quitting smoking" can be seen as a simple event but people can be prompted and guided to various stages of readiness to quit. They also often need guidance, support and prompts at different phases of "quitting smoking" in order to maintain a non-smoking lifestyle over time. Related to this, a second advantage of the TTM is that it addresses recovering from relapse as part of behaviour change maintenance. A relapse of a behaviour occurs when a person regresses or "goes back" to old or problematic behaviours, such as smoking. A relapse can happen at any stage but it occurs most notably and with the highest cost to an investment in behaviour change when people are in a final maintenance phase of behaviour change. This theory addresses relapse as part of behaviour maintenance. The TTM is consistent with the goals of OrbEEt to engage as many users as possible and to support behaviour change that is ongoing and enduring. It is therefore a key theory reflected in the structure of the Behaviour Change Model.

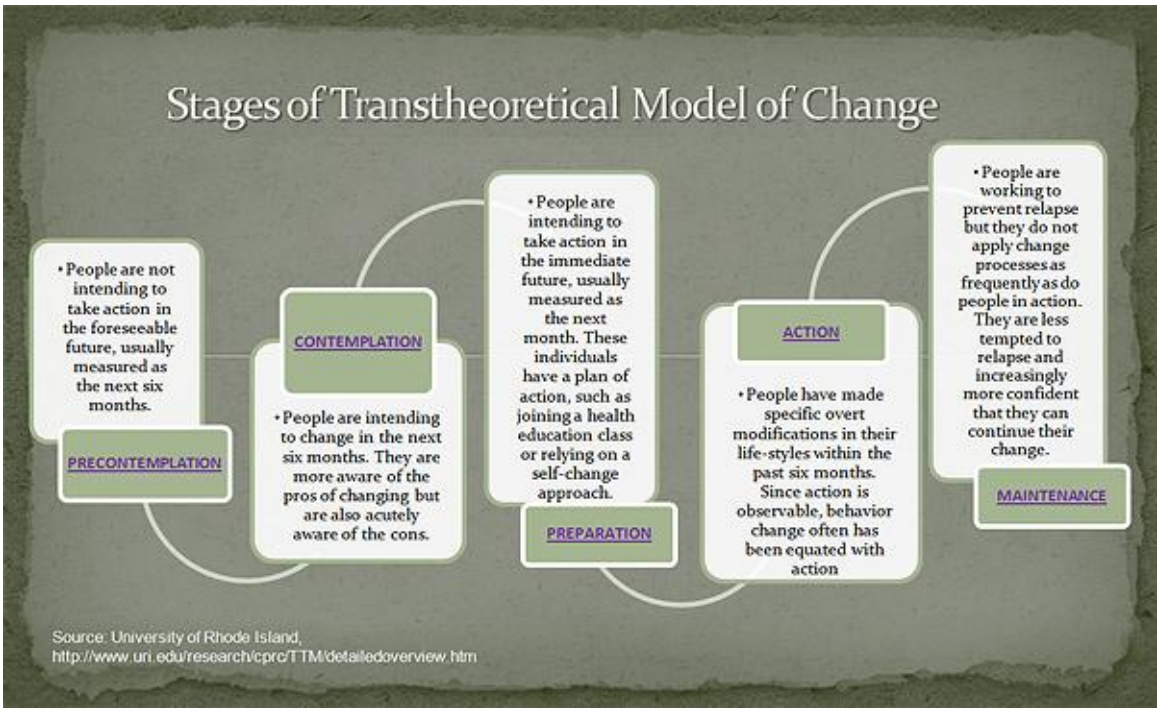

Figure 2. Transtheoretical model of change constructs and description [1]

3.1.2 Self-Efficacy Theory

Self-efficacy can be described as a person's confidence that s/he can engage in certain actions to produce expected outcomes in challenging circumstances. Self-efficacy theory further purports that a person who has a strong belief in their ability to perform a specific behaviour is more likely to performing it and persisting in that behaviour to reach success There are key aspects of the theory that that are based on social learning theory which emphasizes that people not only learn from information, but also learn from watching others and from being supported emotionally by others (Bandura, 1977, 1986, 1997). Self-efficacy theory was applied early on to learning and therapeutic contexts (e.g., treatment for phobias). In the past few decades, it has been applied to broad areas such as health, sports and businesses in which behaviour change is also key to success.

Self-efficacy is a dynamic model in which personal factors, environment and behaviour continually interact. The assumptions of this theory are a good "fit" with the OrbEEt platform. The OrbEEt platform is also a dynamic interactive system in which the environment is constantly being monitored through the game interface which considers personal facts to provide gamified interactions intended to influence behaviour that leads to changes in the environment (e.g., temperature, humidity, energy use). Information about these changing behaviours and changes in the environment are fed back into the system to constitute ongoing dynamic interactions.

According to self-efficacy theory, a person's beliefs in their abilities to engage in certain actions that will lead to expected outcomes in challenging situations are enhanced through the key mechanisms shown in Figure 3 below.

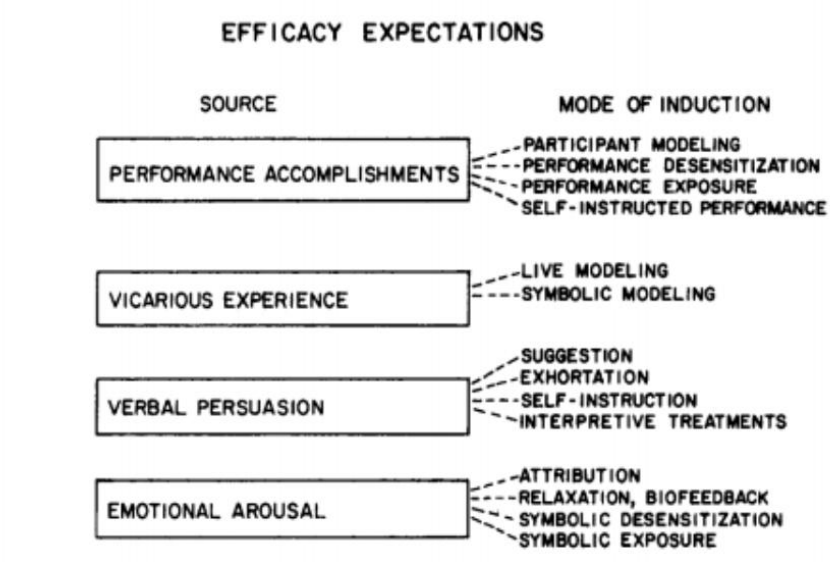

Figure 3. Sources of Self-Efficacy Information[2]

These sources and modes of induction seen in Figure 3 are described in more detail below with an emphasis on their relationships to possible implementation on the OrbEEt platform.

- **Performance Accomplishment**—When people directly engage in behaviours that are part of reaching a goal and master them, their confidence in their abilities to reach a goal naturally increase. It is critical that performance accomplishments when learning a new behaviour minimize the occurrence of failures and maximize success. Learning contexts should allow people to engage directly in mastery experiences, especially early on in the process, to promote engagement and enhance learning.

- **Vicarious learning through role models**—In addition to learning by directing engaging in mastery experiences, people gain confidence in their ability to carry out challenging behaviours when they learn vicariously through role modes. People learn particularly well when in gamified approaches, vicarious learning can occur when players watch other perhaps more experienced players engage in challenging behaviours successfully. Role models can also be provided by in-game characters (avatars) who can also act as role model and mentor. Role models who are shown struggling through difficulties and reaching their goal have been found in general to be more motivating for behaviour change that models of experts easily engaging in a difficult behaviour. Role models who show that their behaviours lead to a clear success are also more effective in changing behaviour. The advantage of the OrbEEt platform is that behaviours related energy efficiency can be made more tangible and visible through data visualizations than is usually the case with energy management. It can thus more clearly show a relationship between engaging in a behaviour and an outcome.

- **Verbal persuasion**—Verbal persuasion alone has very little effect on improving people's confidence in their abilities to engaging in target behaviours through challenges; however, people are persuaded that they have the skills to engage in target behaviours in a context then the persuasion occurs in a context in which they have actually mastered those behaviours. This can be seen as performance-based persuasion. In OrbEEt, mastery and

accomplishments should be acknowledge and used to provide feedback to users so that they can reflect on how their accomplishments reflect their capabilities.

- **Emotional response**---When engaging in target behaviours, people often gain information by monitoring their emotions. Emotions such as anxiety can be mislabelled as fear and may feed into people uncertainty regarding their ability to carry out a behaviour. It is often helpful to help people manage and label their emotions in healthy ways during learning experiences. For example, if someone's heart is pumping and they are sweating while practicing to give a presentation, these manifestations of anxiety can be labelled as their drive to do well and to focus on delivering content in a way that informs the audience rather than labelling it as a generalized fear of giving public presentations. It will be important when designing the gamified interface of OrbEEt to induce positive affect in learners so that they can appraise their behaviour change efforts as positive as well as their overall engagement with the OrbEEt platform.

