Employee Profiles and Preferences towards IoT-enabled Gamification for Energy Conservation

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Abstract

Gamification can be used to effect positive behavioral change in various fields, including energy conservation. This paper reports on a survey we conducted to formulate a holistic view of users' profiles and preferences in an Internet of Things (IoT)-enabled gamified mobile application that provides personalized energy-saving recommendation tips to employees, towards conserving energy and adopting a more green behavior at the workplace. The collected insight dictates that a gamified app promoting energy saving at the workplace may become a daily habit for its users if it at least includes three game design elements: progression, levels and points. Additionally, we complement existing design guidelines about the requirements of each HEXAD gamification user type (Philanthropist, Socializer, Free Spirit, Achiever, Disruptor, Player) in game elements, specifically for energy efficiency applications. Thus, we apply and validate the HEXAD gamification user typology in a new context – multicultural workplaces – as well as domain – energy-saving. Moreover, the collected insight inspired us to devise a modular, rule-based mechanism for formulating personalized energy-saving recommendation tips tailored to the users' profiles and game design choices. This research may assist researchers, as well as practitioners, in designing personalized gamified behavioral interventions, especially towards energy conservation in workplaces.

Keywords: *Gamification; IoT; Energy Conservation; Personalized Recommendation; Workplace.*

1. Introduction

A recent report by the European Environmental Agency suggests that measures targeting behavioral change may help to achieve energy savings up to 20% [1]. More importantly, the buildings sector consumes 20% of the total delivered energy worldwide and the commercial sector features the fastest-growing energy demand, with its consumption projected to grow by an average of 1.6% per year until 2040 [2]. Our efforts towards energy conservation in commercial buildings must therefore be increased, towards addressing the worldwide recognized issue of energy wastage.

Inspired by these facts, our ultimate research goal is to design, develop and assess a gamified application in the course of the ENTROPY EU H2020 research project, whose

objective is to motivate employees towards reducing energy consumption at the workplace. The ENTROPY Internet of Things (IoT)-enabled innovative ecosystem monitors energy consumption at workplaces, collecting and analyzing data streams from interconnected, heterogeneous sensor nodes installed at the workplaces. After advanced data analysis on the sensed data, they shall feed a mobile gamification application that will provide personalized energy-saving recommendation tips to the employees/users, with the aim of increasing their energy awareness and improving their energy consumption habits.

Our first research goal is to design an effective gamified app that offers a playful experience and fosters positive behavioral change in the long term. Thus, we need to delineate the employees' / users' needs and preferences in order to design an app, which the users will embrace and include in their daily work routine towards increasing the possibilities of adopting a more green behavior. This paper reports on the findings of a survey we conducted to explore the potential users' profiles and game design preferences in a gamified app that promotes energy efficient practices and behaviors at the workplace. Our survey sample included 99 participants from three office spaces in different EU countries: a technology business incubator in Italy, a university campus in Spain and a technology park in Switzerland. Considering that the survey participants are situated in different countries across Europe featuring different cultures, as well as climate conditions, energy needs and habits, we aspire that this variety of workplaces will ensure more interesting results with increased potential to reach generalizable outcomes. Tondello et al [3] state that the existing research results about the user preferences for the personalization of gamified systems are limited and highlight the need for further validation of the HEXAD gamification user type model in the general population. This research applies and validates the HEXAD model in a radically different environment, featuring employees from multi-cultural workplaces spanning across three different countries.

The responses of the survey participants prescribed that a gamified app promoting energy saving at the workplace may be appealing to the users and become a daily habit if it should at least implement three game design elements: progression, levels and points. The collected insight complements the existing design guidelines that address the requirements of each HEXAD gamification user type in game elements, within the application domain of energy conservation. Moreover, we gained valuable insight to devise a modular, rule-based mechanism that can be used for formulating personalized energy-saving recommendation tips tailored to the users' profiles and game design choices. Thus, we promote tailored gamified behavioral interventions through the personalization of recommendation tips. Overall, this research aspires to assist researchers, as well as practitioners, in designing gamified behavioral interventions focused on energy conservation at the workplace.

The rest of the paper is structured as follows. First, we review related work presented in the literature. Then, we describe the survey instrument (questionnaire) we utilized, as well as the acquired results. Afterwards, we present a mechanism that generates personalized feedback promoting energy saving. We conclude the document with a discussion of our findings, as well as our future research plans.

2. Related Work

2.1 Gamification at the Workplace

Gamification, in its most widely accepted definition, has been defined as "the use of game design elements in non-game contexts" [4]. The most commonly stated objective behind its application is to encourage behavior change in end-users, usually involving increased participation, improved performance, or greater compliance [5]. However, gamification might contradict with some personality types and cultural norms [6] and there is a risk

associated with stressing extrinsic motivation towards a topic (through competition, rewards, badges, etc.), with respect to intrinsic motivation that is fundamental for sustained long-term behavioral change [7]. Therefore, as extrinsic incentives can crowd out intrinsic motivation [8], it is important to design gamified applications to match the profile of their target users, at the same time carefully selecting which game mechanics to use. To do so, the different types of end-users and their respective characteristics, as well as preferred game mechanics, must be distinguished and taken into consideration [9].

Introducing games into the workplace has a considerable history, especially as human resources tools and entertainment interfaces for repetitive tasks like computer process management [10]. At the same time, the Soviet Union workplace-based "socialist competition" experiments and the 1990s-2000s American management trend of "fun at work" preceded the gamification-of-work movement [11].

The analysis and design of gamification applications in corporate environments, requires different approaches to consumer environments. First of all, in a work environment, gamification can focus on business processes, or outcomes, to improve employee satisfaction [12]. Furthermore, when these organizational goals are aligned with player goals, employees can become fully engaged with new company initiatives [13]. At the same time, applying gamification in a workplace environment requires caution, as inappropriate extrinsic incentives might crowd out intrinsic motivation [8]. In addition, gamification in the enterprise must also be compatible to long-term objectives further to initiative-specific objectives [14]. Finally, players tend to be more invested in intra-group competition than in inter-group competition [10]. The forementioned facts inspired us to apply gamification as a means of producing and sustaining positive behavioral change in the workplace, in the form of energy conservation.

