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Customisation Guidance Document
CAREGIVERSPRO-MMD 1st Version

CAREGIVERSPRO-MMD PROJECT

Document information

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Executive summary

This deliverable is the first version of the Customisation Guidance Document (D2.2) which present activities and progress made on gamification (T2.2), personalisation (T2.4) and interface adaptation (T2.5) of the CMMD platform. Factors influencing treatment adherence will be reported in the accessibility report of T1.1, but interface adaptations and ways to improve the treatment adherence of PLWD and caregivers (T2.3) are reported in the current deliverable.

The relationship between the PACT analysis results and posterior tasks of the WP2 leads to the structure of the document and its outline. After summarizing the results of T2.1 (fully reported in D2.1), new developments in tasks of the WP2 in terms of user interface adaptations and functionality representation for user categories will be presented in detail. The above progress made will be based on the usability studies performed.

The second main focus area is gamification. Towards designing an attractive operational environment for all user categories, but most importantly for PLWD and caregivers, gamification will be described as one of the best ways to create motivation. An extensive analysis of current trends and best gamification practices will be reported as reference for the development of the platform in WP3. The award system of the CMMD gamified platform will be described in detail.

The contents of the next session is derived from the analysis of the treatment adherence services. Starting from the fact that people with mild to moderate neurocognitive impairment have different skills, abilities and interests than others, the results of literature reviews and state of the art will be reported along with specific ways to improve treatment adherence for PLWD and caregivers (dyads) of CMMD.

This document is completed with actions towards personalization and interface adaptation. Methods to customize the platform to end-users based on user profiles will be developed and reported. This includes the description of ways to adapt the interface design in order to make it usable and intuitive for people with mild and moderate neurocognitive disorders.

This document will be closed with conclusions and future work to be done in the second version of the deliverable (D2.3) to be delivered by the end of the project. It is expected that solutions described in here may receive reasonable changes or they may be better adapted to the progress made by later phases of the project.

List of Acronyms

Acronym	Title
AAL	Active Assisted Learning
AccMD	AccessForAll Meta-data Specification
ACM	Association for Computing Machinery
AfA	Access-for-All
API	Application Programming Interface
CAP	Common Access Profile
CGs	Care Givers
CP	Collaborative Personalization
CRs	Care Receivers
CMMD	Caregivers-Pro MMD
gaML	Game Markup Language
GDL	Game Definition Language
ICT	Information and Communications Technologies
ICF	International Classification of Functioning, Disability and Health
IDE	Integrated Development Environment
IEEE	Institute of Electrical and Electronics Engineers
JSON	JavaScript Object Notation
MDA	Mechanics-Dynamics-Aesthetics (model)
OS	Operating System
PACT	People-Activities-Context-Technology (method)
PHP	Hypertext Preprocessor
PLWD	People Living With Dementia
SDP	System Driven Personalization
SG	Serious Game

TA	Treatment Adherence
UCD	User-Centred Design
UDP	User Driven Personalization
UI	User Interface
UM	User Model
VUM	Virtual User Model
WHO	World Health Organization
WYSIWYG	What You See Is What You Get
XML	eXtensible Markup Language

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1 Introduction

What makes the design of CMMD special is the need to apply a standard deployment procedure for the overall platform, the gamification layer and the adaptation and personalization at the same time. Thus, the details for the rewarding system of the gamified environment (levels, points, rules and other gamification elements) should be applied to the overall CMMD platform design, its architecture and challenges. For validation of design ideas user testing will be used on a regular basis (e.g. monthly) to gather end user's feedback and perform improvements on the designs prior to full implementation. The gamified environment will be tested with potential users based on functional prototypes. The development of the gamified platform, customization and interface adaptation will be based on two approaches: a. building custom solutions and b. using third party solutions like one of the many gamification platforms available on the market today.

The accessibility report (D1.1) and the customization guidance document for screening and interventions (D1.5) will be used along the results of the PACT and focus groups analysis performed in D2.1 as input for the design and development processes described above. But those findings and requirements have first to be cross-fertilized with evidence coming from the gamification literature.

1.1 Platform Enhancement and Design Adaptation Objectives

The main objective of WP2 is to redesign existing services, as well as to create new ones to fulfill the requirements of end users for integration in WP3. Persons with reduced cognitive abilities will be placed in the center of the design processes (Patient-centric design) regarding gamification, treatment adherence services, interface adaptation and personalization. Methods to customize the appearance and functionality of the CMMD platform go beyond the use of standard accessibility guidelines for elderly people, PLWD with cognitive decline and their caregivers. This design process may be more complicated than initially estimated because accessibility, treatment adherence and gamification are three pillars of the platform design not extensively applied either in literature or in real world applications.

Gamification and social networks in market and in education has been previously applied with great success. But a gamified social environment for people with cognitive decline is an ambitious objective. Design ideas and proposed solutions will go through a standard validation and evaluation procedure in WP5, but ground making is coming first in WP2.

A safe route to deliver a realistic yet ambitious plan for gamified and personalized services is to study literature at first for progress made so far by other projects and research teams. The next sections provide an overview of the eHealth and gamification literature and present the results of a systematic mapping study. Those findings will record current trends to be applied in the CMMD platform. Later on, design approaches in gamification services will be defined as results of gamification elements and mechanics. Actually, a wide range of gamification elements needs to be studied before making any suggestions for the gamified platform because not all elements may be applicable in the context of CMMD. The selective use of appropriate gamification elements will be followed by a background story as a

conceptual container for all gamification, socialization and treatment adherence services of offer. It is expected that the story narration will foster social interactions and will maximize the total time people spend in the platform. There also some threads coming out of design processes to be handled. Those threads are identified and proper solutions are proposed in a special section of the design approach.

The implementation of the platform will be performed in WP3 but some preparation material should be presented in here. Thus, a comparison study for gamification technologies is performed. A whole ecosystem of gamification tools is presented with respect to pricing and applicability issues. Examples of visual components from gamified environments give an overview of the gamification experience as it will be perceived by end-users. In addition, the rules of the gamified environment are being described using game definition languages.

The Treatment Adherence component will monitor the user's behaviour regarding the degree to which the user correctly follows medical advice and treatment plan. In CMMD this will most commonly refer to interventions compliance, both pharmacological and non-pharmacological. The treatment adherence component will be connected to other components of the platform like the gamification and the personalization component. More specifically, the desired user's behaviour -when achieved- will be awarded by the gamification engine and the results will have an effect on the decision making for personalizing the treatment.

Last but not least, customization and personalization is studied in the last section as a set of services to accommodate specific individuals (e.g. caregivers, PLWD) or groups of PLWD (e.g. dyads, group of Italian healthcare professionals, etc.) to improve healthcare results, satisfaction and loyalty on all healthcare services consumers. Today, personalization is considered as a key-element in social networks and eHealth systems and should not be neglected by CMMD.

2 Outcomes of the PACT analysis and Requirements Elicitation

This section presents the outcome requirements of the PACT analysis, the Focus Groups and the Usability studies performed up to M15. According to the international standards for accessibility, deliverable D5.1 (Usability Studies) and the Focus Groups reports derived from the D2.1, as well as all other WP1 activities which generated knowledge on the requirements and best design practices, **Table 1** summarizes the key-points.

To be noted that the first versions of the platform were not complete as of the wished functionality and not free of technical problems and bugs. The majority of those problems identified during the focus groups and the usability study were addressed and solved by M15. Thus, **Table 1** reports no bugs and possible system failures, but comments on functionality of offer, as well as desired functionality clearly expressed by the users themselves.