3.1.3 Work on Expert Tutors

We draw from the classic work of Lepper and colleagues (Lepper et al. 1997) to describe the goals that the OrbEEt system should embrace to maximize motivation and engagement among users. This is a classic approach to promote motivation and engagement with digital interactive tools. The acronym, "INSPIRE", summarizes the approach that expert tutors use to engage individual learners.

- **I**ntelligent—The tutors were knowledgeable on the subject and also about approaches to teaching and learning. If the OrbEEt system can demonstrate these attributes in interactions, it will serve to create a relationship of trust between the user and system to promote ongoing engagement and satisfaction with the process.

- **N**urturing— Interactions between the tutor and student are characterised by behaviours that are attentive to ongoing responses and also empathy with the user struggles and successes. This promotes a relationship of trust between users and the OrbEEt system and promote user confidence in the face of challenges.

- **S**ocratic—Feedback should be through questions that hint at "correct" user responses. Information is not stated declaratively but hinted at. This is similar to more recent approaches of Problem-Based Learning (PBL). This approach will present a playful sense of challenge and interaction between the user and the OrbEEt system.

- **P**rogressive—Routines and material were progressive in difficulty with playful breaks interspersed with easier material to boost confidence. Progress comes only after mastery of material is demonstrated. Progress is also tailored to an individual's progress. On the OrbEEt platform, desired behaviour changes should be supported and scaffolded until target behaviour change goals are met.

- **I**ndirect—Feedback is indirect and never states directly that a student (in our case user) is "wrong." This is consistent with the Socratic Method mentioned above. This interaction style in OrbEEt will promote active learning and discovery and promotes a users' sense that they are mastering the material rather than being judged as right or wrong.
- **R**eflective---Expert tutors promote students to be reflective by asking questions (Socratic Method) that promote students to think about underlying reasons for problems, relationships to the real world, and connections with past learnings.

- **E**ncouraging—Expert tutors enhance motivation and confidence by celebrating success, downplaying failures, conveying confidence in student efforts. This approach enhances motivation and positive affect in the learning process of cognitive AND behaviour change.

- The INSPIRE approach should serve as a guideline for developing the content, especially feedback provided to users of the OrbEET platform to encourage and motivate users to learn and make progress.

3.2 Games and Gamification

Under the behavioural theories outlined above, gamification and gaming is applied within OrbEEt to stimulate intrinsic motivation to reduce consumption, support engagement with the platform, and scaffold behavioural change through gamified feedback. Central to its application is the consideration of the three interface components, primarily the smartphone game, but also how gamification concepts transfer to the non-interactive office displays and intranet portal. This section reviews a range of examples of the use of games and gamification in contexts similar to OrbEEt, noting that prior research in the identical context of public buildings is limited. However, a number of issues are identified in this section and discussed in terms of a wider understanding of how games and gamification have been applied in the past to address behavioural challenges. An initial example of the use of games to address energy behaviours is that of Börner et al. [3]. Here the authors discuss the use of pervasive interventions within a workplace to stimulate environmental awareness and learning. Similar to OrbEEt, the approach combines displays with personalised feedback and game-based elements, though with goals in terms of awareness and learning rather than direct changes in behaviour. Whilst awareness can be linked to behaviour, predominant behavioural challenges are those for which awareness alone is inadequate; since awareness itself can be quick to transfer but hard to measure. This relates to behavioural theories in the previous section which often posit that awareness of a problem is only a single step towards achieving change, moderated by a range of internal and external factors. Attempts to model these factors [4], show values to be a key influencer alongside knowledge, as illustrated in Figure 4.

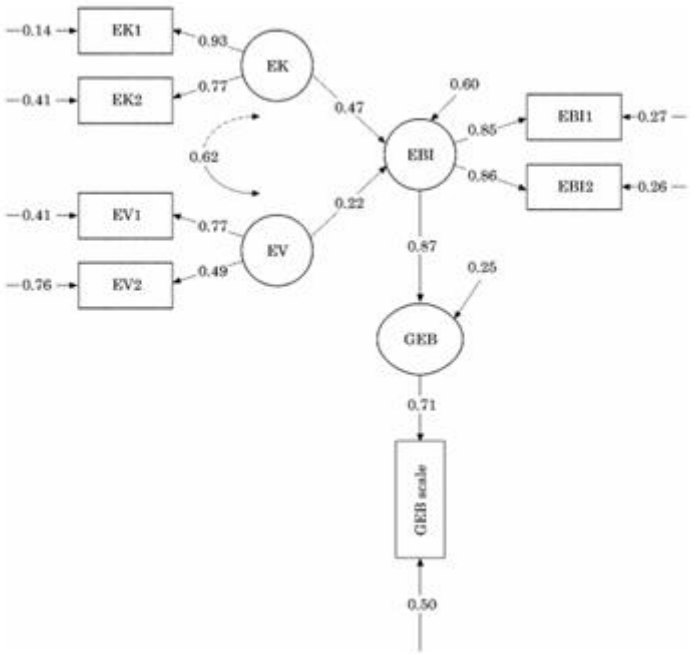

Figure 4: Structural model of the relationship between behaviour, intention, knowledge and values, from [4]. GEB=general ecological behaviour; EBI=ecological behaviour intention; EK=environmental knowledge; EV=environmental values. Numbers indicate β (correlation) coefficients

The relationship illustrated in Figure 1, should be noted in terms of its limitations as a structural model, principally that the metrics used were self-report Likert-based surveys and therefore the data shows links between self-reports rather than objective actions. However, it does offer some insight into factors which OrbEEt gamification components could target in additional to awareness. Games hold the potential to convey narratives and stories, which in turn can act as emotive or affective influencers towards values. Simgreen [5] is one example of a game which uses fictional contexts and situations to face players with immediate challenges, towards encouraging reflection and changes in day-to-day practice. As with other game-based interventions in the area, social components are placed at the fore with players assuming roles and teams. Ultimately the game seeks to motivate behaviours through the use of pervasive technology, in this case using augmented reality.

Use of a game as a motivator rather than educational resource is further exemplified by Piccolo et al. [6]. Knowledge can be a popular target to address as knowledge transfer is comparatively easier to achieve and measure than behavioural change. For example in road safety, modern interventions seek to ensure knowledge is applied, as in the majority of developed countries the correct principles for safe crossing are widely taught and known but frequently disregarded in practice. Similarly in the context of OrbEEt, knowledge of ideal behaviour is likely widespread; though can be tuned by the detailed feedback from sensors. To go beyond this layer of behavioural change requires a framework that enables, encourages, and rewards the application of this knowledge in an office context.

Central to effective gamification is the understanding that points, badges, leaderboards, achievements, and other common components (commonly termed "PBL" gamification) are not effective in isolation [7]. As an example the evaluation of Mindergie [8] showed players self-reports to indicate more enthusiasm and preference for challenging scenarios and problems, than for collecting badges and points. This is not to say PBL components are

universally ineffective, rather that without consideration of the meaning of each component to an individual, and how this meaning is constructed, their introduction can run the risk of gamification on only an aesthetic rather than a meaningful behavioural level. A meta-review of the influence of extrinsic rewards on intrinsic motivation, seeking to address whether extrinsic reward can negatively influence intrinsic motivation; or whether it has an additive "overjustification" effect. Findings of this review suggest extrinsic rewards have most value in studies where motivation is operationalised as task performance; hence, for gamification within OrbEEt, it is worthwhile to consider how individual tasks are structured and performance measured against them.

Task structure also relates to the common notion of "flow" within gamified and game-based scenarios [9]. A central concept here is gauging task difficulty against an individuals performance, in order stimulate a flow context, whereby immediate goals are self-attainable yet remain challenging enough to engage a user. In Vygotskyan terms, this can be seen in placing an individual in a zone of proximal development [10], in which they can develop in a self-contained and unobstructed fashion, rather than requiring intervention from more-able peer or trainer. Several components of games can make them ideal candidates for inducing a flow state. Firstly, challenge can be derived abstractly or added through mechanics which make an action more difficult to engage the user. This is also important when considering the findings noted above as related to Mindergie [8], fundamentally that users may be more likely to want challenge than reward. Secondly, when reward is given, it can be through rapid game-based feedback that supports steady progression towards goals or objectives, made tangible through aesthetic components.. This is advantageous particularly when related to energy-actions, as in the absence of additional feedback and scaffolding these actions can be typified by nebulous or intangible rewards, such as reducing global warming.

A further consideration of flow relates to the difference between perception of challenge, and challenge itself. To obtain an optimal flow state, Cziksentmihalyi argues, requires a degree of task balancing such that difficulty and ability are balanced, and both consistently increase. For a task designer, this requires creating scenarios or adaptive content which can address a user's steadily increasing level of ability as they learn experientially [11] on a task. For a game designer, this is commonly reflected in the player's reflexes being increasingly tested as they familiarise themselves with an increasing set of controls, but also the capacity to adjust the player's perception of their ability. Players are seldom ranked globally, and even games which utilise global leaderboards also tend to make careful affordances towards individual profiles and relative scores. For the "single player" game, the perception of ability lies purely with the design choices - a failure can be a "near miss" or complete disaster based purely on how feedback is provided.