2.2 Gamification for Energy Conservation

Leveraging the engagement of games to promote desired real-world energy actions among players and change their energy behavior has been suggested in the literature [15] and applied in various contexts. Real-world input has also been utilized to gamify real-world processes [16]. The empirical effects of a number of serious games in changing knowledge, behavior and attitude towards energy-saving have been positive [17], with reported energy savings in the range of 3-6% on average and >10% achievable on a number of studies featuring the application of gamification to reduce energy consumption [18]. Furthermore, research shows that direct feedback on energy consumption can lead to savings in the range of 5 to 15%, indirect feedback up to 10% [19] and both types of interventions combined have led to 7.4% savings on average [20]. However, as there have also been inconclusive studies [21], there is room for improving existing energy game designs, especially towards meeting their goals for behavior change [22]. Moreover, gamified energy efficiency solutions should optimally be considered as a way to introduce people to the intrinsic satisfaction of conserving energy, even after they have been decommissioned [18].

Examples of energy efficiency games that have been deployed in the workplace include "Cool Choices", "WeSpire", "Ecoinomy", "Energy Chickens" and "Carbon4Square". They feature both individual, as well as team play mode and include tangible rewards [18]. Interestingly, WeSpire claim having a track record of over 5 million positive actions in 45 countries [23]. At the same time, Cool Choices claim that through their solution, organizations across multiple industries have increased their savings and reduced CO2 emissions, via 7,243 participants that have already made 259,410 "Cool Choices" and shared 22,411 sustainable ideas, for a total estimated annual saving of an impressive $3,914,208 [24]. Moreover, "Energy Chickens" have led to a decrease in employees' plug-load energy consumption by 13% compared to baseline (23% on non-work days and 7% on work days) [25].

Overall, personal norms have been found to positively influence employee energy-saving behavior in interventions conducted within organizational environments [26, 27,

28]. Furthermore, promising means towards engaging employees at the workplace, where no personal monetary gains from energy-saving behavior are normally expected [29], include educating them in low-energy work routines, as well as utilizing feedback to improve norms and increase awareness of their own behavior and its consequences [30]. More importantly, utilizing tailored information in feedback interventions has been proven to be more effective towards energy behavior change [29]. At the same time, Self-Determination Theory (SDT), which suggests competence, relatedness and autonomy as basic antecedents of intrinsic motivation, has been widely used to examine the motivational effects of gamification [31].

Inspired from the above, in the course of the EU project ENTROPY, we will design and deploy a gamification application that receives input from an IoT-enabled ecosystem and provides personalized, real-time energy-saving recommendation tips to employees, motivating and educating them to adopt a more energy efficient behavior. In line with the theories discussed above, we aim to utilize this personalized feedback functionality to provide energy-saving recommendation messages, in order to activate and enhance employees' energy-saving norms at work. To increase their motivation to save energy at work, this feedback will focus on enhancing employees' perceived competence in energy saving, as well as respect their needs for autonomy and relatedness at work. Finally, taking into account the insight provided in existing literature on gamification, especially regarding energy saving, and workplace environments, we will deliver energy-saving recommendation tips through our gamified mobile app, while considering the end-users' profiles and preferences.

2.3 User Typologies in Games

Developments in game business practices have increased the need for distinguishing between types of players and play styles [32]. Different people choose to play games for very different reasons, and therefore the same game can have very different meanings or consequences for different players [33]. Combining adaptation and educational games for example can uniquely present a personalized supportive motivational experience [34]. More importantly, personalizing gamified interactions can increase their effectiveness in behavior change compared to the "one size fits all" approach [35]. To that end personalization has been investigated along several dimensions, including personality, as well as player types and gamification user types [35]. Furthermore, although gamification is not primarily focused on entertainment, studying gamer typologies can aid in understanding gamified app users' motivations to play, as well as the game mechanics that fit each player type [36]. Therefore, a comparison of player types and appropriate game mechanics may be helpful for design decisions of gamification applications [36].

Game designers can develop an engaging game enjoyed by all its players, by incorporating appropriate game mechanics that do not allow one user-type to dominate the others, and ensure there is proper harmony in the gamified system [37]. At the same time, although game mechanics can motivate users to exert effort and persevere, for the successful application of gamification, all users must feel that they are capable of performing the tasks they are assigned [14]. To that end, one of the most popular taxonomies of player types was described by Bartle in 1996, who defined four game player types (Killers, Achievers, Socializers and Explorers), as well as their interactions [38]. Based on the observation that different players find different things fun, he later developed an extended concept of eight different player types, by dividing each of the original four types into two sub-types (an implicit and an explicit one) – while noting that a player can possibly change type over time [39]. Notably, player personalities interact with each other and get engaged with the game differently [14]. Furthermore, based on Bartle's approach, Yee also presented a motivational model based on three components: achievement, social and immersion [33]. Interestingly, gamification users have also been categorized based on the Meyers-Briggs Type Indicator (MBTI), largely because of its popularity as a corporate training and development tool [40]. Finally, gamer and player

typologies have also been synthesized into seven key dimensions – Skill, Achievement, Exploration, Sociability, Killer, Immersion and in-game demographics – in a meta-analysis of the existing literature [32]. However, we stress that the above mentioned typologies are specifically focused on games and not gamification.

2.4 The HEXAD Gamification User Typology

The HEXAD gamification user type model, which we will be employing in our research, builds on Bartle's Player Types and the BrainHex model. It was developed by Andrzej Marczewski in 2013, who attempted to segment users based on their receptivity to varying gamification strategies, intrinsic and extrinsic motivational factors. The six gamification user-types defined and delineated in the model are: "Socializers", "Free Spirits", "Achievers", "Philanthropists", "Players", and "Disruptors" [41]. Different player types correspond differently to various game elements, as well as present different game preferences. Furthermore, mapping user personality, through the HEXAD user typology, to design elements has been attempted.