Table 1. Key-points for the design of the CMMD platform, possible barriers and desired functionalities

A/A	Key-term	Description	Proposed solution
1	ICT literacy immaturity	Users may not be confident computer users and this creates suspensions in using the CMMD functionality	Offer instructions written in simple language and online help on demand (show hints, popup-balloons, etc.)
2	Navigation	A portion of users who tested the platform faced difficulties in navigating from one place of the platform to another	Use very clear links and descriptions in the left menu and project first the most common activities of the platform
3	Platform too intrusive in user's life	Some functionality related to information sharing appears to be very intrusive and this created some criticism	Respect the stepped social processes by offering full control over the sharing of personal information and online activity of the users. Especially for sharing medical info dyads should give a positive answer to responses coming from medical and social professionals
4	Too much information in one page	Information overload is a well-known problem in the ICT design literature. The difficulty a user, especially those having MCI or mild Dementia have on understanding an issue and making decisions is caused by the presence of too much information in a single page.	Reduce rendered information in user's interfaces, avoid any additional or not required materials in the interfaces used by the people having the most severe medical situations and accessibility issues.
5	Font sizes	Low-vision problems are very common in the targeted by the CMMD platform population and the most frequent complain was about the font-size.	Avoid small font sizes and personalize the text appearance according to low-vision conditions and personal preferences. Personal preferences should have a higher priority than accessibility rules.
6	Too text orientated interface	When users face large amounts of text in the interface tend to be tired earlier than expected and	Although there is a conflict sensed in using icons instead of text, it is better to use text in early phases of user's

A/A	Key-term	Description	Proposed solution
		they may lose their interest	participation. The use of icons can be more intense after users have become experienced.
7	Security and privacy of information	PLWD and their caregivers expressed their worries against the sharing of their personal information, medical data and the data they produce by their normal activity on the platform	Personal information will be shared only among members of personal social network, medical information will be shared with qualified clinical and social personnel after a request. In addition, the visibility of message postings and forum discussions will be controlled by the users themselves through personal preferences and message post settings.
8	Icons	The use of emoticons was, in general, not appreciated.	Emoticons are icons used to express feelings. According to the results of the usability studies in M13-M14, users expressed their discomfort on the fact that the used emoticons expressed both positive and negative feelings. The use of only positive feelings was advised by the clinics.
9	Colours and themes	Opinions were mixed on colours and themes used in the platform pages	Personal aesthetics will be respectful when possible
10	Cognitive games for stimulation	The need for cognitive training through games was requested by portion of uses and the same was confirmed by the site's researchers	A set of Playful interactive interventions for training skills like **visuo-spatial short-term memory, orientation, semantic memory, language** and **problem solving** will be included in the platform as apps.
11	Help to manage health conditions and stress	To provide help in order to manage health conditions and stress is up to the main objectives of the CMMD platform.	Provide tools to: 1. sense health conditions and stress, 2. to report the findings of the user monitoring, 3. Support decision making and 4. Recommend treatment plan and interventions

A/A	Key-term	Description	Proposed solution
12	Playing of games	Most users do not play games but would be interested to some skills training through playful activities.	Already addressed in #10
13	Terminology and functionality	Much of the platform terminology and functionality was unfamiliar to these users	Adapt both content and UI to user's knowledge and abilities. E.g. avoid too technical or medical terminology, difficult language and complicated procedures. Simplify processes as much as possible. Follow the 'three clicks rule' when possible (access all functionality of the platform with no more than 3 clicks from the entry page)
14	Irrelevant info visibility	The visibility of irrelevant to the users information was not appreciated	Proceed with cautious when design interfaces for users, especially PLWD. Sense current action and hide the not necessary information.
15	Communication and inter-operability with other well-known apps	Users expressed their wish to command third party applications from within the CMMD platform	User's demands or wishes cannot be satisfied if not related to the objectives of the CMMD project and when very distant to the expected functionality of the platform.
16	Interactions with other users	Participants in usability studies reported they wanted the platform to facilitate more frequent interactions with HCP whereas a major objective of the platform is to reduce pressure on health service providers.	Respect health service providers and professional's efforts and available time resources to reduce pressure. On the other hand, offer communication tools and educate users on how to use those tools with responsibility.
17	Searching for resources	Offer an advanced search engine for resources	Allow searching for resources based on search criteria defined by the users. Project relevant information on the findings and help users navigate through results.
18	Motivation	A possible lack of	The method to create

A/A	Key-term	Description	Proposed solution
		motivation for participation in online activities was sensed at the early beginning of the platform development based on the literature findings.	motivation for participation is -among others- the use of a gamification approach. A gamification engine and a concept adjusted to the characteristics of the targeted populations are to be developed and used by dyads.

3 Gamification Platform

3.1 Gamification in eHealth

Gamification is about the application of game elements in non-leisure contexts and for a purpose other than just simple entertainment. A gamified solution cannot be considered as a game, but this does not exclude humour, challenges, luck and competition, or other game features. The basic concept in healthcare domain is to transfer motivational elements to other than pure entertainment products like health education, diagnostic processes, treatment adherence, etc. Similarly, gamification platforms developed, provided or used by healthcare systems and groups of beneficiaries have become quite common in the recent years.

Evidence from the literature show that user's experience is more enjoyable after gamification [Deterding *et al.*, 2011; Schacht & Schach, 2012] and this is extended to the feedback collection and diagnostic tools as people find the content of the survey more interesting, easy to read and to answer [Downes-Le Guin *et al.*, 2012]. Especially for PLWD and people who provide help either as formal caregivers and healthcare professionals or any other form of informal helpers, gamification principles can provide a whole new world to perform and act. Also, the communications between user groups, like between PLWD and caregivers for example, can be hosted in a social network and be boosted by the social structures of a virtual community which follows the typical stages of communication and social relationship development [Chang 2011]. Gamification is an additional feature to be applied in the existing social network, as an attempt to improve user engagement and defeat apathy.

Just like marketers and managers use gamification to engage customers –studies report that gamification resulted in 20% increase on time spent on web platforms [Zichermann & Cunningham, 2011] and an increment up to 80% in the number of users completing online tasks [Takahashi, 2010; Nepal et al., 2015], this gamification–by-design approach is expected to result in similar outcomes.

Gamification has been widely adopted in clinical and healthcare settings, especially the last five to six years. It is expected that gamification can link directly the existing clinical processes and health records with target user groups and can fulfil their treatment

adherence or educational and skills training needs. In this section, a systematic mapping study is performed to capture current trends in applying gamification in healthcare domains. More specifically, this state of the art study focuses on the use of gamification principles and technologies by the eHealth designers and final product users or service consumers users like PLWD, caregivers, doctors, nurses, etc. Major analysis criteria and review findings include gamification goals, purpose of use, scope, user acceptance and clinical effectiveness. A pool of twenty three (N = 23) quality literature publications were set under examination. Those findings are of particular importance for eHealth and gamification designers, healthcare policy makers, professionals, caregivers, PLWD, and their families.

3.1.1 Similar Projects

Ongoing games and gamification projects or projects which include gamification platforms are discovering the potentialities offered by modern game elements. Most of them refer to young children or students like ProsocialLearn[1] for example, which initiates a game development and distribution platform for the production of prosocial games that engages children 7-10 years old and stimulates technology transfer from traditional game industry to the education sector. ProsocialLearn will establish a new market for digital games aiming at increasing prosocial skills necessary for positive relationships, team working, trustworthiness and emotional intelligence. Although the target audience and the objectives are different to CMMD, the ProsocialAPI proposed, is an interesting feature that will allow developers to integrate available functions into games.

No One Left Behind[2] will create a new mobile media-rich programming environment for mobile devices targeted to children. It aims to unlock inclusive gaming creation and experiences in formal learning situations. As a general purpose gaming ecosystem using asset-based applied games in various real-world contexts, RAGE aims to develop, transform and enrich advanced technologies from the leisure games industry into self-contained gaming assets that support game studios at developing applied games easier, faster and more cost-effectively.

To name a few of the newer examples, gamification experience in health monitoring and interventions management emerge from the PRECIOUS[3] project, which proposes a preventive care system to promote healthy lifestyles using gamification motivational techniques to change the user habits toward more healthy conduct. 3D-TUNE-IN[4] enable end users with hearing loss to explore, review and customize hearing aid devices and technology. It creates a toolkit to support the visual, audio, haptic design and development of game applications using gamification techniques. From the very new projects, POLYCARE proposes a collaborative environment to help chronic PLWD in acute phases, in self-health management and fostering interaction with medical and social care services based on gamification basis in order to be more attractive and accessible. Since it began on the start of 2016, there is no published dissemination material yet.