Reaching, then, the conclusion that feedback is a central consideration in how OrbEEt creates flow and engagement by challenging its users, a next question is how might this feedback be visualised and constructed? Here we must consider the individual components of in-office displays, smartphone gaming, and intranet portal both individually and in synergy. Some high-level considerations immediately emerge, firstly whether a user is required to engage with all three components of the platform to benefit from the OBCF. Given that gaming, whilst increasingly pervasive, is still not a universal recreational activity, a risk exists of excluding non-gamers, or failing to deliver a challenging experience for gamers by attempting to cater to all backgrounds. It is worth noting that other interventions in the area have considered 16% uptake of an energy game against a general audience as "high" [12]. OrbEEt has the immediate advance of deploying tangible interfaces, particularly in-office displays, at the start of intervention, and these provide a potentially powerful means of communicating with users. Similarly the use of smartphones offers advantages in terms of pervasive, personalisation under the behavioural framework, whilst the intranet portal offers a means for

facilitating learning and personalised messaging. In the following three sections 2.3-5, the relationship of these individual components to the overall OBCF, and role of gamification within it, is described.

3.3 Gamification and Office Displays

It could be argued that as a medium which is not immediately interactive, office displays have only a limited relationship to gamification within the OrbEEt OBCF. However, whilst interaction is not through typical control inputs, a feedback cycle does exist between the behaviour of staff within an office, and the information fed-back by the in-office display: if they collectively save energy, they should expect to receive positive feedback. A number of previous approaches to providing feedback in a similar fashion have generated some insight towards best-practices. Pierce et al. [12] explore interaction design for eco-visualisations, outlining some key strategies for their use, though without specific affordance to gamification. Below we restate these strategies in specific terms of the OBCF and gamification of in-office displays:

- Offering behavioural cues and incentives. Under this heading, we consider that the displays trigger behaviours based on the data derived from the system outlined in more detail in D1.2. In gamification terms, these may not be restricted to immediate office behaviours (e.g. "close a window"), rather, related to the goals and objectives set within the smartphone game. Typically under "incentive" here a PBL gamification approach might suggest a slight evolution of "close a window" to "close a window for 100 points"; under the considerations noted in the previous section, these incentives should rather be considered in terms of their social influence, an individual's self-efficacy, and ultimately how these points are made desirable.
- Providing tools for analysis and insight. Whilst gamification and behavioural models often posit that knowledge alone is not sufficient for behavioural change, it is nonetheless an important contributory factor [4]. Therefore, providing this knowledge in a meaningful and considered way is a principal goal. This should accommodate consideration of how competition and collaboration are scaffolded; a risk in presenting information alone is a reduction in perceived self-efficacy if individual efforts are offset by group trends, conversely, a high-performing group may encourage an individual to make little personal effort.
- Creating social incentive to conserve. The impact of in-office displays on peer dynamics is likely to prove a central component of their role within the overarching OBCF. Hence whilst in-office displays provide a means of directly communicating consumption (e.g. energy and CO_2 as per the sensor metrics described in D1.2), they also offer an opportunity to re-frame this information in collaborative and competitive terms, supporting the overall behavioural model.
- Connecting to material impacts of consumption. Comparators are a useful tool here with respect to the office displays. Is, for example, the energy emission for the office higher or lower than other pilot sites? What is the longer-term consequence of emission or consumption at this level? Abstract and engaging visualisations here may be more impactful than raw data alone.
- Encouraging playful engagement and exploration with energy. Links to the smartphone game and progression within offer a means to create a more pervasive gaming environment, similarly, seeing the immediate impact of actions (e.g. turning off a device), or long-term outcomes offers a way to encourage people to experiment and explore how the data afforded by the OrbEEt platform allows them to explore "what-if" scenarios and

try new methods within their office to reduce consumption, reflected immediately in the data available on the display.

- Projecting and cultivating sustainable lifestyles and values. Informational aspects of displays offer potential for changing values, another important contributor to behaviour [4]. Values can be largely driven by peers, and how their performance and that of the group is an essential concern when seeking to change culture and values by in-office messaging. Links to the smartphone game may also allow for some aspects of in-office displays to provide more abstract and narrative-based components that seek to engage users and prompt discussions. The impact of these components on emotion and affect can be considered in terms of how it may contribute to the establishment or adaptation of lifestyle and values beyond the confines on the monitored environment within OrbEEt.
- Facilitating discussion and raising public awareness. Given the social context of the office, information provided or problems posed by displays should aim to stimulate discussion and interaction within the office. Problems can be framed either in terms of links to sensor data, e.g. "consumption has gone up over the past week", or general environmental questions intended to stimulate debate. A final consideration for pilot sites that include publically-accessible displays is how these displays should accommodate for awareness-raising as well as providing information salient to employees.
- Stimulating critical reflection. Temporal visualisations of data are important here. A principal goal of feedback under an experiential model is to stimulate reflection such that a user can adjust their future actions under a cyclic process [11].Hence, allowing a user to see the impact of their actions enables them to reflect and adjust future behaviour to learn and adapt towards a positive outcome. Important also here is the need to balance self-efficacy against supporting group and peer dynamics; showing "per user" data on an in office display may be beneficial for competitive motivation, but also risks negative impact with poor-performers feeling singled out for negative feedback. How this information is framed and presented, for example showing only a top performer rather than a complete ranking, can ameliorate or avoid these potential negative impacts.
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Given these overall strategic considerations, how gamification can be applied to these strategies forms the basis for its role within the OBCF as relates to the office displays. Recurrent themes identified above include how to provide feedback in a tangible and immediate way; how to scaffold collaboration and competition through how information is presented; and how to encourage experimentation and discussion within an office space. An advocation within the OBCF would be consideration from both individual and group standpoints of how a visualisation or message impacts behaviours. Gamification is therefore salient in terms of its capability to grant immediacy to feedback through abstract goals, achievements, and objectives, as well as its potential in providing group and individual feedback which supports collaboration and competition.

3.4 Smartphone Game

The smartphone game offers a particular opportunity to use abstraction, aesthetic, and fiction to engage users, particularly those who may not be immediately concerned with energy consumption or optimising office processes. Reviews of serious games, which tend towards defining them as approaches seeking to create bespoke interventions and environments for set objectives, contrast with gamification which largely seeks to adapt existing processes and models [13]. Consequently, serious games have both inherent advantages and disadvantages

when compared to gamification approaches. Firstly, as they need not necessarily have an existing process or system at the core, they can afford to be more abstract and creative in terms of how learning or behavioural objectives are addressed. Orland et al., [14] for example use "energy chickens" in various states of well-being to metaphorically illustrate consumption. However, this also risks learning outcomes being less tied to immediate systemic impacts or measurable behaviours, as the game can be removed from the same process it seeks to measure. This is evidenced in the large range of evaluations of serious games that seek to assess contributory and transient factors relating to behaviour such as awareness, rather than objectively measure the behaviour itself [15].

Games with large scale reach or more concrete evaluations of efficacy have tended to make more use of narrative elements and place gameplay as central , rather than as an added layer of content. For example Code of Everand created a fantasy-MMO game design, abstracted far from its serious objectives in terms of road safety, and successfully attracted over 100,000 users for an average playtime of over 90 minutes [16]. Similarly Re-Mission demonstrated measurable improvement in treatment adherence amongst adolescent cancer sufferers through the implementation of a game with sci-fi shooter-based gameplay [17]. As Connolly and Boyle note in their review [15], little comparative evidence exists for games which are designed principally with educational material at the forefront, though what does exist suggests these games are successful in a context where they replace an existing classroom or training activity [18] and can therefore rely on an audience intrinsically and extrinsically motivated to engage. Engaging users in additional work or learning activity, outside of formal classroom training time, is a more challenging goal to address, and again other successful games in this area such as America's Army have tended to again place gameplay at the fore [19].

Specifically considering the themes of organisational behaviour change and energy consumption relevant to OrbEEt, further game-based interventions have been applied in the area, but few have robust data validating or verifying a particular design decision or framework. The aforementioned example of Orland et al. [14] placed all subjects in a baseline condition for 4 weeks, then proceeded with the intervention, showing a reduction in overall energy use during the 4-week intervention phase of 13% (n=42). Whilst this is a promising indicator of impact, it remains difficult to ascertain or infer what particular elements of this approach contributed to this impact. Similarly, Simon et al. [20] provide some useful design guidelines for pervasive, work-based energy interventions, but in the absence of their validation they provide points for consideration, rather than answers to design decisions. Many serious game design frameworks similarly outline considerations rather than evidence specific design choices, although the successful examples above reinforce Zyda's early point that gameplay should be at the forefront of a serious game [19].