The suggested design elements for each gamification player type were [3]: (i) Philanthropists: collection and trading, gifting, knowledge sharing, and administrative roles, (ii) Socialisers: guilds or teams, social networks, social comparison, social competition, and social discovery, (iii) Free Spirits: exploratory tasks, nonlinear gameplay, easter eggs, unlockable content, creativity tools, and customization, (iv) Achievers: challenges, certificates, learning new skills, quests, levels or progression, and epic challenges/"boss battles", (v) Players: points, rewards or prizes, leaderboards, badges or achievements, virtual economy, and lotteries or games of chance, (vi) Disruptors: innovation platforms, voting mechanisms, development tools, anonymity, anarchic gameplay. Finally, it is important to note that, although these six motivation clusters are presented as user types, individuals are rarely motivated by one of them exclusively and, although users are likely to display a principal tendency, in most cases they will also be motivated by the other gamification user types to some degree [3].

3. User Survey

We performed a survey with the main target of collecting the prospective users' feedback in order to design a personalized gamified app that enables a smooth adoption and playful experience and, ultimately, is effective in altering energy consumption behavior. More specifically, we decided to design the app while considering the personal profiles of the prospective participants in order to increase the chances that they adopt it in their daily work routine. Therefore, we conducted the users' survey to record their game design preferences, as well as their gamer profile characteristics. Overall, the collected insight will guide us in our design efforts to personalize the application by suggesting specific game design elements to cater to the different user profiles.

3.1 Survey Instrument

We designed a questionnaire that characterizes the employees/participants based on the HEXAD gamification user typology [41, 3], as well as identifies their preferences in game elements to be included in a game promoting energy conservation at the workplace. Our primary objective was to reach conclusions regarding the matching between player types and game elements within our specific context, towards providing a more personalized gamified experience to our end-users. We chose to employ the HEXAD typology as, in contrast to other game player typologies, it is directly and specifically focused on application in gamification and not games in general. Furthermore, it has already been utilized and applied in a variety of different contexts, such as player type simulation in gamified applications [42], personalized persuasive strategies in gameful systems [43],

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personalized e-learning [44], peer-to-peer environments [45], computer-supported collaborative learning [46], and personalization of gamified rehabilitation systems [47].

Tondello et al. [3] describe a 24-items survey instrument to score users' adherence to the six different gamification user types described in the HEXAD framework, which we adapted and administered as part of our survey (see Appendix). Additionally, in their review of gamification in theory and action, Seaborn & Fels [5] suggest that various game elements often interrelate and can bear similar names in the literature. Hence, to avoid confusion, they derived a concise classification of basic game elements with their definitions, which we adopted to capture the users' individual personal preferences in game elements, within our specific context and field of application (see Table 1).

Table 1.*Game Elements Terminology (adapted from [5]).*

Game Element	Definition	Alternatives
Points	Numerical units indicating progress	Experience points; score
Badges	Visual icons signifying achievements	Trophies
Leaderboards	Display of ranks for comparison	Rankings, scoreboard
Progression	Milestones indicating progress	Levelling, levelup
Status	Textual monikers indicating progress	Title, ranks
Levels	Increasingly difficult environments	Stage, area, world
Rewards	Tangible, desirable items	Incentives, prizes, gifts
Roles	Role-playing elements of character	Class, character

We described the game elements in the questionnaire to support the participants' understanding of their meaning and, thus, collect truthful, valid preferences. Concurrently, we asked the participants to answer the following question: *"The following table includes and explains the functionality of game elements that a game may include. Please state how important it is for you, that each one is utilized in a game aimed at reducing energy consumption at the workplace, by selecting between 1- (Not Important) to 7- (Very Important)."*.

We chose to utilize the game elements' classification and definitions suggested by Seaborn & Fels [5] to capture the users' individual personal preferences in game elements within our specific context and field of application, as they have resulted from a very thorough systematic review of gamification and game elements delving deep both in theoretical and practical works and exploring the use of gamification in studies involving interactive systems and human participants [48]. Furthermore, by studying the effects of individual game elements in our specific context – energy saving at the workplace – we can derive insight that can be of use to designers of similar gamified behavioral interventions in the future, towards making informed decisions regarding the use of specific game elements [5].

Finally, the last section of the questionnaire included questions to ascertain the demographic characteristics of our sample (gender and age). By combining the collected insight from all the questionnaire sections, we aim to personalize the application we are designing by selecting specific game design elements to be utilized according to the users' profiles. The complete questionnaire instrument can be found in the Appendix.

3.2 Survey Execution

The prospective users of the gamified solution we are designing are employees in three organizations (our pilot sites): (i) a technology business incubator facility situated in Italy, (ii) a university campus in Spain, and (iii) a technology park in Switzerland. Prospective participants on all three sites were contacted by e-mail and invited to participate in the survey. An additional two reminder emails were sent, while two employees at each of the three sites actively assisted in the process of reminding employees to take part in the survey. The questionnaire was administered to employees of various roles in their organizations through an online platform. An introductory passage explained that this research "…studies the energy consumption in public buildings and proposes a framework that aims to facilitate achieving greater energy efficiency and conservation in public buildings", while a total of 99 completed questionnaires were collected. The participants were in their majority (74/99) aged between 25 and 45 years old, 18/99 between 45 and 55 years old, while only 7/99 were either younger than 25, or older than 55 years old. Regarding their gender, male outnumbered female participants on all sites (73 male vs 26 female). Additionally, to our knowledge, no serious games or gamification applications had been introduced in the surveyed workplaces in the past, especially regarding energy conservation.

4. Survey Results

Following the collection of results, we performed five kinds of analyses to explore the player types in our sample, their demographic characteristics, and how they relate to game element preferences: (i) Reliability analysis on the six HEXAD gamification user type sub-scales. (ii) Descriptive statistical analysis, to gain insight on the general trend of our sample's characteristics and preferences. The 7-point Likert answers were re-coded, to group results into three basic categories. High preference / agreement to a statement was deduced by an answer of 5, 6, or 7. Similarly, neutrality was deduced by an answer of 4 and disagreement / low preference was deduced by an answer of 1, 2, or 3. (iii) Bivariate correlation analysis to explore correlations between the six gamification user types in the HEXAD typology and the participants' preferences in game elements. (iv) Bivariate correlation analysis to explore the relationship between our control variables – the demographic characteristics of our sample – and the six gamification user types in the HEXAD typology (correlation analysis is used to describe the strength and direction of the linear relationship between variables [49]). (v) Independent sample t-test to compare the mean scores recorded by male vs. female participants on the six HEXAD types. All statistical analyses were performed using IBM SPSS Statistics v.23.