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[1] ProsocialLearn: ProsocialLearn - Gamification of Prosocial Learning for Increased, http://prosociallearn.eu

[2] No One Left Behind, http://no1leftbehind.eu/

[3] Precious: PREventive Care Infrastructure based On Ubiquitous Sensing, http://www.thepreciousproject.eu

[4] 3D-Tune-In: 3D-game for TUNing hEarINg aids, http://3d-tune-in.eu

On the other hand, there are services for older adults not closely related to the health conditions, but they are targeted to the Active Assisted Living (AAL). PERSSILAA[5] offer services to prevent frailty which is an elevated risk of vulnerability for age related decreasing health. The services support users through 3 modules: healthy nutrition, physical exercise and cognitive function.

3.1.2 Gamified Applications for Healthcare

Used technologies for gamification may not be different to web technologies. While gamification mostly refers to back-end functionality, it is perceived (visually recognized) by end users as a front-end functionality. Indeed, some visual elements and the overall interface design can reveal the level of gamification penetration, which is how much the application has been gamified. Below a set of health and fitness applications are presented in three categories according to the level of received gamification.

iTriage[6] app is a iPhone application which help people to find medications, diseases, and medical locations and instantly get answers to their questions on their iOS device (**Figure 1a**). Although it utilizes motivational cues, it is observed that the penetration of the gamification principles is quite low. The same is observed for the Diabetes app[7] (**Figure 1b**) which is a diabetes management application with features like tracking the factors that influence blood sugar level, monitoring the fluctuations, planning ahead accordingly and sharing data with doctors. In those two examples gamification elements are used in minimum. They are limited to appealing graphical elements and progress bars to communicate quantitative data like the consumed and remaining calories.

Nike+[8] (**Figure 1c**) and is a typical example of gamified environments for mHealth and lifestyle. Similarly, MySugr Companion[9] (**Figure 1d**) is an FDA-approved gamified diabetes management application that helps people with insulin-treated diabetes take control of their therapy through play. Those applications make use of the most usual gamification elements like endless loops (user's participation never ends), timed tasks (the player must achieve a task within a limited time) and symbolic awards like badges. Some examples of badges are derived from FourSquare (social networking application) in **Figure 1e**, but they are typical examples of rewards given for a special accomplishment.

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[5]PERSSILAA: PERsonalised ICT Supported Service for Independent Living and Active, https://perssilaa.com

[6] iTriage app, https://itunes.apple.com/us/app/itriage-health-doctor-symptoms/id304696939?mt=8

[7] Diabetes app, https://itunes.apple.com/us/app/diabetes-app-blood-sugar-control/id387128141?mt=8

[8] Nike+, https://secure-nikeplus.nike.com/plus/mobile

[9] MySugn, https://mysugr.com

a. iTriage app

b. Diabetes app

c. Nike+ app

d. MySugr
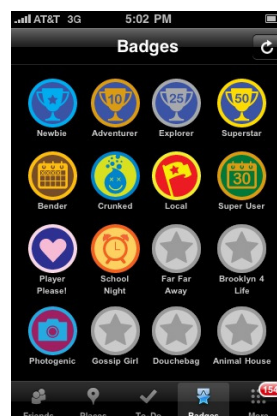
e. Badges used in FourSquare
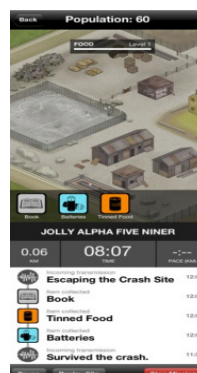
f. Lenny US

g. Zombies, Run! iPhone app

Figure 1. Examples of gamified mHealth applications: Low gamification (first row), moderate gamification (middle row) and extensive gamification (third row).

In a third level, fully gamified tablet and smartphone applications make extensive use of gamification elements and offer cartoon-like visual elements like the Carb Counting with Lenny US[10] by Medtronic Inc. (**Figure 1f**) used for health and fitness. Some others offer a background story like the Zombies, Run![11] (**Figure 1g**). In a fully imaginary context, there was a zombie epidemic and the player is considered the only surviving. The player is a runner en-route to one of humanity's last remaining outposts. Other people need the player's help to gather supplies, rescue survivors, and defend their home. While exercising (running), the player receives audio directions through ear pieces. This way city running becomes interesting and stimulating.

Baby Blocks[12] by UnitedHealth (**Figure 2**) includes an appointment-reminder system that encourages new and expectant mothers who are eligible for Medicaid to keep track of scheduled care during pregnancy and the first 15 months of their child's life. The gamification approach is to earn points out of every user's action (daily health, plan management, check-ups, etc.). It is specially mentioned in here because it combines an online community with a strong rewarding system around user motivation and adherence and this is in line with CMMD priorities.
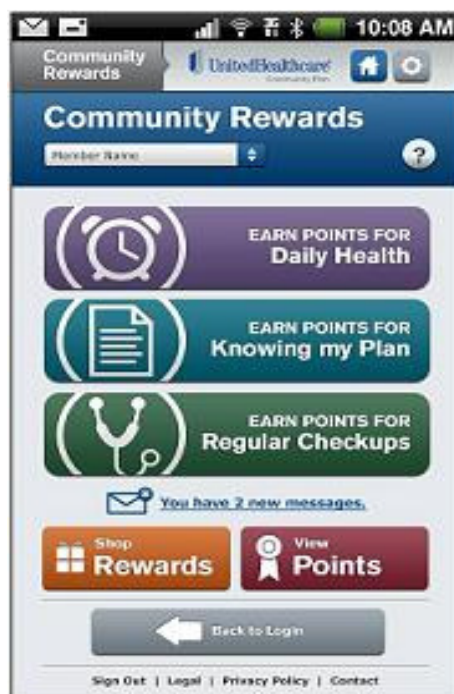
Figure 2. The Baby Blocks makes an extensive use of a pointing system to award users

3.1.3   The need for a Systematic Study on Gamified eHealth Environments

In any case, the healthcare and Active Assisted Learning (AAL) services described earlier present a wide range of conceptual and technical characteristics and not all share a common

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[10] Lenny US, https://itunes.apple.com/us/app/carb-counting-with-lenny-us/id516080517?mt=8

[11] Zombies, Run!, https://zombiesrungame.com

[12] Baby Blocks, https://www.uhc.com

view on gamification principle, neither do they make use of the same gamification elements. A gamification approach based only on definition as "*the use of game design elements in non-game contexts*" [Groh, 2012] is not enough due to many parameters which make healthcare environments quite complicated and the elderly people unique according to their needs, preferences and objectives.

Thus, a systematic study may present useful results to include in design guidelines. The following study aims to present current trends in gamified environments and to propose featured gamification elements to be used in CMMD according to the objectives of the project, the description of end users and the needs of the PLWD. At first stage gamification approaches will be clearly defined and closely related to specific gamification elements.

At later stage, the resulted set of gamification elements will be narrowed down to exclude those not helping much the characteristics of the targeted audiences and those not applicable to a healthcare environment for elderly users. The final set will be studied under the objective to create motivation and behavioural changes like: active enrolment, enrich empathy, trust, curiosity, fairness, compassion, generosity, cooperation, and trigger Emotional Intelligence for strong emotional experiences.

3.1.4   Systematic Study Protocol and Methodology

This study search for empirical evidence on gamification for eHealth, clinics and healthcare systems. The main objective of this section is to collect and review contemporary eHealth initiatives which offer gamified experiences to their end-users. From the whole gamification ecosystem, we need to classify active trends and to identify current design approaches in eHealth settings. Those objectives can be achieved by formulating research questions related to the publication trends, cover topics, thematic focus, use of gamification elements and outcomes:

'Q1: What is the purpose and scope of gamification for healthcare on offer? ', 'Q2: Which game elements are used in existing gamified environments for health?', 'Q3: What is the impact of gamification on therapeutic outcomes?' and 'Q4: What gamification technologies are mostly used and which characteristics of the gamification platforms on offer are more popular?'