The frameworks that do exist range from the 4-dimensional consideration of usage context, representational medium, learning requirements, and audience, expanded to include a consideration of feedback modalities [21], through to models heavily advocating participatory design and iterative development [22]. The latter advocation is certainly valid insofar as iteration against a problem is likely to yield an incremental solution, the dilemma, therefore, is how to conduct such iteration within finite resources and timescales. Often the cost of a highly iterative approach is a less-polished end product, and supporting exploitation under the business models for OrbEEt (D1.1) benefits particularly from a highly usable and validated end product, within the scope of both functional and non-functional requirements. Similarly, participation can be invaluable in gaining ideas and concepts which are already understood and advocated by a target audience, however, there is a risk in attempting to ask a participant with a limited background in technology, behavioural theory, or educational design to design an educational resource or behavioural intervention [23, 24]. Rather, their inputs require

moderation and consideration by experts from relevant backgrounds, and can add complexity, fundamentally resulting in interventions that attempt to impact an entire demographic and consequently fail to engage a clear target group.

From an entertainment design perspective, consideration of audience is often an intial step towards designing to specification. Bartle's established taxonomy of gamers into "achievers", "killers", "socialisers", and "explorers" [25] derives in-part from psychological type theories, in turn based on established work in this domain [26]. Whilst the critiques of such typification remain true, in particular that a user may transition between types rather than remain in a constant classification, the value of Bartle's work lies principally as a design aid in considering that any game which successfully appeals to all four types is more likely to attain and retain a critical mass of users. The types themselves are loosely-defined and cross gaming genre boundaries, though apply principally to multiplayer gaming, relevant to the social theories of behaviour outlined in Section 1. In such a context, "achievers" are likely to be driven by clear goals with immediacy of feedback, predisposed to the aforementioned "flow" state of goal-setting and accomplishment against adversity and challenge [27]. "Killers" are competitors, driven to defeat or better other players, though this can be in ways other than directly "killing" them in game as the title suggests, for example leaderboards can provide a means for players to defeat others without direct in-game conflict. The third category of "socialisers" relates to players who principally use a game as a communication and social medium, in practice this can mean non-gamers who have little interest in defeating the game, but are willing to engage to communicate with colleagues. Finally, "explorers" are content-consumers, and potentially the hardest group to accommodate, as they constantly require new or expanded content to explore. This can be in the form of worlds and virtual spaces, or in terms of new objectives, mechanics, and tasks: however, all require development time, and therefore a principal consideration when seeking to develop a game which engages players throughout an intervention such as that of OrbEEt, is how to best align resources to meet the needs of all four types of player.

Aligning a consideration of player types to the observation that high-impact serious games have typically used abstraction alongside compelling game mechanics, it becomes possible to view the OBCF in these dimensions. Below, outline recommendations for the game, interfaced to the sensor architecture in D1.2, are provided:

- Supporting achievers. Goals in the game should be made immediate, relevant, and allow a high-degree of self-efficacy in their accomplishment. It should be explicitly clear to a user what their immediate goals are within the game, and these should be related to the wider OBCF, however this wider relation need not necessarily be visible or transparent to the user. It is possible to use achievement to scaffold indirectly desirable outcomes rather than drive down consumption itself; e.g. find a more efficient way to conduct a business process, or initiate a social interaction towards building stronger social ties or peer norms.
- Supporting killers. How competition is handled is a common design challenge in a serious game. Performance can be assessed at individual, office, site, or all site levels, the design challenge is in how these performances are framed to be simultaneously inclusive, allow self-efficacy, and encourage collaboration. Synergy between interfaces is important here; the in-office display, for example, is a viable means of providing group-feedback, whilst individual feedback can be provided by the intranet portal and serious game. Similarly important is the notion of asynchronous multiplayer, as users may not be available to play simultaneously and therefore these components, such as leaderboards or drop-in/drop-out multiplayer during single player sessions warrants consideration.
- Supporting socialisers. How communication is handled both within the game and across interfaces is important, but should also be considered in the context that OrbEEt "players" may well be co-present within an office or site. Stimulating an office discussion beyond

the confines of technology can be a more useful tool than insisting users communicate directly through the platform and interfaces, moreover, this type of interaction has greater potential to translate to real-world action lowering consumption or optimising a business process.

- Supporting explorers. Designing a game to which players return frequently rather than play in a single session is a particular challenge in itself, as a game that establishes a flow experience can be played to completion in a continuous, long, play session rather than experienced in short bursts ideal to the OBCF. Links to real-world data can induce a potential "wait time", though this needs to be carefully managed to avoid frustration and disengagement. Allowing users to create content (of which an exemplar of a non-serious game would be MineCraft), or use procedural tools to create an expansible self-creating gameworld can provide means by which to create scalable content without requiring continued and protracted development time.

Alongside the above considerations, strong narrative and storytelling elements can also provide a means to engage users, particularly with respect to the aforementioned role of values in behavioural change. Many serious games use narrative as a core element [28-30], ranging from its implementation as an overall "back-story" explaining the player's presence and purpose in the world, through to a more frequent use through cut scenes or dialogues, which are frequently interactive and multiple-choice. In either case, this can be offset against a real-world, simulation based narrative, or a fictional, abstract storyline. In the case of a fictional storyline, the greater degree of freedom afforded in writing can allow for emotive and affective aspects to be more quickly realised, similarly, users are familiar with fiction and role-playing in games, with even non-digital gamers largely familiar with the concept of taking a role within a table top game.

An overall informed game design for OrbEEt, therefore, takes into account its audience as outlined in this section, and analysed in more depth in Section 3.1. Existing evidence would support a case for using a fictional and abstract scenario as a basis for the game: examples could include users in a future world in-crisis due to global warming; a fantasy world with "light" and "dark" areas related to consumption, or a procedural "rogue-like" single player game that allows other OrbEEt users to drop in and out to assist a player. Undertaking such abstraction requires linkage and scaffolding back to metrics (D1.2), this functions on an understanding that sensor inputs, as with any other variable, can ultimately be distilled to a discrete or continuous value and used to drive an input. Similar to the use of a wide range of novel interface devices to drive gameplay states, such as BCIs [31], sensor data in real time and filtered in spatiotemporal terms can be used as inputs to support behaviours or states regardless of the narrative or abstract context of gameplay.

3.5 Intranet Portal

As a persistent resource for OrbEEt participants, the intranet portal offers the potential for a more learning-centric content. This synergises well with the game and in-office displays, allowing the former to focus on rapid feedback and engagement, and the latter with easily understandable information, formatted with the considerations of Section 2.2 in mind. It also offers the potential for a user to gain a more direct and personalised view of OrbEEt sensor data, supporting the need for self-efficacy as well as group collaboration and competition. A number of previous reviews and projects have considered the use of web-based information resources to convey sensor data, including the frequent concept of a carbon "dashboard", that gives users either control of, or information from, a set of connected devices. A design method put forward by Suppers et al. [32], though focused on domestic rather than office-

based energy use, categorises users as "pinball", going from state to state without consideration; "shortcut", looking for ways to game or circumvent a system, or "thoughtful", considering their actions and consequences. It provides some insight as to how to scaffold these various user types' interactions with an interface, suggesting adaptivity or a wide feature set is required to support all potential behaviours.

Similarly, Yun et al. provide a set of principles for instigating workplace behaviour change regarding energy [33], going on to implement these in a dashboard-type environment [34]. They place self-monitoring, advice, and control as overriding themes, an important consideration given much of the sensor data collected by the platform is difficult to link to a single user (D1.2). Whilst, for example, a single device's consumption may be tied to a user, it may indirectly benefit others (e.g. a desk fan) or be critical to a business process (a desktop PC). Regardless of monitoring technology deployed, it can prove difficult to assign consumption to a single individual's behaviour within a shared space, making the themes of Yun et al. interesting in principle but difficult to implement in practice, with the corresponding study showing limited improvement in the absence of a comparator. A subsequent question, with a partly ethical basis, is how reasonable it is to present information to a user such that it engenders an illusion of self-efficacy and control, rather than control itself. For example, whilst a user switching off a desk fan might in turn lead to a colleague opening a window, resulting in an individual decrease in consumption but an overall increase. How this is communicated to individual users through the portal requires careful consideration when seeking to induce and reward both individual and group behaviours.

Whilst learnt knowledge alone is often insufficient for behavioural change, it is a component of many models, and the intranet portal offers potential for transferring both immediate and background knowledge to a user. There are two immediately viable models for learning within the intranet portal:

- Experiential learning [11] through the capacity of a user to act, reflect on data, and subsequently adapt their behaviour to gain increasingly positive feedback. This is primarily driven by the data from the OrbEEt platform, and how it is interpreted and presented in the intranet portal. As noted above, this should be done with careful affordance towards target behaviours under the OBCF as identified in Section 1.
- Knowledge transfer of best practices through static content within the web portal documenting from an existing or bespoke evidence base tips, advice, and guidelines on how to reduce consumption, as well as the long-term benefits. This can be augmented by the use of social media aspects (e.g. forums), ensuring content is dynamically created by users, though requires a degree of critical mass, which may be further complicated by linguistic or cultural barriers towards cross-site communication.