4.1 HEXAD Gamification User Types

We performed a scale reliability analysis on the six HEXAD gamification user types' subscales. Our results showed good internal consistency in four out of the six scales, with Cronbach alpha coefficients over .70: Philanthropist (a=.841), Socializer (a=.836), Disruptor (a=.779) and Player (a=.779). The Free Spirit (a=.599) and Achiever (a=.561) scales presented relatively low reliability scores.

As per the dominance of the six player types, the analysis of the survey answers highlighted the presence of the six gamification user types in our sample as follows: (i) Achiever items were rated high by 89%, (ii) Philanthropist by 88%, (iii) Socialiser by 76%, (iv) Free Spirit by 75%, (v) Player by 43%, and (vi) Disruptor by 12% of the participants. Therefore, Achiever and Philanthropist motivations were the most identified within our sample, with Socialiser and Free Spirit following closely, while Player and Disruptor were the least popular. The results from the correlation analysis between player types can be found in Table 2.

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Table 2. *Observed Correlations (Pearson's r) between HEXAD gamification user types.*

	Philanthropist	Socialiser	Free Spirit	Achiever	Disruptor
Socialiser	**.588****				
Free Spirit	**.283****	.200			
Achiever	**.425****	**.385****	**.380****		
Disruptor	.045	-.178	**.470****	.082	
Player	**.276****	**.306****	**.308****	**.361****	-.017

***. Correlation is significant at the 0.01 level (2-tailed)*

Concerning the relationship between demographic variables and the HEXAD gamification user types, we found that the Achiever (p = -.213*, r = .037) and Player (p = -.230*, r=.024) motivations were negatively correlated with the age of the participants, indicating that younger players have a relatively higher inclination towards the Achiever and Player motivations. Additionally, male gender was correlated with the Disruptor motivation (p = .247, r=.016). An independent samples t-test was conducted to compare the scores for the Disruptor motivation between male and female participants. Results revealed that, equal variances assumed (Levene's test p=.902), there was a significant difference in scores for males (M=3.884, SD=1.157) and females (M=3.207, SD=1.145; t=2.446, p=.016). The magnitude of the differences in the means was moderate (eta squared =.061, indicating that 6.1% of the variance in the Disruptor motivation is explained by gender). Independent samples t-tests conducted to compare the scores between males and females for the rest of the HEXAD motivations (Philanthropist, Socialiser, Free Spirit, Achiever, and Player) revealed no significant difference in scores across genders.

4.2 Game Elements Preferences

The survey participants' preferences in game elements that should appear in a gamified app focused on energy conservation at the workplace are presented, in a descending order, in Table 3.

Table 3. *Game Elements Preferences in decreasing order.*

Game Element	High Preference	Neutral	Low Preference
Progression	**85%**	9%	6%
Levels	**74.2%**	18.6%	7.2%
Points	**72.4%**	13.3%	14.3%
Rewards	64.6%	15.2%	20.2%
Status	60.4%	15.6%	24%
Leaderboards	59.8%	16.5%	23.7%
Badges	57.3%	15.6%	27.1%
Roles	53.1%	18.4%	28.6%

Based on the results, a gamified app should at the least include (i) progression, (ii) levels and (iii) points (pref. by >70%), in order to match our target users' game design preferences, and thus have increased prospects of becoming a part of their daily work routine towards energy conservation.

Further to the insight gained through the descriptive statistics already presented, we also analyzed the survey data to discover the specific game design preferences of the six gamification user types. Table 4 presents the bivariate correlation coefficients (Pearson's r) and significance between the six HEXAD gamification user types and the eight basic game elements we examined through our survey.

Table 4. *Correlation between HEXAD user types and eight basic game elements.*

	Points	**Badges**	**Leader-boards**	**Progres-sion**	**Status**	**Levels**	**Rewards**	**Roles**
Philanthropist	.084	**.322****	.078	.189	.066	.129	.142	**.283****
Socialiser	**.276****	**.330****	.108	.050	-.059	.156	**.299****	**.241***
Free Spirit	**.248***	**.328****	.186	**.289****	**.290****	**.238***	.180	**.223***
Achiever	.046	.104	.160	.166	.030	-.033	.126	.176
Disruptor	.042	.129	.028	.099	**.224***	.136	-.021	.147
Player	**.277****	**.240***	**.335****	.087	**.236***	.099	**.530****	.130

***. Correlation is significant at the 0.01 level (2-tailed)*
**. Correlation is significant at the 0.05 level (2-tailed)*

Based on the above correlation results, Table 5 summarizes the game design preferences of our sample per game player type. Combining the findings of the analysis described above, we conclude that the gamified app that we are designing for energy conservation at the workplace may be appealing to the users and become a daily habit if it should at least implement progression, levels and points, a finding also corroborated in a larger sample (N=226) [50]. However, to provide a more personalized – and potentially more motivating – experience to its target audience (across all HEXAD user types) we can include all of the eight game elements and utilize them accordingly to satiate the needs of each player type in a more personalized way (see Table 5).

Table 5. *Game Elements Preferences per user type*

User type	**Preferred Game Elements**
Philanthropist	Badges, Roles
Socializer	Points, Badges, Rewards, Roles
Free Spirit	Points, Badges, Progression, Status, Levels, Roles
Achiever	-----
Player	Rewards, Points, Badges, Leaderboards, Status
Disruptor	Status

5. Towards a Gamified App Utilizing Personalized Energy-Saving Recommendation Tips

5.1 Personalized Energy Saving Recommendations / Tips

We aim to design gamified behavioral interventions to increase employees' intrinsic motivation to conserve energy, by providing personalized positive feedback aimed at reinforcing existing positive norms and forming new ones. Hence, the gamified mobile app we are designing will provide messages (tips) that recommend energy conservation actions to its end-users. Additionally, the IoT-enabled platform that has been developed – in the course of the EU H2020 ENTROPY research project that we are participating in – hosts a recommender engine that generates and transmits energy saving recommendations to the gamified app. More specifically, this engine produces energy saving tips for the app players taking into account the sensed context changes captured by IoT devices (i.e. sensors that capture temperature, illumination etc. in the offices). We emphasize that these energy saving tips are personalized because the engine also considers the users' profile in terms of adherence to gamification player types and game design preferences identified.