Although systematic reviews share commonalities with mapping studies in using search engines of scientific libraries and study selections, they are different in objectives and used methods [Petersen *et al.*, 2008]. A peer-reviewed methodology to collect and assess multiple studies before summarizing research evidence was followed. The protocol of Petersen *et al.* [2015] was used as a guideline for conducting quality systematic mapping studies.

First, the search string had to be formulated and the length and the topics of the search had to be specified. Widely known digital libraries, like the database of the Institute of Electrical and Electronics Engineers (IEEE) IEEEXplore, PubMed and the Digital Library of the Association for Computing Machinery were selected to achieve a good level of representativeness. The search string was formulated by connecting the terms 'Gamification' and 'Health' with an AND Boolean operator. The search string was applied in the title and abstract of the papers. In addition, a publication year range was set to cover the

last decade, so from 2006 to 2016. At the initial search engine results a set of inclusion and exclusion criteria were applied to narrow down the sample. To be mentioned that in some cases the search string had been modified according to limitations of specific search engines in such way to obtain the same results that would had been achieved using the original one if no limitations were present.

3.1.5   Inclusion and Exclusion Criteria

Gamified eHealth environments may include a wide range of software and gamification characteristics, and thus a set of clearly defined inclusion and exclusion (**Table 2**) criteria needed to be defined. Results were mapped to a classification schema, although this classification used criteria mostly derived by the definition of gamification.

The definition of Gamification [Huotari & Hamari, 2012] was used as an inclusion criterion to shape the current meaning and to correspond to a shared understanding. In any case, the main inclusion criterion *Incl1* requires a piece of software to merge non-entertainment purposes with typical gamification and games elements in a complete structure. Also publication date limits were introduced in order to capture recent trends in gamification design. According to this publication rule, studies published after 2006 were included (*Incl2*). We support that this year as a starting point in time is appropriate to screen all the elation that gamification in eHealth might well have presented in recent years.

Table 2. Inclusion and Exclusion Criteria

#	Criterion	Description
Inclusion Criteria		
Incl1	Be a gamified environment	Meet the gamification requirements by definition
Incl2	Publication year	Studies published from 2006 to 2016
Incl3	Language	Papers written in English (full text and not just abstract).
Exclusion Criteria		
Excl1	Not full digital games	Gamification level may vary, so all the SG characteristics should be met
Excl2	Healthcare use	Not designed, adjusted or modified for use by the healthvcare sector (e.g. use of 'game' word in a metophorical meaning)
Excl3	Gray literature	Technical reports, MSc and PhD theses
Excl4	Pharmacy	Not pharmacy-related studies
Excl5	ICT based	Exclude non-digital games
Excl6	Non-educational context	Not targeted to educational outcomes only

But from the plethora of papers related to gamified eHealth environments initially found on the digital libraries, not all participated in this study according to a set of exclusion criteria. A large group of gamification applications, although they might utilized game technologies, they did not meet all the criteria of gamification because they delivered typical gaming experiences. Thus (*Excl1*) refers to the classification to distinguish games and gamified environments. Games for Healthcare and Serious Games for education of white professions

in fact were finally disqualified. Also, some non-digital gaming interventions like the 'RePlay Health' by Kaufman *et al.* [2015] and card games for treatment adherence [Khazaal et al., 2011].

Selected applications in this study had to be designed, adjusted or modified for use in clinical operations and serve healthcare purposes. This rule excludes game-like applications outside of healthcare context or studies not directly related to health outcomes like in Okitika et al., [2015] (*Excl2*).

The third quality exclusion criterion was about the eligibility of grey literature. Thus, technical reports, masters and doctorate theses were excluded from the pool of selected studies (*Excl3*). Alternatively, when possible, alternative studies referred to the same gamified environments were used.

3.1.6   Results

The use of gamification in healthcare settings as a growing trend is reflected in the scientific literature. Conceptual principles, gamification elements, design and implementation guidelines have started being standardized. Also, testing methods were being used to test if gamified environments, as final outcomes of a gamification process over an existing system, have been correctly designed to serve the needs of beneficiaries. On the results of the inclusion criteria, the exclusion criteria were applied and duplicates were removed to conclude to 23 studies. The pool of selected papers is presented in **Table 3**.

Gamification in Healthcare for serving purposes in specific domains

Previous applications can be found not only in eHealth [Walz & Deterding, 2014], but also in business [Richer *et al.*, 2015], in education [Dicheva *et al.*, 2015] and in health professions education [Rojas *et al.*, 2014a; 2014b]. Although most existing solutions focus on customer experience using gamification techniques to make an application more attractive in many ways [Detjaroenyos *et al.*, 2014], another part of the literature is target to clinical procedures like in the work of Byrom [2015] in which gamification was used in clinical trials. Applications oriented to specific disorders or illnesses, like for the Attention Deficit Hyperactivity Disorder test [Craven *et al.*, 2014] and empowering people with diabetes [Gomez-Galvez *et al.*, 2015]. In other application domains, gamification solutions have been applied to monitor PLWD or wider audiences for a healthier lifestyle. Such examples are childhood obesity [Hu *et al.*, 2015] and proactive self-monitoring as part of a novel approach to enhance the intrinsic motivation of users towards a personalized healthy lifestyle [Burmeister *et al.*, 2013]. Gamification approaches with a purpose for behaviour change include also non-clinical applications like in Setiawan & Putra [2015] to increase voluntary blood donors' participation, and have wider audiences like in Pereira *et al.* [2014] which is targeted to changes in eating habits.

Table 3. Pool of Selected Papers

A/A	Game/app name	Reference	Primary objective	Target Audience	Technology		Evaluation	
					Tools/Protocols	Devices	Method	Subjects
1	-	OGI et al., 2015	Improvement of the health consciousness, to attract people's attention	wider public	Wi-Fi	Mobile phones	Subjective (Questionnaire)	41
2	We4Fit	Pereira, et al., 2014	Behavioural Change, motivational trigger (eating habits and promoting a healthy life) by blending elements of social integration and competition	Younger than 18	Web, persuasive technologies, PhoneGap framework	Mobile phones	-	-
3	SmartAssist	Burmeister, et al., 2013	Ambient Health Monitoring towards a personalized healthy lifestyle	Elderly people	Ambient Dynamix, context-aware computing, REST-API, Bluetooth, WEKA	Android devices	Subjective (Usability evaluation)	9
4	?	Lapao_2016	Improve Nurses' Hand Hygiene Compliance	Nurses	smart beacon's technology, WiFi, GSM	Indoor location system	Subjective (interview)	?
5	The Heart Game	Dithmer et al., 2016	Assist heart PLWD in their telerehabilitation process	heart failure, myocardial infarction, or angina pectoris, healthcare professionals and PLWD	?	Tablets (Android)	interviews, participant observations, focus group interviews, and workshop	10 dyads (2 to 12 weeks)
6	sjekkdeg.no	Gabarrona et al., 2013	Prevention of Sexually transmitted diseases for Youth	North-Norwegian youngsters	Web	laptop, smartphone and tablet	Objective	344 visitors
7		Raymund et al., 2012	Achieve desired behaviours and healthy lifestyles (exercise and diet)	Employees	Facebook-like social networking/gamification portal	-	Objective (behaviour analysis on time & kind of information searched)	20 employees