A focus of this section is how these components can be enhanced through the use of games and gamification. In the case of experientially-driven learning from sensor data, this is relatively straightforward to align to game-based learning approaches, as many derive from or expand experiential principles, a consequence of many serious games using simulation-based cores [35, 36]. Effectively, the role of game elements here is commonly to add immediacy of relevance, or frequency, to feedback cycles. Game-based approaches have shown benefit in terms of learning transfer when making feedback shorter in duration and more frequent to an alternative condition [37]. Harnessing this ability within the intranet portal requires the consideration of each data source in terms of how feedback to the individual and group can be made more frequent, such as by the use of real-time data from sensors linked to actions, and how it can be made relevant to an individual's sense of self-efficacy and short-term action. Again, the granularity of sensor data can be exploited here to provide metrics against both immediate action, short term outcome, and longer-term goal.

In the case of knowledge transferred by the platform, gamified approaches have shown promise in encouraging content linked to achievements and rewards to be viewed and shared more by users [38], when compared with content alone. Social mechanisms such as "likes" can be viewed from a gamified perspective as users seek to create "liked" comments and perspectives, and an overriding requirement of a gamified approach to such content is to allow a certain degree of user responses and adaptivity; e.g. use of a wiki versus a static resource; linking between knowledge elements and discussion forums; or allowing simple, rapid feedback from users demonstrating their preferences for content or enabling them to recommend it to others. Gamification here can be subtle rather than invasive, for example encouraging users to share or collaborate by social status, such as their user "tag" on a forum related to their number of posts, rather than involving PBL explicitly. A drawback of such approaches is a requirement for a critical social mass, difficult to ensure with a limited set of pilot sites and end users, and further complicated by cultural and language barriers, as well as different regulatory practices and objectives which may influence how ubiquitously "correct" information can be.

In the absence of a guaranteed large number of simultaneous users, asynchronous methods of communication are likely to synergise more efficiently with limited time within a workspace, differing working patterns, and levels of engagement with OrbEEt. Therefore, forums appear a more viable mechanism than live chat, similarly, wiki-based resources may prove a useful means for encouraging users to collaborate to develop content without requiring their synchronous participation or communication. Under the OBCF, a goal here is to not only transfer knowledge and best-practices, but also engage users socially within the OrbEEt platform to create a sense of OrbEEt identity and social standing amongst peers. This further links to the use of sensor data to the individual and group profiles, providing a means for a user to further extend their self-efficacy by influencing, guiding, and helping less-able partners in developing their understanding of the OrbEEt system as well as their wider sense of pro-environmental values and behaviours.

3.6 Summary of Games and Gamification in the OBCF

Section 2 has presented a high-level consideration of the role games and gamification play under the OBCF, with specific references to the individual interfaces in Sections 2.3-5. A principal goal of the use of games and gamification is to synergise with the behavioural models identified in Section 2.1 towards the holistic OBCF presented in Section 4.

The high-level concepts from this section can be briefly summarised as follows:

- The game and gamification layer runs across the individual interfaces, with game-based elements and mechanics present in all three user interface components
- The in-office displays are designed with specific regard to how individual and group performance is fed back. This applies a consideration of how key game based elements of collaboration, competition, and the relationship between feedback and sense of self-efficacy can be scaffolded and supported by the abstraction of sensor data (D1.2) into gamified visualisation.
- The smartphone game builds on abstraction and metaphor to place engaging gameplay at its forefront. This aims to facilitate uptake and engagement with the OrbEEt platform as a whole, with the sensor data being used as inputs to the game at a variable level (for example, though not limited to, a game world becoming more oppressive as consumption increases). Due to challenges in establishing and retaining a critical mass of players, gameplay should be viable in a standalone "single player" fashion, but in view of the wider goals of supporting social interaction within the OBCF, affordance should be given towards asynchronous multiplayer through comparisons of performance or drop in/out multiplayer.
- The intranet portal acts in concert with the other two interfaces to provide informational data from sensors and learning resources to the end user. Gamification here supports the use of asynchronous methods for allowing users to adapt content, contribute to discussions, and develop their own profiles when using the portal.

4. THE ORBEET CONTEXT

This section aims to detail the specific pilot sites in OrbEEt, as well as the wider exploitation goals. It seeks to provide a means to consider the behavioural theories examined in the previous section in terms of the particular advantages and constraints of the OrbEEt platform.

4.1 Audience and Context

A strength of OrbEEt is a wide diversity of cultures and roles in audiences across pilot sites. Whilst this offers an ideal opportunity to gain insight into how the OBCF can apply to these different audiences, it also presents a challenge in adapting and designing OrbEEt components within finite resources to offer an experience accessible and usable to all groups. Localisation is a particular challenge, not only in translating content to different languages, but also in reflecting how cultural differences might inform adaptations to user interface and experience design.

The below tables summarise a secondary analysis of the outcomes of pilot-site requirements, available in more detail in supplementary reports obtained within Year 1 of OrbEEt. The particular focus of this secondary analysis is identifying the audiences within each pilot site.

Pilot Site Audience and Context - BHoE
"Proposed rooms: • one set of rooms used for museum purposes • one set of rooms used for event purposes • one set of rooms used for office purposes" This offers a wide set of contexts (discussed further in S3.2), but also a diversity in the audiences that will experience the displays provided by OrbEEt across the platform. The possibility also exists of visitors using the OrbEEt game, though an immediate concern is how to adequately balance a smartphone game to ensure both single-session play alongside the retention likely to be needed to impart meaningful behavioural change. "The first set of rooms is the main use of the Imperial Palace Innsbruck (round about 30%). In the Museum there is regularly one exhibition per time. The actual exhibition “The Last Things in Life – An Exhibition about Death and Mourning 1765 – 2015” will be shown from 6th June 2015 until 10th January 2016. The first planning activities for the following exhibition have already started. The expected number of visitors (the updated number from last season) will be around 300 to 350 visitors per day. The Museum is opened nearly 365 days (there are only few closing days, mainly because of public events, like an Official Reception of the Provincial Governor of Tyrol), 7 days and 9 hours per day. There is nearly no restriction in regard to measurements, except official events (as described above)." A particular consideration for the BHoE site is this potential engagement with visitors as well as staff. "The set of rooms for events is using round about 4% of the Imperial Palace Innsbruck. Due

to the varying load there is no restriction as well as it is opened like the Museum. The third set of rooms is dedicated to office work. This set is using round about 17% of the total area. In these offices there is no direct contact between civil servants and citizens. Only 20 persons (staff members) are working there. Some of them share an office area and others are always on their ways through the building. The official working time is between 8:30 a.m. and 4:30pm."

Visitor engagement presents a specific challenge to the OBCF as measuring impact on visitors, who may only use a single component such as the office displays, will be difficult due to the transient nature of their interactions with OrbEEt. Thus, at this pilot site, there will be an emphasis on applying the OBCF to focus exclusively on interactions between staff/building managers and energy data. There will be little to no input from visitors and interactions with them at BHoE

Pilot Site Audience and Context - Erlangen

"Erlangen has selected the Interdisciplinary Centre for Health Technology Assessment (HTA) and Public Health (IZPH) as the pilot sites. The following six rooms (with the appendix of the floor plan of IZPH) are suitable for the project [see pilot report for more detail]: Director's office, Data management office I, Data management office II, Researcher's office I, Researcher's office II, and Meeting room. The heating system and electricity system are regulated and paid by the hospital management system. The hospital management system will take the building as a whole, so there is no energy consumption data for the pilot site alone."

The Erlangen audience includes research professionals and data management staff. These are likely to have a high level of technical understanding as well as academic awareness of the project and its objectives. On the one hand, this suggests they will be able to engage quickly with the OrbEEt platform and apply a degree of self-solving to technical issues with prototypes; on the other, their expectations of the platform and its performance may be higher than less technical or academic office spaces on other sites. An interesting side-consideration will be whether, under the stages of change [1] approach advocated by the OBCF, these staff fall into the "maintenance" category having already high-levels of engagement with environmental considerations. This can be, though is not guaranteed, linked to their educational level and profession [3]; however, it may equally be the case that demanding business processes limit affordances for pro-environmental behaviours.

Pilot Site Audience and Context – Asparenna

"The first two [of the three sites], are main areas where take place the daily administrative activities of the Municipality. Their occupants, are the only diary and regular staff at the Town Hall and they perform administrative and municipal office tasks. Both offices are connected through a glass door (always opened) and it could simplify data collection during the project. There is also an available desk (almost never used computer, telephone...) in the Public attention office and a thermostat, to regulate the temperature of all the first floor, in the Administrative office.