At the same time, we took into account that positive feedback (a.k.a. "verbal rewards") has a significantly positive effect on intrinsic motivation [51] by enhancing perceived competence, only when perceived as autonomy supporting [52]. Furthermore, feelings of competence will not enhance intrinsic motivation unless accompanied by a sense of autonomy and relatedness [31]. Therefore, to be effective in an organizational setting, feedback should be positive, facilitate competence while supporting the employees' autonomy, utilize a minimum of controlling language and present poor performance as a problem to be solved instead of providing criticism [53].

Guided by the facts presented above, and in accordance with the identified game-player characteristics, as well as game elements preferences, a list of in-game energy-saving recommendation tips can be produced, tailored to the six different gamification user types and their game design preferences. To illustrate, in Table 6 we present the personalized content of the recommendation tip for the six HEXAD user types when the sensed condition in the context is *"Temperature in the room < 20^o C and Season = summer"* and the corresponding energy saving action is *"Turn up the thermostat"*.

Table 6. *Personalized Energy Saving Recommendation Tip per User Type*

User type	Personalized Energy Saving Recommendation Tip
Philanthropist	The temperature in this room is quite low. Adjust the thermostat to raise the temperature. Earn a badge after N times / become energy champion.
Socialiser	The temperature in this room is quite low. Adjust the thermostat to raise the temperature. Become the team leader after N times.
Free Spirit	The temperature in this room is quite low. Adjust the thermostat to raise the temperature. Unlock new functionality - N more actions to progress to the next level.
Achiever	The temperature in this room is quite low. Adjust the thermostat to raise the temperature, whenever you see this message for N times in a row and win the "temp challenge".
Player	The temperature in this room is quite low. Adjust the thermostat to raise the temperature, whenever you see this message to win "X" points.
Disruptor	The temperature in this room is quite low. Adjust the thermostat to raise the temperature, whenever you see this message to become the best in your team.

Overall, the content per each personalized energy-saving tip in the gamified app is formulated according to the following modular structure:
[Sensed Condition in the Context] + [User/ Player Action Recommended / Energy-saving Tip] + [Gamification Reaction / Benefit], where:

- Sensed Condition in the Context: A short sentence that describes the sensed condition that has been observed in the context (e.g. in the above example: *"The temperature in this room is quite low and Season = summer"*).
- User/ Player Action Recommended / Energy-saving Tip: The proposed action by the gamified system to the user in the current scenario (e.g. in the above example: *"Adjust the thermostat to raise the temperature"*).
- Gamification Reaction / Benefit: The effect/benefit the user will receive in the game in case he adopts the tip / suggested action. Example Gamification reactions have been introduced in Table 6, personalized for the six different HEXAD user types. In the example presented, the gamification reaction for the Socializer type is: *"Become the team leader after N times"*.

When the tips encourage the users to take immediate action, this modular approach exposes the behavioral effect of the gamification application in real time. This is feasible only when the user's reaction to the tip can be matched to the sensed energy (electricity) consumption events recorded through the project's IoT platform. Otherwise, where tracking the effect of the user's action in real time is not feasible, we should convert the message and put the "gamification reaction" part of the message before (instead of after) the reason for its activation. This stems from the fact that when the validation of the user's energy-saving actions can be performed in real-time within the game, the delivery of rewards to the user can also be immediate. In this case, a feedback message can contain both: information regarding the suggested action to be immediately taken by the user, as well as their current status towards gaining rewards in the game, in one consolidated message. In the opposite case, where the user's energy-saving actions cannot be validated in real time, rewards will have to be provided in fixed time-frames. Consequently, in the "delayed validation of actions" scenario, feedback messages that would prompt the users to perform energy-saving actions in real-time cannot at the same time contain information regarding their progress towards cumulative rewards. However, for example, in fixed timeslots (e.g. in the morning of each day), the user can receive feedback regarding their accumulation of rewards, awarded based on their past performance (e.g. during the previous day).

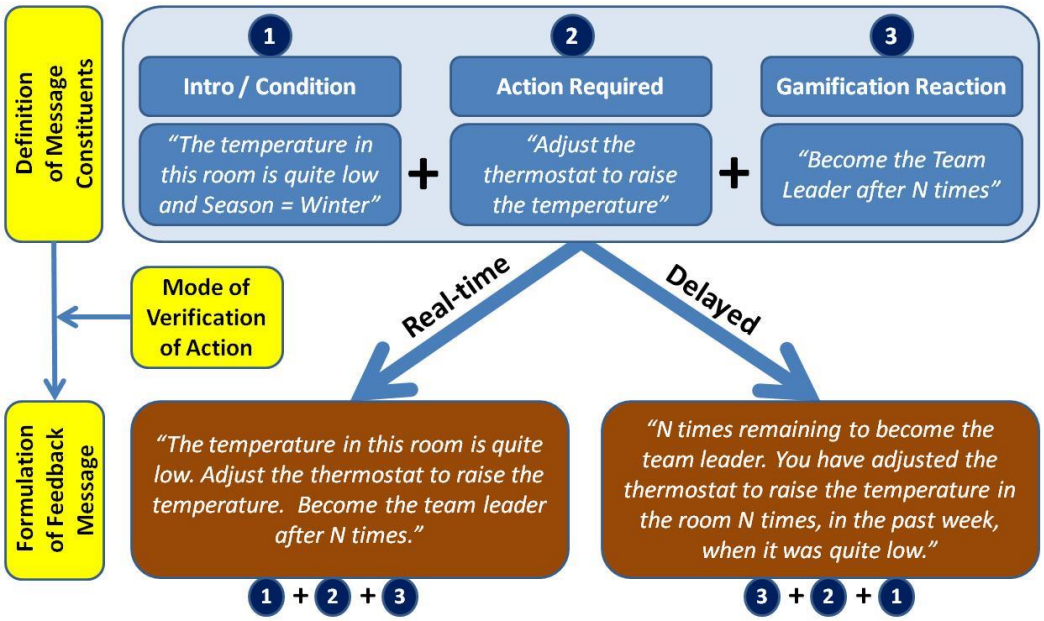

Figure 1. *Energy Saving Recommendation Tip Formulation Process (real-time and delayed validation example for user type Socializer)*

An example of two alternative tips, in case of real time or delayed validation of user compliance to the tip (in the context of the example provided in Table 6 for the Socialiser user type) is provided in Figure 1.