A/A	Game/app name	Reference	Primary objective	Target Audience	Technology		Evaluation	
					Tools/Protocols	Devices	Method	Subjects
8	Stim'Art	Yasini et al., 2016	Improve cognitive function through Serious Games on memory and brain training	Older adults with cognitive disorders	Mobile applications	iOS and Android mobiles	Objective (Game performance)	15 older adults
9	SureWash	Lacey_2016	Prevent Hospital Acquired Infections (HAIs) by culture change	Hospital staff	Gesture recognition	Cart-based kiosk eLearning system	Objective (no. of interactions with the system per month and pass rate)	?
10	-	Cameirão et al., 2016	Motivate and evaluate physical exercises in stroke survivors to increase compliance	Stroke survivors	home-based rehabilitation system, Emotion recognition, Microsoft XNA Game Studio 4.0	Microsoft Kinect 1	System Usability Scale questionnaire, Stroke Impact Scale v3.0,	?
11	iLift	Kuipers et al., 2015	Train nursing in lifting and transfer techniques to prevent lower-back injuries health behaviour change support system	Healthcare professionals (Occupational Therapists, Nurses and Caregivers),	?	?	Subjective (Focus group interviews)	37
12	RePlay Health	Kaufman et al., 2015	Inspire shifts in thinking about public health and healthcare policy	PLWD, policy makers and voters	Game website	Board, printed materials	Subjective (Questionnaires)	31 young adults (medical students)
13	Polio Eradication	Okitika 2015	Increase public interest in globalhealth	Wider public	?	Board	qualitative analysis (open-ended questions)	197 game participants
14		Jaarsma et al., 2015	Increase exercise capacity and level of daily physical activity at home, to decrease healthcare resource use and to improve self-care and health-related quality of life	PLWD with heart failure (HF)	Exergaming technologies	Wii	randomized study	600 PLWD
15	mHealth	Brown-	improve patient–clinician	Health professionals	VR, 3D immersive	iPad	Subjective	8

A/A	Game/app name	Reference	Primary objective	Target Audience	Technology		Evaluation	
					Tools/Protocols	Devices	Method	Subjects
	TLC	Johnson et al., 2015	communication, degrease lung cancer stigma (LCS) and promote optimal self-management	(nurses, doctors, researchers)	technologies		(semi-structured interviews)	
16	MyPsySpace	Brahnam et al., 2014	Offer new and virtual translations of traditional expressive therapies	?	VR, 3D immersive technologies (Second Life)	Surface computer, laptop, wall projection, large flat screen TV, VR CAVE systems and Oculus Rift.	?	?
17	Scavenger Hunt	Hagler et al., 2014	Improve the early detection of neurological problems, to provide feedback and monitor for cognitive interventions in home (estimate the results of the pen-and-paper trail making)				? executive function, as well as visual pattern recognition, speed of processing, working memory, and set-switching ability	30 older adults
18	PlayMancer (3 minigames: Temple of Magupta, Face of Cronos and Three Wind Gods	Jansen-Kosterink et al., 2013	Achieve physical rehabilitation	PLWD with chronic musculoskeletal pain	Exergame, motion capture	Motion suit, various infrared cameras (IOtracker), electromyography electrodes	Both objective and subjective (Core Elements of Gaming Experience Questionnaire-CEGEQ, Pain Disability Index-PDI, visual analog scale-VAS, SUS)	10 PLWD (for 4 weeks)
19	-	Hammond et al., 2012	Improve motor and psychosocial outcomes in children with	Children with Developmental Co-	VR, 3D immersive technologies	Video game console	A randomized crossover controlled	52 children

A/A	Game/app name	Reference	Primary objective	Target Audience	Technology		Evaluation	
					Tools/Protocols	Devices	Method	Subjects
			movement difficulties	ordination Disorder (DCD),		(Nintendo's Wii Fit)	trial (DCDQ, BOT-2, CSQ, SDQ)	
20	Virtual reality balance training (VRBT)	Cho et al., 2012	Investigate the effects of virtual reality balance training (VRBT) with a balance board game system	Chronic stroke PLWD	VR, 3D immersive technologies, bluetooth	Wii Fit balance board (by Nintendo), a 42-inch LCD screen television	Posturography, BBS, TUG, MMSE	24 subjects (controls and chronic stroke PLWD for 6 weeks)
21	-	Lockery et al., 2011	Telerehabilitatithrough a gaming system	Clinician, Physician, PLWD	Telerehabilitation system, CMS, JavaScript, JQuery, AJAX, PHP, MySQL	Webcam, magnetic motion tracking system- 6 DoF, miniBIRD 500	Objective (Speed, time)	?
22	"Refurbishment and Expansion of our Low Secure Service"	Fitzgerald et al., 2010	Consult with service users on the design, layout and refurbishment of the expanded low secure service	Service users with serious mental illness	-	Board	Subjective (semi-structured interview)	-
23	Michael's Game	Khazaal et al., 2011	Promote the dissemination of cognitive therapies and familiarize healthcare professionals and PLWD with cognitive therapy of psychotic symptoms		Card game	Board, cards	Subjective (BCIS and PDI-21)	135 PLWD

Gamification Technologies

Apart from serving various purposes, gamification solutions are characterized by the technologies used for development. Various types and genres of SG for people with dementia [McCallum & Boletsis, 2013] can be implemented with different gaming technologies and can be easily integrated at the time of the platform design (like in CMMD) or at later (after the first market-ready version has been released).

No matter if gamification is applied on design or on existing platforms, there are 2 components technologies are applied: the gamification and the sensing component. Technologies used for online experiences are not much different than typical web development technologies. While gamification technologies mostly refer to the back-end of the platform, designers follow two approaches: 1. to develop the gamification mechanics form the beginning (from scratch) or 2. to use a market-ready gamification engine. The later comes as a ready-solution and can be applied on the top of existing online platforms to offer a gamified environment. This approach may be suitable for existing websites and inline communities, but it requires re-design of the visual layouts (interface) in order to communicate the gamification component with the users. There are paid gamification engines (e.g. eMee[13]) as well as free ones (e.g. PlayLife[14]) and those which follow mixed approaches (e.g. Mambo.IO[15]). For standalone initiatives, which usually have been developed from scratch, there are other technologies like Virtual Reality (VR) used to offer immersive experiences.

The other domain in which gamification technologies are being applied is the sensing component. This is a mandatory element in gamification projects used to sense user's states and monitor patient's conditions (for telemedicine applications). Various sensors and hardware/software for establishing network connections are used in a sensing component. For online platforms like CMMD the sensing could be implemented online using feedback collection tools like e-surveys and questionnaires. It is of particular interest the current trend to gamify the feedback collection process using gamification principles, mechanics and aesthetics in the eSurvey design [Downes-Le Guin *et al*., 2002].

Distribution of Publications per Year

The distribution of papers per publication year was considered a worth mentioned topic to study. The number of publications related to gamification for healthcare and eHealth systems was found to be increasing since 2010 (study starting year). Sparse publications were noticed in the middle year period up to 2013, but a significant growth after 2014. According to these data (

Figure 3), an estimation for future growth comes to 142% growth in publications by the year 2020 (linear regression, r^2=0.752).

Clinical Outcomes

The set of selected studies was tested against potential clinical outcomes. Indeed, most studies report a positive clinical effect after experimental studies. Healthcare benefits are reflected in outcomes related to the treatment adherence and motivation for PLWD and

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[13] eMee, gamification platform (http://www.emee.co.in/)
[14] PlayLyfe, online gamification platform (https://playlyfe.com)
[15] Mambo.IO, gamification software (http://mambo.io)

other groups of beneficiaries. In most cases, studies had reported the use of feedback collection instruments like questionnaires for a certain period of pilot testing of the gamified environments. A meta-analysis of the results was found difficult to be performed because of the lack of standardized results reporting. In the majority of the studies, findings were meaningful only when compared to specific application characteristics. But from a broader field of view, clinical effectiveness was related to patient's motivation for participation and their willingness to redo the activity in a regular basis.
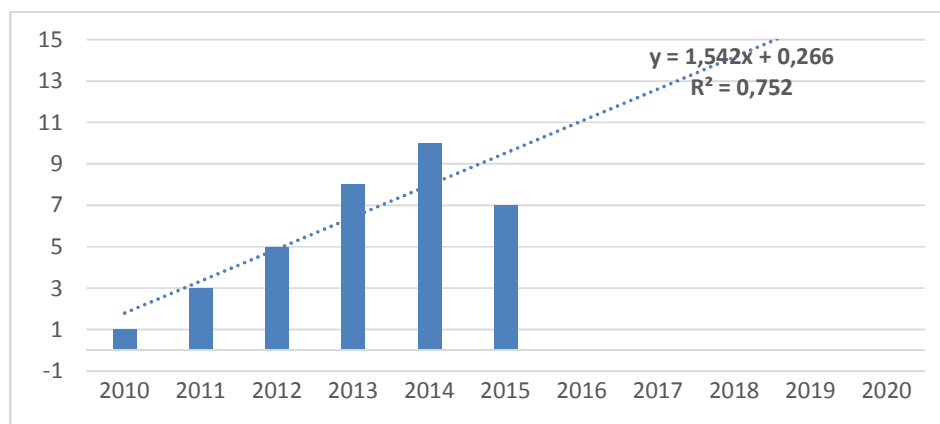