Mayor's office is the other interesting area, because of the diary processes that take place in

there and because of the Mayor, as municipal representative, is a regular user of the Town Hall performing there many tasks and meetings. In this room, there is a thermostat to regulate the temperature of all the second floor (excepting Plenary Chamber).

There have been omitted three individual offices and a double ne, because they are not always used and several occasional workers use them to do many different task, thus it could be a problem to coordinate everything within the project. The Plenary Chamber and a small meeting room neither have been considered because their use is occasional."

Asparrena's Mayoral Office presents yet another differing audience for the OBCF to tackle. The majority of work on this site is administrative, though this also includes high-level mayoral duties and meetings. In contrast to BHoE, visitors are more likely to interact directly with staff for extended periods, undertaking different business processes, rather than viewing exhibits and exhibitions as is the case with BHoE. As such they become actors in these processes, and there may be a greater affordance for their engagement with the OBCF as a consequence. However, multiple visits are also unlikely, and the core target remains the staff within the office rather than visitors.

Pilot Site Audience and Context – Pernik

"Integration with district heating installation (it is the same for all pilot areas):

The heating in the building of the Pernik Municipality is centralized. Each room is heated by one cast iron radiator. There aren't any individual closing valves nor thermostats, therefore the decision making level of the occupants with regards to the heating of the offices is zero. The bills for the heating consumption are paid in regard to the occupied surface.

Occupants profiling:

The employees in the Reception room accept documents for social assistance. There is one computer used during the working hours for reports and fillings of submissions.

The rest of the employees in the Social Security Department use computers and other electronic devices during the whole working day for processing documents. Most of the rooms are interconnected with internal doors.

Total number of employees in both departments – 20. "

Pernik offers a relatively large number of employees within the pilot site, and thus social components of the OBCF are likely to be well-supported here. However, this also challenges the OBCF in terms of self-efficacy, as site members have no control over the ambient temperature as noted above. A particular consideration of this as an exemplar of a pilot site wherein all processes and systems are not necessarily under the control of the staff is how the system adapts and functions in the absence of a particular capability or functionality. This also relates to the overall functional requirements of the system (D1.1).

The comparison of these pilot sites in the above tables gives some insight into the opportunities and restrictions within which the OBCF and its stages of change must function. These can be summarised as follows:

- Support and consideration of visitor engagement. The challenges with this as noted above are that visitors across OrbEEt can come from a wide range of backgrounds and different contexts, for example being involved with a business process at Asparenna or Pernik, or visiting an attraction at BHoE. Furthermore, as visitors may only observe a single component of the system, and be difficult to individualise and encapsulate within the OBCF, impact on visitors is difficult to measure. Therefore, an advocation with respect to this point is that wherever possible displays be made meaningful for passive observers, wherever a design decision needs to be taken between participant and visitor support, it should fall in favour of the participant. A further consideration particularly relevant to in-office displays is that as visitors may observe these, anonymity and data protection for participants should be observed at all times.
- Support and consideration of limitations in user control. As in the Pernik example, from a cross-pilot perspective individuals may not have either the technology or authority to make changes in their office environment. Part of the solution here is to design the OBCF such that this inability is accounted for; the other part lies in usage of the intranet portal and supporting services to allow employees to collectively identify recommendations for changes to business process or environment and communicate these to staff who may not themselves be based within the pilot site, but have the authority or control to enact them. This is also crucial from a self-efficacy perspective.
- Cross-cultural and linguistic localisation. Providing bespoke solutions to all four pilot sites is beyond the scope of OrbEEt, furthermore, the projects central goal is a holistic solution which can function in a wide range of public offices rather than being limited by extensive situated and localised requirements. Support for this therefore requires text to be kept at a minimum in both smartphone game and in-office displays, instead using visual representations which cross cultural and linguistic boundaries wherever possible. Similarly, allowing content to be co-created or uploaded to the intranet portal by participants and host organisations allows both the means for this content to be expansible and dynamically generated, and also allows employees to create their own resources based on their office culture, social dynamics, and wider environmental views.
- Support for a wide range of initial levels of engagement, both with the project and its environmental goals. Within the stages of change approach in the OBCF, these stages are already recognised and accounted for, hence, to support these differing levels of engagement requires the behavioural model to be fully contextualised for OrbEEt and its technologies, as outlined in Section 4.

In summary, reflecting on the data provided by pilot sites audiences and contexts provides a means to ground the behavioural theories presented in Section 1 against the context not only of the pilot sites, but also in terms of a wider potential future audience. This supports the business plan (D1.1) by ensuring that sites meeting functional and non-functional requirements can expect to deploy and gain benefits from the OrbEEt platform without requiring extensive adaptation to meet their needs. Whilst areas such as game content, intranet portal moderation, and technical support for sensor infrastructures are likely to require a model of sustained investment when deployed beyond the immediate project, the OBCF seeks to optimise the performance of the platform under a wide range of audiences and contexts as illustrated by the diversity of the pilot sites. In the next section, we outline with reference to D1.2 the technical opportunities and constraints of the sensor and business process monitoring and modelling.

4.2 Technology

OrbEEt presents the opportunity to scaffold interactions with the OBCF through the integration of an extensive suite of energy and business process metrics. These are provided at differing levels of granularity, for example focusing a specific or immediate timeframe, or certain location. In terms of the concepts outlined in Section 2, this is of particular relevance to how individuals' senses of self-efficacy can be realised through immediate feedback cycles. This can range for an immediate update of an in-office display, to an impact on game-based feedback by adapting a scenario or mechanic in-line with a reduction or increase in consumption of efficiency. The measures can largely be grouped into energy and business process dimensions; whilst OrbEEt's principal aim is one of energy-efficiency, this can be thought of as either a reduction in consumption whilst maintaining the performance and output of a process, or an improvement in the output of a process whilst maintaining consumption. In both cases, the outcome is a net gain in efficiency, with a business process gain ultimately demonstrating increased output under the same input. Hence, it is important to consider both of these measures in combination when seeking to ascertain the value of a particular action, behaviour, or process change.

There are therefore two steps in establishing a positive behavioural change under the models reviewed in Section 2.1 and presented in Section 4 as the OBCF. The first is to consolidate and quantify sensor data such that a change can be perceived as positive from both business process and consumption dimensions. The second is to feed-back and support the user in promoting this change to peers socially, as well as empowering them with a sense of identity and self-efficacy as making a positive change on workplace efficiency. In both cases, all three interfaces of in-office displays, intranet portal, and smartphone game are of relevance, though in the case of establishing a positive change, this requires technical structure and consideration rather than self-determination from the user. Such an approach addresses the fact that a user may misperceive a short-term gain but long-term loss, a common issue identified in environmental, and more general, psychology [39]. For example, routinely shutting down and restarting a PC could have immediate impact on energy consumption, but also interfere with a business process such that the loss in overall efficiency over the longer-term of rebooting and shutting down every time a business process initiates outweighs this positive impact.

With respect to supporting and scaffolding behaviours, provided optimal metrics are derived which combine consumption and business processes, as is the case with OrbEEt as detailed further in D1.2, the goal of the OBCF is to guide and support towards these processes. The range of initial metrics and levels of granularity are identified in D1.2, and are consolidated into Table 1 on the following pages for discussion in terms of their relevance to the OBCF under the concepts outlined above. Coupled with the consideration of audience and context provided in Section 3.1, this provides a complete background of the environment in which the OBCF is intended to function. Whilst the principal target in this case is the pilot sites, this high-level comparison is also relevant to the organisational needs of future potential sites which meet the functional and non-functional requirements outlined in D1.1.