In the real-time validation of energy-saving actions scenario, the user receives a message that comprises of: (1) the condition met *"The temperature in this room is quite low."* + (2) the action required *"Adjust the thermostat to raise the temperature"* + (3) the gamification reaction *"Become the team leader after N times"*. Oppositely, when the validation of energy-saving action cannot be made in real time, the user receives a message that comprises of: (3) the gamification reaction *"N times remaining to become the team leader"* + (2) the action already enacted by the user that led to the gamification reaction *"You have adjusted the thermostat in the room N times in the past week"* + (1) the condition under which the user has enacted the said action *"when it was quite low"*.

5.2 Personalization Mechanism

As already discussed, users may adhere to a mixture of gamification user types, in various levels. Therefore, to more closely match their actual profile, we propose the utilization of the following mechanism in order to generate and distribute personalized tips:

1. Personalized tips are constructed, for the six different user types, based on the process outlined in section 5.1.
2. Each user's average score on all six gamification user type question-sets is calculated (four questions per each of the six HEXAD user types). Thus, scores ranging between 1 and 7, including decimal values, can be calculated per user on each of the six HEXAD gamification user types. We refer to this set of scores as the user's "Gamification User Type Profile" (GUTP) for the remainder of this paper.
3. A pool of personalized energy saving tips are built according to the user's six calculated scores (i.e. the user's GUTP).
4. The user receives tips corresponding to the different HEXAD types, as represented in his profile, proportionately and according to his GUTP.

For example, let's assume that we have recorded the following average scores for the six HEXAD types in a users' profile, a.k.a. the following user's GUTP: {Philanthropist=7, Socializer=6, Free Spirit=2, Achiever=3, Player=1, Disruptor=1}. Then, this user should receive recommendation tips matching each of the six gamification user types proportionately, e.g. for each amount of messages equal to the sum of the scores in his GUTP (7+6+2+3+1+1 = 20), i.e. for every 20 feedback messages, he should receive: 7 Philanthropist type messages, 6 Socializer, 2 Free Spirit, 3 Achiever, 1 Player and 1 Disruptor type message. Therefore, the suggested mechanism should distribute the messages according to the users' profile in a proportionate (and preferably random) way.

6. Discussion

Gamification, a relatively new instrument in the "orchestra of motivation" [54], has been suggested as a means of positive behavioral change in various contexts and for various targeted behaviors. However, its effectiveness lies subjected to the characteristics of both the specific application domain, as well as the participants' profiles. Therefore, delineating user types and their in-game preferences is necessary to ensure that the application designed appeals to its targeted audience in the best possible way, towards accomplishing their active participation, as well as behavioral change. In this spirit, we conducted a survey with prospective users of a gamified app aimed at energy conservation at the workplace and we deduced that indeed the preferences of the six different HEXAD gamification user types in game elements are distinct. Furthermore, our sample's demographic characteristics (age and gender) affected their matching to the six HEXAD user types. More specifically, we discovered indications that younger players have a

relatively higher inclination towards the Achiever and Player motivations and men towards the Disruptor motivation.

As per the reliability of the HEXAD sub-scales, in previous studies the Player subscale featured relatively low reliability (a<.70), while the Free Spirit, Achiever, Disruptor, Philanthropist and Socializer subscales achieved the desired reliability (a>0.70) [3]. In contrast, we found that four out of the six sub-scales (Philanthropist, Socializer, Disruptor and Player) featured a good internal consistency, with Cronbach alpha coefficients >.70, while the Free Spirit and Achiever scales presented relatively low reliability scores (a<.70). Therefore, although it has been suggested in the literature that the Player gamification user type scale could be improved in future work [3], our analysis prescribes that the Free Spirit and Achiever scales are the ones that would benefit from future improvement.

Regarding the adherence of our sample to the HEXAD types, Achiever and Philanthropist were the most identified with in our sample, with Socialiser and Free Spirit following closely, while Player and Disruptor were the least popular amongst the questionnaire participants, in line with observations in the literature [3]. As per the inter-correlation between user types in our sample, they are in line with the findings in [3], except from the connection between Socialisers and Free Spirits, which was not significantly verified in our study. The overlap between HEXAD types in past research [3] was also verified through our observations, strengthening both its validity, as well as generalizability. Furthermore, complementing the generic preferences of the HEXAD gamification user types in game elements offered in existing literature [3], we found that a gamified app aimed at energy conservation at the workplace may be appealing to the users and become a daily habit if it should at least implement progression, levels and points. However, to provide a more personalized – and potentially more motivating – experience across all user types, all of the eight game elements we surveyed should be utilized according to the identified correlations with the HEXAD types (Tables 4 and 5). Therefore, the survey findings complement the general guidelines towards the preferences of each HEXAD user type in game elements, in the specific application domain of gamified energy conservation.

Having mapped our survey participants to the HEXAD user types, and uncovered their game elements preferences within a gamified energy conservation app, we have also proposed a mechanism that generates personalized energy-saving recommendation tips. We provided examples of how these tips could be differentiated between user types, as well as suggested a method to serve them proportionately to the end users, according to their HEXAD profile. We shall thus be in a position to better tailor gamified behavioral interventions in the future through the personalization of recommendation tips aimed at our targeted audience. That way, we expect the behavioral results of such interventions to be optimized. We aim to further calibrate and test the utility of the proposed mechanism through practical experimentation in the future. Some key points and takeaways of our findings are summarized in Figure 2.

Our overall research ambition is to investigate if and how personalized gamification applications can motivate employees towards energy conservation at the workplace. The main practical contribution of this research will be a set of design and evaluation guidelines to be used by future researchers and practitioners that are interested in gamified personalized apps for energy efficiency purposes. Our research consists of a series of steps. The first step, which we report on in the present paper, was to conduct a requirements analysis towards designing a gamified app and personalizing the gamified feedback mechanism. Next steps include (i) developing the application, as well as conducting preliminary testing before its release, (ii) pilot and validation phases where we collect information from end-users and derive changes that need to be made to the application before its final release and, ultimately, (iii) a test phase where we will test the resulting gamified application in real workplace environments, towards assessing its effectiveness in producing sustained energy behavior change among employees.