Figure 3. Distribution of publications per year of publication

Popular criteria used in experimental validation to estimate actual clinical effects and knowledge acquisition included time spent in reading content about specific medical problems, treatment plan and general purpose information, time spent at searching around and navigating in the gamified environment (including social networks when present) and the overall duration of the in-platform activities. In the majority of the studies, the gamification elements and user's responded back actions were well fitted on the clinical processes and treatment plans. Most authors attribute those findings to stronger motivation gamification had created for their targeted populations.

Other systematic studies determined that gaming experiences may be useful in improving health outcomes [Primack *et al.*, 2012] (69% improvement of psychological therapy outcomes, 59% of physical therapy outcomes, 50% of physical activity outcomes, 46% of clinician skills outcomes, 42% of health education outcomes, 42% of pain distraction outcomes, and 37% of disease self-management outcomes). What were rarely found on the literature is cognitive outcomes after using games or gamified environments.

Apart from positive outcomes, some negative aspects of the gamification has been reported, mainly related to the sensing component. User monitoring has mainly been associated with negative consequences for the individual (invasion of privacy, dissatisfaction, stress, and distrust) as reported recently by Nelson *et al.* [2016]. Thus, in CMMD design we may handle the sensing processes with caution to avoid such negative consequences.

3.1.7 Threats to Validity and Mitigation Actions

As most systematic studies, this effort made was exposed to validity threats. Authors defined research questions in advance and stated well defined inclusion criteria based on gamification definition. On the other hand, regarding the information bias and the thread of misclassification, a strict exclusion criterion was applied on all selected studies in order to

ensure that gamification-featured applications for healthcare settings is what selected studies were about.

Limits on date of publication were applied to reduce inclusiveness to recent studies following recent history on the evolution of gamification. Some other restrictions were imposed in order to stay focused on a particular domain of gamification which is healthcare and eHealth platforms. Thus, a broad overview and very generic results was avoided.

Threats related to the search engine selection may have resulted in some missed papers, but it is not expected that this loss was significant. A set of major electronic databases were used as in most relevant studies. The terms 'Gamification' and 'Health' involved in the search string are quite generic and may resulted broad results, but a careful meta-search selection excluded papers not closely related to the topics. Some papers mentioned Health as a topic for gamification, but the actual thematic focus of the papers were moved elsewhere.

According to the quality management followed, gray bibliography such as theses and dissertations were excluded from the results, or replaced by relevant publications under the rule that replacements refer to the same final product.

In overall, results of the state of the art were systematically retrieved following a typical mapping study methodology. This methodology gave emphasis on collecting a representative input and presenting current trends. Thus it is believed to be robust in limited selection biases.

Another validation thread in systematic studies was related to misclassification. Custom-made classification schemas or arbitrary combinations of varying approaches may conclude to results non-comparable to other studies. In this work, a current popular definition of gamification was applied as inclusion criteria to eliminate false positives in the pool of selected gamified applications.

But not all classes or categories of gamified environments had the same probability of being misclassified. Some studies did not disclose enough information to ensure that the applications they refer to were gamification systems. Some faced difficulties in distinguishing gamified environments from games, Serious Games and simulations. Therefore, before applying the exclusion criterion #1, it was at high risk that a paper was selected for review even though the referred application was not gamified according to the definition. In some studies, this leaded to a typical differential misclassification, in which an overestimation of the true values occurs. Therefore, the presence of gamified environments in healthcare systems may appear -in scientific literature- to be higher than in reality.

Similarly, another misconception came from the clinical effectiveness of the gamification used in healthcare systems and lifestyle. A lot of noisy estimations have been drawn in literature mainly because most studies presented only important findings (effective gamified applications). User acceptance may appear to be higher in gamification applications because of the gaming elements and not because of their therapeutic and prevention effect.

3.2 Design Approach for CMMD Gamification Services

3.2.1 Rationale

The environments previously mentioned offer intense gamification elements and usually involve Serious Games (SG) in their platforms. Although game-mode experiences may be interesting for young and middle-aged populations, play-mode experiences would be more appropriate for the elderly. The distinction between those two modes is based on a simple concept: *Play* is an open-ended territory in which make-believe and world-building are crucial factors, while Game is a confined area that challenges the interpretation and optimizing of rules and tactics [Walther, 2003]. In other words, "*Gamefulness*" describes the experiential and behavioural qualities of gaming and "*Playfulness*" describes the same for playing [Groh, 2012]. Hence, in the HCI context playful interaction is distinguished from gameful interaction although differences may be relatively small.

Computer-based gaming for Dementia are targeted to cognitive, physical or social/emotions games [McCallum & Boletsis, 2013] like the KiMentiais, a Kinect-based application, designed for individuals with dementia to allow the elderly to perform mental and physical exercises at the same time [Breton *et al.*, 2012]. Applications like that can be included in the CMMD platform, but as extra training/exercise material. Although separated features, Serious Games (SG) and the rest of the gamification platform can communicate via connectors to monitor the frequency of SG use and the achieved performance in order to feed the award system with more information about patient's overall activity. In any case participation on SGs will not satisfy the requirements for gamified experience in the CMMD platform. The platform itself will present game-like functionality and gamified visual elements.

The gamification platform will be implemented on the top of the CMMD platform, so it will be applied in a social networking environment. Instead of handling users as separate entities, gamification design should be aware of the 'socially constructed presence' [Arminen *et al.*, 2008] the communities of the end users create. Users are expected to have a strong social presence and most of services require that circles of users are regularly activated, thus including social elements to gamification can further enhance user's engagement [Nicholson, 2012; cited in Al Marshedi *et al.*, 2015]

Overall, what is needed is gamified social environment for people with Neurocognitive Disorders, their caregivers and professionals. Videogames exclusively for PLWD are welcomed for skills training, but not required. Thus, connections will be created to easily adapt new game applications in the gamified platform and indicative material will be inserted for demonstration purposes, like memory games and games for cognitive conditions screening. The gamified CMMD platform will be the result of gamification elements inserted into the platform. Those elements have to be carefully selected in order to make sure that they are suitable for the target audiences and the concept of the project.

3.2.2 Major Motivators per User Group

All kinds of users of the CMMD platform need some kind of motivation to participate in the platform activities. Even if they are active members of the community, motivation will help them do their best and keep logging on at a regular basis.

On the other hand, there is a need to support the less experience members of the community. At least half of the caregivers have not received any training related to providing assistance to older people and people living with disabilities including dementia (Sotirakou et al., 2015).

Table 4 is an attempt to present the motivators for elderly people, PLWD, caregivers and professionals which can be implemented by the application of the gamification principles into the social networking services of CMMD. The concept is to connect those motivators with the awarding system of the gamification.