	Measure (D1.2)	Relevance to OBCF interfaces		
		In-office display	Intranet portal	Game
Sensor measurements	Energy Consumption per m^2	At immediate temporal granularity allows for the impact of actions on energy saving to be made visible to the office.	Can provide social sharing and discussion medium(s) helping users collaboratively identify and track actions that reduce consumption. Consumption per process in particular is a longer-term consideration which requires collaboration between office members to ensure reductions in consumption are not offset by losses in productivity. Again, the intranet portal can provide social tools and mediums to enable this communication and negotiation.	At immediate granularity as well as longer-term measurement can be used to drive game mechanics as an input variable
	Energy Consumption per device	At immediate temporal granularity allows a high-degree of self-efficacy in visualising immediately a device deactivation (or activation) to the group. Over the longer term allows users to develop a sense of ownership and responsibility for a device.		Can be used to drive game mechanics as an input variable that can be immediately modified; however care should be taken to avoid compromising business processes (e.g. switching off a critical desktop PC).
	Energy Consumption per Business Process	Provides more individualised, small group feedback on costly processes encouraging users to optimise.		At immediate granularity as well as longer-term measurement can be used to drive game mechanics as an input variable
	Energy Consumption per occupant	Can provide per-occupancy feedback however care should be taken, as this is total / occupants, rather than individual profiling.		
	CO2 Emissions per m^2	See above; however, CO2 can be	Allow for sharing and development	Game narrative and environment

	CO2 Emissions per device	used to push forward environmental savings, whereas energy is more disposed to cost-saving.	of learning resources on environmental benefits; allow for collaborative goal-setting	could adapt in response to monitored CO2 emissions, allowing users to experiment with different consumption scenarios and their future impact.
	CO2 Emissions per Business Process			
	CO2 Emissions per occupant			
Business process measurements	Building Utilization Level (BUL) per Year	This is likely beyond the immediate control of participants, however, its display can help balance the challenges the users face, and be included when computing consumption per occupant for displays.	Allow for sharing and development of resources for participants that join an OrbEEt office space; transfer best-practices so new occupants causing increased utlisation quickly develop good habits.	Can factor in utilisation to use more accurate occumpancy/consumption ratio to drive game mechanics.
	Business Process Cycle time	Communicating this to users via displays encourages considered approach to consumption reduction which does not compromise, and ideally enhances, business processes	Resources on business process optimisation made available for development and sharing via the intranet portal offer a means for staff who may not be able to directly alter process cycles a means to communicate with senior management and colleagues. Staff able to immediately change process cycles can discuss and review ideal methods for their introduction.	Process cycles and utilisation could again drive game input as a variable. Game scenarios could focus on process management and optimisation, though in an abstract medium designed for engagement.
	Business Processes Utilization		Similarly to the above, resources on	

		process utilisation allowing users to identify and share commonalities in optimal or suboptimal processes stimulate collaboration and learning.	
Percentage Building Used	Linked to occupancy; may be difficult to estimate outside whole-site pilots or localise to office space		
Device Utilization Level (BUL) per Time period	Linked to energy monitoring - secondary measure		
Process Resource Use (PRU):	Allows further identification by users of problem areas	Allow again for sharing of best-practices	Linking to game mechanics here offers the ability to rapidly feed back on reductions and reward problem identification and solution.
Active Energy Resource Usage	Separation into passive and active use on displays allows users to identify problematic devices and respond accordingly	Allow for discussion and collaboration over historic trends and causal factors in usage changes; material on common problems and solutions.	
Passive Energy Resource Usage			

Table 1: Relationship between measurements and OBCF via interfaces

4.3 Summary

Before outlining the OBCF in the next section, it is worthwhile to summarise the key outcomes of the consideration of audience, context, and technologies underpinning the OBCF as highlighted by this section. OrbEEt has a breadth of cultures, contexts, and audiences across its four pilot sites, and in accommodating these various needs are identified in Section 3.1 as including visitor as well as user engagement; limitations in user control and their impact on self-efficacy; localisation; and supporting various stages of engagement. From a technology standpoint, principal goals are the identification of target behaviours arising from sensor data, and the application of the OBCF to support the development and continuation of these behaviours. It is worth noting these behaviours can be construed either in terms of changes to immediate actions, for example conducting a process differently, or higher-level outcomes, such as a shift in values and thinking towards more pro-actively searching for opportunities to optimise processes. Underlying this are the needs identified in Section 2 to support this on both individual and collaborative levels. For the individual, a sense of self-efficacy is central to stimulating change under key theoretical models [2], however, this needs to be accompanied by facilitation of peer interactions and social dynamics which themselves can act as powerful motivators under the same models [40]. Consequently, we aim to provide in the OBCF a high-level model which accommodates this wide range of factors.

This also relates the validation of the efficacy of the OBCF within OrbEEt, as behaviours which are difficult to measure are equally difficult to measure the impact of an intervention against. However, this is also why these behaviours remain current challenges in both research and practice. Hence, whilst OrbEEt delivers particular capacity to provide interfaces which respond dynamically to changing information from sensors to address behaviours, the metrics these sensors provide are equally valuable in supporting the assessment and validation of the platforms efficacy. Understanding and recording the differences in audiences and contexts, including the constraints of a particular site on self-efficacy or social collaboration, also offers potential to gain insight into the most critical aspects of the OCBF.

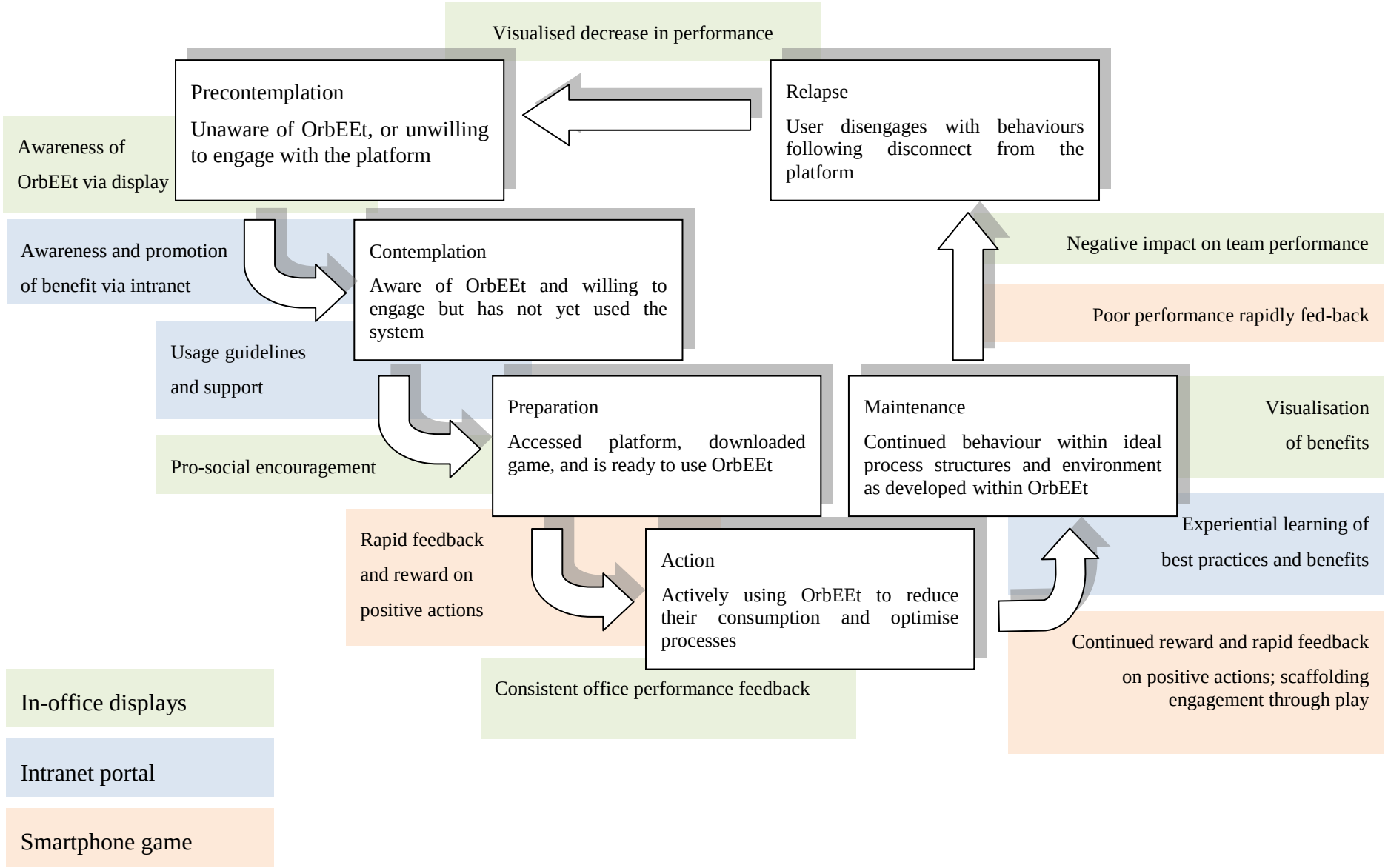
5. THE ORBEET BEHAVIOURAL CHANGE FRAMEWORK (OBCF)

This section presents the initial OrbEEt Behavioural Change Framework (OBCF), building on the foundational theories presented in Section 2.1 and concepts and examples of game-based solutions in Section 2.2. These are offset against the considerations of Section 3, leading to the identification of a high-level framework which identifies the roles of the in-office displays, intranet portal, and mobile game in establishing and sustaining target behaviours.

5.1 High-Level Model

Based on the behavioural change theories and approaches presented in Section 2.1 and in consideration of gamification approaches described in Section 2.2, we propose the OrbEEt Behavioural Change Framework. The structure of the Stages of Change theory is emphasized and the OBCF assumes that the content throughout will be crafted to be consistent with the INSPIRE guidelines from work on expert tutors as well as major tenets of Self-Efficacy theory.