To be more specific we will apply and evaluate the app in three workplaces featuring different work environments in different EU countries. We believe that the application of our findings so far in this real environment would provide evidence towards their practical utility, as well as support the validation of the aforedescribed theoretical correlations.

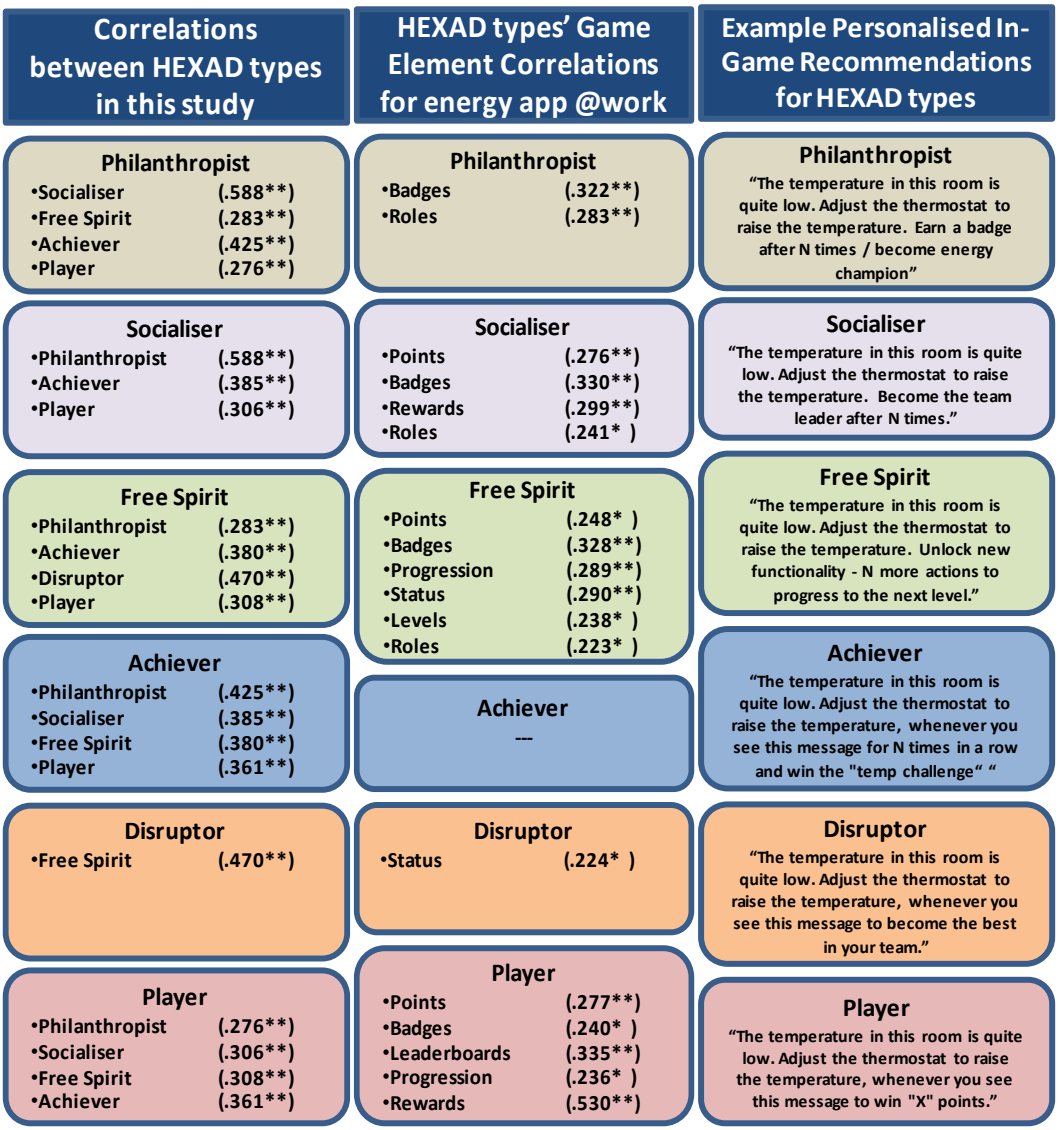

Figure 2. *Summary of Key Research Findings and Outcomes*

To serve our ultimate research goal, i.e. to assess the effect of gamification on the employees' energy consumption behavior, we will utilize the pilot applications of the app in the aforementioned different work environments. Specifically, we will collect and analyze the pilot users' perceived impact of the app on their energy consumption behavior via a survey and interviews. The survey instrument will be designed in line with the behavioral theories discussed in section 2. Moreover, we will obtain more objective findings on the effect of using gamified apps on energy conservation, by utilizing the users' actual interaction data (e.g. number of tips received vs. number of tips realized), as well as recording the actual energy consumed within the workplaces during the pilot trials and comparing it to the energy consumed before the behavioral intervention. To make this comparison meaningful, we will also be taking into account factors that affect energy usage, such as external temperature, day, time and building occupancy. We shall additionally assess the effect of the behavioral intervention on the treatment group of users by comparing their behavioral and energy consumption characteristics with those of

a control group. Representative Key Performance Indicators (KPIs), which we will explore in our research, include: (i) measured energy savings, (ii) user energy awareness level, (iii) user behavior change (percentage of users with more efficient energy behavior and energy-saving knowledge after the intervention), (iv) user satisfaction and enjoyment from the system, as well as from energy saving, (v) adoption (or intention to adopt) the designed solution (% of users that installed / used / intend to continue using the solution).

7. Conclusion

A large number of gamification applications have been implemented in various contexts over the past few years [55]. However, there is a need for further investigation into the application of gamification in a corporate environment, especially towards energy conservation. The ultimate purpose of this research is to conduct experiments, evaluating the effect of gamification on employees' actual energy consumption and behavior change, in the context of three IoT-enabled pilot workplaces situated in different countries. This research study is the first step towards accomplishing our goal. Bearing in mind that a personalized gamified application that matches its potential users' game design preferences has increased prospects of becoming a daily habit and motivating them to conserve energy, we conducted a user survey to explore our target users' profiles and gamification-related requirements.