Table 4. Motivators created by gamification

Motivator by user type	Short description
PLWD	
PLWD_M1	Realize they are not alone or they are not the only people living with Dementia
PLWD_M2	Find a place to express themselves
PLWD_M3	Educate themselves on medical conditions and other side effects
PLWD_M4	Train cognitive skills and memory
PLWD_M5	Keep themselves active and socially present, fight exclusion
Caregivers (Family Members)	
Carer_M1	Learn more about dementia and how to be a better caregiver
Carer_M2	Learn how to better serve their beloved
Carer_M2	Eliminate stress and prevent burn-out
Professional Caregivers	
Prof_Carer_M1	Intrinsic motivator to be better at their work and to offer more to people they provide care
Prof_Carer_M1	Acquire interesting knowledge that will facilitate their work
Medical and Social professionals with low experience	
Prof_M1	Acquire interesting knowledge that will facilitate their work
Prof_M2	Learn form the best professionals
Prof_M3	Expand their professional contacts

3.2.3   Threats to Gamification Design and Proposed Risk-mitigation Measures

Although still in development, most successful examples of gamified healthcare environments include features like motivation for enrolment and active participation, health monitoring, self-management of healthcare and treatment adherence. Gamification principles when applied carefully can create the expected outcomes, but this is not a panacea. Gamification is a relatively new concept but some side-effects have already been studied.

What should be seriously taken into account when designing the gamification platform of CMMD is the *Over-justification* phenomenon. This term is coined to describe negative influences created when intrinsic motivation is shifted towards the extrinsic incentives [Lepper *et al.*, 1973; cited in Groh, 2012]. In simple words, *Overjustification* is a violation of design principles related to motivation. When populations are strongly monitored for a natural behaviour (internal motivation) and they are directly awarded for their outcomes usually by a point system (external motivation), then the quality of this outcome is getting lower. In addition, after applying a strong awarding system there is no way back for users because they will refuse to create outcomes or change behaviour without rewards. Thus, metrics for monitoring

Another issue is derived from age differences and cultural differences. On the one hand, there are age-related barriers to be taken into account when designing fun and challenging elements. Not all ages perceive fun elements uniformly and something that is fun in young ages may not be appreciated by older people. This becomes very important when taking into consideration the fact that elderly people like to make a different use of technologies than young people who belong to the so-called 'Game Generation' [Elizabeth, 2005]. Those differences in preferences can be summarized in Prensky's theory about differences between the *Digital Natives* and the *Digital Immigrants* [Prensky, 2001]. Thus, mild gamified environments may appear more attractive to the elderly mainly because they can combine innovative gaming characteristics with more traditional appliances.

On the other hand, pilot studies will be performed in four different EU countries with four different cultures. The future target groups of beneficiaries cover even wider European areas. Gamification elements are subjects to localization as already performed by the gaming industry. It is quite common for gamification designers to apply localization processes into their product in order to achieve a better adhesion to the local market. Thus, CMMD gamification platform should be adjusted to more than one cultural orientation for present (pilot studies) and future (business plan) market penetration. A realistic approach would be to prepare material according to wider cultural clusters, like those proposed in the work of Gupta *et al.* Societal cluster classification [Gupta *et al.*, 2002] and presented on **Figure 4**. This approach, followed also by industrial game producers to reach international audiences, may exclude local cultural elements but it can complement with elements coming from the cultural clusters. It is worth to mention that pilot sites of CMMD represent two different cultural clusters and the whole EU gathers four cultural clusters.

Cultural clustering strategy may not represent 100% similarities and differences between cultures of the EU region and also there are sub-cultures which sometimes may be more important in platform design than official cultures. Big city populations for example maintain

founding principles of the parent culture, but they may also differentiate themselves from provincial population, especially in lifestyle and the way they handle healthcare.

One last issue to consider is the lack of standards in gamification design that contain the essential components to achieve sustainability. A proposed solution is to follow the framework of AlMarshedi *et al.* [2015] which contained the following components: flow, relatedness, purpose, autonomy and mastery in the design of the gamified platform.
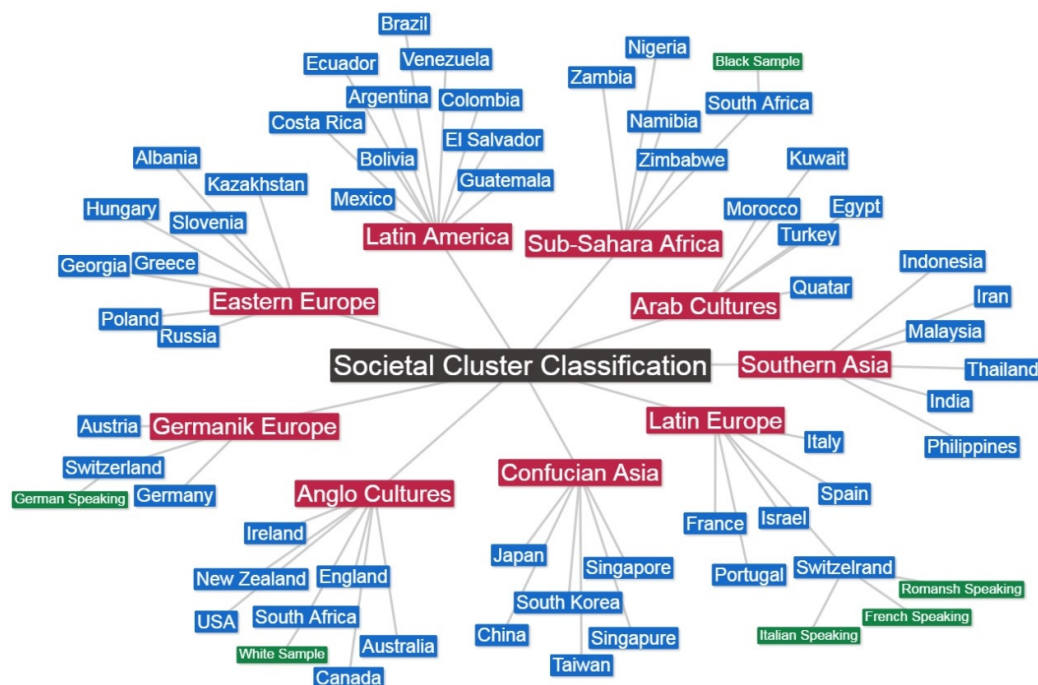

Figure 4. Graph of the Societal Cluster Classification proposed by Gupta *et al.* [2002]

3.2.4 *Gamification Elements*

Since Gamification is an umbrella term, there are a lot of ways to achieve a certain level of gamification in any context. But there are some standardized and recognizable elements, namely gamification elements, which can be inserted into game-like environments and transform the end user experience towards a game-like experience. In this section a collection of gamification elements is presented and an initial validation is performed on their possibility to be inserted into the CMMD gamification platform.

In battle-related elements like enemies, weapons and deadly objects were removed from the list for obvious reasons. Also, elements related to mouse and keyboard dexterity and loss aversion were removed too. The rewarding system which will be designed will work only with positive rules and withdrawal on acquired rights and privileges will not be allowed. The rest gamification elements can be considered selectable for CMMD. The following list presents the gamification elements with comments on their appropriateness for CMMD. Those elements initially were pointed by Al Sweigart [2012] and Andrzej Marczewski [2015] Inspired by a card game that triggers that 'Eureka moment' for gamification designers. Extensions and adjustments were performed based on the possibility those elements to be used by end-users in the CMMD platform.

The taxonomy of the gamification elements follows for designing ways to engage end users of eHealth services given different levels of expected engagement and willingness to commit time to interaction [Robinson & Bellotti, 2013]. Game play motivation frameworks have been proposed in the literature based on a large survey of player motivations [Yee, 2007].

Here we propose taxonomy over the results of a systematic review on gamification elements that suggests the degree to which each one is likely to be exploitable at different levels of anticipated user's motivation and engagement. When those elements are applied to new or existing systems can potentially enhance through stated rules, feedback and rewards other out-of-the-game services, like treatment adherence services, social networking or medical diagnostic services, etc. Games and gamified environments are different in purpose, but they may share some commonalities. Thus, some the game elements may be useful in a new gamification structure and vice versa (**Table 5**).