Figure 5. High-level OBCF, derived from stages of change [1]



5.2 Components

Figure 3 illustrates the high-level OBCF. Detailed descriptions of these components, as part of the overall architecture, derive from this high-level review and are documented in D1.4 as an outcome of T1.4. This derives intentionally from the stages of change approach which has proven to be valid in a wide range of contexts where behaviour change is the principal target outcome [1]. Specific consideration is given to the role of each interface within the model, which serves to identify as essential transitions between various phases:

Precontemplation ► Contemplation

Here the goal is firstly to make the user aware of the OrbEEt platform. This alone may not generate uptake in individuals without intrinsic motivation to improve energy or business process efficiency, therefore, in office displays perform a valuable role in promoting uptake through social dynamics. Similarly, the intranet portal supports the transition by providing an accessible overview of the system's benefits to the individual using an interaction modality they are already familiar with (their desktop PC).

Contemplation ► Preparation

Given awareness of the platform, and the benefits of engagement, the user should be scaffolded towards understanding the various technologies and their use. A pro-social approach via the intranet portal is advocated, which seeks to encourage users to support one another acting as more- or less-able partners.

Preparation ► Action

Defining here action as achievement against a behavioural target goal, the analytical layer of the system supports consolidation of metrics into definable and measurable objectives. Through a more abstract approach to visualising data, which enables rapid feedback, the game and gamification elements also encourage users to engage with and use the OrbEEt platform.

Action ► Maintenance

Transitioning from action to maintenance can be seen both as the user continuing to engage with the OrbEEt platform, or disengaging but continuing with positive habits and behaviours. Whilst pilot site interventions have a fixed duration, it would be anticipated that, "in the wild", the required duration of engagement with the platform could vary depending on availability, or a user's initial behaviours which it should be noted may not be suboptimal in all cases.

Maintenance ► Relapse

A common challenge in behavioural intervention is sustaining target behaviours beyond the lifecycle of the intervention. Whilst, under the business models presented in D1.1 and through WP5, exploitation aim to provide a sustainable means to continue to expand platform content, rapid content consumers ("explorers" in Section 2.2), or individuals who believe their performance is already optimal, may disengage with the platform and relapse. Here the OBCF illustrates the role of services to prevent, rather than support, the process of relapse.

Relapse ► Precontemplation

Given a relapse has occurred, it is important to handle it and support the user in a transition back towards using the platform. As illustrated in Figure 3, social dynamics and mechanics here are important, as in-office visualisations offer a means to show negative team performance. Care must be taken, however, to avoid an individual feeling "singled out" or excluded when presenting data on decreased performance.

6. IMPLEMENTATION GUIDELINES

Within the high-level remit of this deliverable, the guidelines in this section reflect on the individual roles of the in-office displays, intranet portal, and serious game within the OBCF illustrated in Section 4, combining them with insights into platform gamification and behavioural theory from Sections 2.1-2.

6.1 In-Office Displays

Role in OBCF	Implementation guidelines
Awareness of OrbEEt via display	As a first point of contact the display should include a screen or screens directing users to the intranet portal and smartphone game. High-level metrics can be used to illustrate the purpose of the system on additional screens. Information should be included on the benefits of the system to the individual to scaffold a transition from precontemplation to contemplation.
Pro-social encouragement	In-office displays should serve to stimulate discussions as well as provide information. Content could include questions and suggestions intended to promote in-office discussion. Performance data should be principally at the group/site level. Competitive metrics, e.g. against other sites, or against a previous timeframe, can utilise game-based elements to promote collaborative competing.
Consistent office performance feedback	As the feedback is principally on performance, care should be taken to accommodate extraneous variables or using them as comparators. An obvious example would be an increase in energy consumption during a period of cold weather beyond the occupants' control. User feedback should be used to identify situations where feedback is considered irrational or unfair, and feedback design initiated with this risk considered.

Visualisation of benefits	Visualisations of performance should be accompanied with benefits, these can include impact on the smartphone game mechanics due to good performance, or value-based benefits such as positive contribution to local and global energy consumption reduction; or improvements in business process efficiency. Visitors should also be considered in terms of how display messaging may impact their immediate behaviours within a site, or post-visit, though this is not possible to measure. As a particularly implementation-specific note the size of screens and installation should be established at an early stage to ensure the size of text / images / graphs etc. is legible, ideally with uncorrected vision to a reasonable degree.
Visualistion of negative impact on team performance	To address the risk of relapse, granularity should be sufficient that an individual can see, or infer, their impact on team performance; however it should not be possible to identify or single them out from the displayed data.
Visualised decrease in individual performance	Similarly, anonymised individual profiles showing gain or loss can be powerful in promoting self-efficacy. However, anonymity is also key; this should particularly be considered when identifying individual devices on office displays, and care should be taken to prevent indirectly breaching this anonymity.

6.2 Intranet Portal

Role in OBCF	Implementation guidelines
Awareness and promotion of benefit via intranet	The intranet portal provides a means to provide a greater volume of content without obstructing the clarity of the office displays, or interfering with the mechanics and entertainment of the serious game. Design of the portal should strongly facilitate content co-creation by end users, e.g. forums,

	wikis, and allow this to be undertaken asynchronously to avoid problems with critical social mass. This is important in both allowing users control and customisation of content, and also providing a scalable means for generating a volume of locally-relevant material on each pilot site. As an overall goal, the portal should seek to empower users with the ability to promote awareness and benefits to other occupants and visitors. Hence, knowledge transfer under the models outlined in Section 2.2 and supported with gamified elements (e.g. profile reputations, "likes", achievements etc.), should seek to provide such empowerment.
Usage guidelines and support	The intranet portal should provide a clear reference for novice users relating to usage of both portal and smartphone game. It also offers the opportunity to provide a more detailed description of in-office display content; offloading this here allows the amount of text and detail on in-office displays to be minimised preventing information overload.
Experiential learning of best practices and benefits	Learning content on the intranet and its co-creation should be supported by data connections to the system allowing users to experiment and learn experientially through feedback from sensors as they seek to optimise processes and consumption based on this feedback. In particular, it should be possible for users to share these best practices such that experiential learning can take place on a collective as well as individual level, fostering greater retention.

6.3 Smartphone Game

Role in OBCF	Implementation guidelines
Rapid feedback and reward on initial positive actions	Core gameplay mechanics should focus on creating rapid feedback cycles using sensor data as appropriate to drive mechanics. As the in-office displays provide this data in environmental and real-world terms, the game should avoid repetition and instead use this feedback as a basis for creating mechanics related to sensor data as input variables. This could include, for example, 1) A "freemium" model, where reward is achieved through performance against metrics rather than monetary spend. Hence the player could earn "OrbEEt coins" or similar by improving or maintaining strong performance, which they can then spend on in-game upgrades. 2) A dynamic world, which is affected by emission, consumption, or inefficiency; e.g. as these improve a fantasy world becomes more "light" and offers additional content or opportunities to players.
Continued reward for positive actions scaffolding engagement through play	The game dynamics and mechanics should allow for continued engagement, and seek to minimise the need for large volume, bespoke content creation. A procedurally generated world and/or challenges would offer one potential solution. Continued engagement typically necessitates a sense of progression in both player ability and difficulty level to maintain a sense of "flow". Actions in game and the wider OrbEEt platform should be considered in terms of long-term progression and development within the game. Mutiplayer is a worthwhile consideration, though due again to risk of low critical mass for initial pilots, should be asynchronous if incorporated.
Poor performance rapidly fed back	Gaming allows for negative feedback and outcomes to be rapidly used to impact the player in an individual fashion. This should

	be supported again by consideration of self-efficacy and the risk of penalising the player for events beyond their control.

7. SUMMARY AND CONCLUSIONS

This deliverable has outlined the high-level OrbEEt Behavioural Change Framework (OBCF), drawing on theories of behavioural change, in particular the transtheoretical "stages of change" approach, to outline considerations and use cases for the various interfaces subsequently to be developed in WP3. It has provided a basis for the integration of the OBCF as a cornerstone of the design and integration of the system, with respect to both how sensor data is managed and presented to users, and how business process models are incorporated within the overall behavioural change strategy. The principal summary findings of reviews of behavioural theory and games and gamification within this deliverable include the need to support both self-efficacy and peer dynamics in design, and provide means for users to adapt and potentially extend content through their inputs, rather than being passive consumers. The OBCF illustrated in Figure 3 outlines high-level methods for achieving this with respect to the in office displays, smartphone games, and intranet portal developed in WP4. Hence, this deliverable serves as essential design input into both D1.4 and WP3.

8. ACRONYMS AND TERMS

BCI ..... Brain-Computer Interface
BUL ..... Building Utilization Level
DoA ..... Description of the Action
EBI ..... Ecological Behaviour Intention
EK ..... Environmental Knowledge
EV ..... Environmental Values
GEB ..... General Ecological Behaviour
MMO ..... Massively Multiplayer Online
OBCF ..... Organisational Behavioural Change Framework
PBL ..... Problem-Based Learning
PRU ..... Process Resource Use
QA ..... Quality Assurance
TTM ..... Transtheoretical Model
WP ..... Work Package

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