Analyzing the responses of our survey participants, we categorized them based on the HEXAD gamification user typology. As per the reliability of the HEXAD sub-scales, our analysis prescribes that the Free Spirit and Achiever scales would benefit from future improvement. Furthermore, we discovered indications that younger players have a relatively higher inclination towards the Achiever and Player motivations and men towards the Disruptor motivation. Additionally, Achiever and Philanthropist motivations were the most identified with in our sample, with Socialiser and Free Spirit following closely, while Player and Disruptor were the least popular. Moreover, the overlap between HEXAD types in past research was also verified through our observations, strengthening both its validity, as well as generalizability. At the same time, we found the inter-correlation between user types in our sample to be in line with previous research, except from the connection between Socializers and Free Spirits, which was not significantly verified in our study.

Although significant on their own, player typologies must be practically utilized and tested in real world applications to gain additional meaning. Tondello et al [3] suggest that they have performed the first step toward a standard survey that assesses user preferences for the personalization of gamified systems. However, they also state that their results feature limited generalizability to the general population, as it was acquired from a limited sample of students from one university. They furthermore suggest that including people from different cultural origins and a broader age range will aid in validating the HEXAD model, and survey instrument, for the general population. Our research aids to fill this identified gap by validating the HEXAD model in a radically different environment, featuring employees instead of students, in a multi-cultural workplace setting spanning across three different countries.

Moreover, we identified the survey participants' preferences in game elements in our research context. We deduced that a gamified app for energy conservation at the workplace may be appealing to its end-users and become a daily habit to them if it should at least implement three game elements: progression, levels and points.

Additionally, we combined the collected insight regarding both our users' adherence to HEXAD gamification user types, as well as game elements preferences, towards producing tailored energy-conservation focused feedback. Since tailored feedback has proven more effective towards energy behavior change [29], we proposed a mechanism that generates personalized energy-saving recommendation tips built according to a

modular, rule-based process. Taking into account our participants' preferences, we provided examples of how these tips could be differentiated between user types, as well as suggested a method to serve them proportionately to the end users, according to their HEXAD profile. Overall, this research aspires to assist future researchers, as well as practitioners, in designing and developing gamified apps, and especially those focused on personalized energy conservation in workplace environments.

However, apart from its merits, our study also bears some limitations. First of all, we have so far relied on self-report measures to deduce our conclusions. Albeit their valuable insight, these measures have been known to also carry the personal bias of their source to a certain degree. Therefore, a study including observed, apart from self-reported, information would produce more reliable results. We aim to further fortify our conclusions through practical experimentation in the same context, towards gaining impartially recorded insight. We expect that the accuracy, as well as the validity of our insight on the characteristics and preferences of the HEXAD gamification user types, as well as the proposed personalized energy-saving recommendation tips engine, will be significantly enhanced through a practical application of our findings. Specifically, we will apply and validate actual gamified energy conservation applications in the three IoT-enabled pilot sites. Moreover, as our sample was limited to 99 participants from three workplaces in three geographical locations, our findings would also be better grounded, and more generalizable, if we were given the opportunity to expand this survey to a much larger sample of employees, across different industries and geographic areas. Additionally, the questionnaire was administered once in each site, therefore recording information relevant to the time it was collected. In our future research efforts, we plan to face this issue through a longitudinal experimental study that would hence provide more accurate results, as well as additional insight not currently recorded.

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Appendix: Questionnaire

Game Interaction Design*

For each of the following statements, please state the degree of your agreement selecting between 1-(Strongly Disagree) to 7-(Strongly Agree).

1. I like being part of a team
2. It is important to me to follow my own path.
3. I enjoy group activities
4. It is important to me to always carry out my tasks completely
5. I like to question the status quo.
6. It is difficult for me to let go of a problem before I have found a solution
7. I dislike following rules.
8. Interacting with others is important to me.
9. Rewards are a great way to motivate me
10. It makes me happy if I am able to help others
11. Return of investment is important to me.
12. I see myself as a rebel
13. I like helping others to orient themselves in new situations.
14. The wellbeing of others is important to me.
15. I like mastering difficult tasks
16. It is important to me to feel like I am part of a community.
17. Being independent is important to me.
18. I like to provoke
19. I like overcoming obstacles. [a]
20. If the reward is enough I will put in the effort. [a]
21. I like sharing my knowledge
22. I like to try new things.
23. I like competitions where a prize can be won.
24. I often let my curiosity guide me.

Player Type	Quest. Items
Socializer	1, 3, 8, 16
Free Spirit	2, 17, 22, 24
Achiever	4, 6, 15, 19[a]
Disruptor	5, 7, 12, 18
Player	9, 11, 20[a], 23
Philanthropist	10, 13, 14, 21
[a] modified item phrasing	

*** Adapted from:** [3] Tondello, G. F., Wehbe, R. R., Diamond, L., Busch, M., Marczewski, A., & Nacke, L. E. (2016). The Gamification User Types Hexad Scale. In Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '16. http://doi.org/10.1145/2967934.2968082

Game Element Evaluation

The following table includes and explains the functionality of game elements that a game may include. Please state how important it is for you, that each one is utilized in a game aimed at reducing energy consumption at the workplace, by selecting between 1- (Not Important) to 7- (Very Important).

Legend of game element terminology **		
Term	**Definition**	**Alternatives**
Points	Numerical units indicating progress	Experience points; score
Badges	Visual icons signifying achievements	Trophies
Leaderboards	Display of ranks for comparison	Rankings, scoreboard
Progression	Milestones indicating progress	Levelling, levelup
Status	Textual monikers indicating progress	Title, ranks
Levels	Increasingly difficult environments	Stage, area, world
Rewards	Tangible, desirable items	Incentives, prizes, gifts
Roles	Role-playing elements of character	Class, character

** **Adapted from:** [5] Seaborn, K., & Fels, D. I. (2014). Gamification in theory and action: A survey. *International Journal of Human Computer Studies*, *74*, 14–31. http://doi.org/10.1016/j.ijhcs.2014.09.006

Demographics

Age:
- ❍ 18-24
- ❍ 25-35
- ❍ 35-45
- ❍ 45-55
- ❍ 55-65
- ❍ >65

Gender:
- ❍ Male
- ❍ Female