Table 5. Game Mechanics

GE1	Endless loops (Action Repeats Until You Die)	☑
Description	There is no victory condition in the environment. User's and environment's actions keep going until an external condition interrupts the activity. In pure gaming environments (casual leisure games) this is identical to player's die, but in here we consider various external conditions capable of stopping the activities.	
Appropriateness for CMMD	Endless loops are a common way to keep the end user busy and maximize the time players get involved with the environment and its contents. It is proposed that endless loops should be inserted into the gamification platform. Even if users manage to achieve all of their goals, the environment will still repeat its actions.	

GE2	Remember an Increasing Number of Things	☒
Description	Tests the short-term memory of a player.	
Appropriateness for CMMD	The environment requires that users have to remember an increasing number of things in order to perform well. Although MMD affect short-term memory and healthcare should include mnemonic strength exercises, this may not be eligible for the gamification platform. In D1.2. memory loss is mentioned as a standard in the analysis of symptoms and thus PLWD with memory complains will not feel comfortable with this feature.	

GE3	Repeat Pattern	☑
Description	The player must repeat a series of given steps	
Appropriateness for CMMD	Repeat patterns are allowed for all categories of users. Actually, fun elements sometimes are introduced as repeated processes (cycles of user's actions). This will help users with MMD to remember stepped processes and will maximize their self-confidence in using the platform.	

GE4	Forced Constant Movement	☒
Description	The player cannot stand still at any point.	
Appropriateness for CMMD	These elements are more common in pure leisure games. The forced constant movement in CMMD platform would generate anxiety to users. The allowance of such a gamification element would be contradictory to the typical profile of PLWD and caregivers (behavioural-psychological symptoms in D1.2).	

GE5	Block Puzzles	☑
Description	The game involves standard sized objects that must be moved around in a specific way (like in the Tetris game for example)	
Appropriateness for CMMD	Although puzzles could be useful for all categories of users, a block puzzle challenge requires a straight game environment with objects or pieces moving along certain routes to achieve a wished end-configuration. This element must be changed in order to be used in the gamification platform Changes include the use of symbols and icons as blocks (e.g. other users, friendship requests, awards, etc.) over standard processes. It will be applied more as a drag-and-drop modality to perform tasks than a puzzle to solve.	

GE6	Game Keeps Gets Harder Until You Die	☒
Description	The difficulty level keeps increasing all the time until users cannot follow the changes in the status of the environment and usually the end user's experience is terminated.	
Appropriateness for CMMD	The level of difficulty is considered very important factor for motivating elderly people and all other user categories. It is one of the most sensitive parameters to be adjusted because a lower than expected level of difficulty could make the gamification platform to appear as boring, while a higher level of difficulty may cause elderly people to feel disappointed. The level of difficulty will be increasing when needed based on user's performance and frequency of use but only up to an upper threshold.	

GE7	Uncountable Number of Possible Paths	☒
Description	Use of mechanic means to generate a very large number of possible paths, so that it is not obvious which is the best to follow.	
Appropriateness for CMMD	It is nice feature to offer alternative paths to users but when the space in the gamified environment becomes tremendous, then Information disorientation issues raise. Indeed, PLWD and other elderly users face disorientation in their symptomatology (D2.1. Cognitive-clinical symptoms).	

GE8	Information Overload	☒
Description	This happens when the environment presents to the user too many pieces of information that finding patterns become very difficult.	

Appropriateness for CMMD	Information overload is mentioned as a negative phenomenon and undesirable design element is ICT products [Speier *et al.*, 1999]. But under certain circumstances, this may be challenging for users. Usually young players find it fascinating to challenge their ability to recognize patterns in a messy world, but the same is not true for elderly people. PLWD and caregivers may fail to make any sense out of the presence of too much information.

GE9	Disinformation	☑
Description	The opponent (user of the environment) try to bluff into thinking he/she is stronger or weaker than they really are.	
Appropriateness for CMMD	Disinformation, contrary to the information overload, can be handled by all categories of end users. It requires critical thinking and some luck in understanding whether other participants or the gamified environment overestimate or underestimate things. Bluffing the opponents may be helpful in creating traps, change the flow of the status and make fun.	

GE10	Switch Modes	☑
Description	Users can switch between two or more modes to make progress.	
Appropriateness for CMMD	Switching modes under a predefined set of modes and under a controlled rhythm can help users to make progress towards their goals and create some fun if rules for switching between 'cat' and 'mouse' modes can be implemented.	

GE11	Bouncing Object	☒
Description	According to this element, users cannot directly control an object's movement, but can try to direct it so that the environment directs its path.	
Appropriateness for CMMD	This element is more typical to gaming environments. It would be difficult to be transferred to a gamified environment for healthcare. The decision for elicitation is rather negative for this element.	

GE12	Gravity	☒
Description	Objects are pulled either in a certain direction or are pulled towards certain objects.	
Appropriateness for CMMD	Zero or reverse gravity are elements typical to gaming environments. Thus, it would be difficult to be transferred to a gamified environment for healthcare. The decision for elicitation is rather negative for this element.	

GE13	Spinning Plates	☒
Description	The player's attention split between multiple simultaneous objectives.	
Appropriateness for CMMD	Tasks in which users must split their attention in two or more objects or targets, require selecting attention and concentration. Those two cognitive abilities, as well as others, may be affected unevenly and thus it may create barriers for some users, especially those facing severe cognitive conditions.	

GE14	Squad	☑
Description	Rather than a single character, users control multiple characters that must work together to achieve an objective.	
Appropriateness for CMMD	It is expected that users will face no problems to control multiple agents (characters) who appear in the digital story telling (narration). Those characters can be real users or in-game characters (non-player characters). Indeed, some of the end users like the doctors and social workers follow more than one PLWD. Squad control meets their role and can be successfully transferred in to the gamification platform.	

GE15	Hidden Image / Where's Waldo?	☑
Description	Players are looking at a complex scene for a particular item, clue, or pattern.	
Appropriateness for CMMD	Instead of a game scene we will have a gamified environment in which users will try to recognize a pattern, find a clue, a piece of information or an object. This game element can be used as a gamification element in the platform to give a sense of an adventure game in the whole end user's experience.	

GE16	Timed	☑
Description	The player must achieve a task within a time limited.	
Appropriateness for CMMD	As long as the time limits can be adjusted by end-users themselves and/or the personalization mechanism proposed in T2.4 (Personalization of software), the timed processes are good examples or gamification elements suitable for all user categories, including PLWD. This way, some performance indicators, goals and achievements can extend the time.	

GE17	Protect a Target	☑
Description	The user must protect a target from enemies or risks.	
Appropriateness for CMMD	Apart from staying alive and give a social presence in the gamified environment, users have to protect something from other opponents or risks. This element can offer multiple dimensions in the end-user's experience and maximize the feeling of control and responsibility. From a psychological point of view PLWD will feel not the subject of protection but a subject which offers protection to others too.	

GE18	Undirected Exploration	☑
Description	Users can wander freely around a big map and obtaining items or solving clues will help open up new areas. The player often backtracks through places.	
Appropriateness for CMMD	Instead of having a big map, users in CAREGIVERPRO-MMD platform can have a big information space to wander. Navigation around social structures and educational or treatment material can constitute a big map. In either case, undirected exploration of the gamified environment will be crucial for keeping users busy, and the platform interesting.	

GE19	Buy Low, Sell High	☒
Description	The game has different items that have changing value. The player must identify when it is good to acquire items when they are plentiful or cheap, and when it is good to sell them when they are scarce or valuable.	
Appropriateness for CMMD	'Trader instincts' expressed as the simple rule to buy low and sell high can provide additional motivation to all categories of users, as long as the trading rules are accepted and agreed by all participants without discriminations.	

GE20	Dialogue Tree	☑
Description	When users talk to others, they select one of many possible things to say.	
Appropriateness for CMMD	This feature is used quite a long time in leisure games which allow participants to exchange messages. Specifically for the CAREGIVERSPRO=MMD gamification platform, this element could be proved of special importance, mainly because PLWD with neurocognitive disorders appear to be slower in text typing. Selecting choices from a pool of ready-made expressions can very helpful.	

GE21	Building	☒
Description	Users can place different types of building blocks anywhere in the world to construct objects.	
Appropriateness for CMMD	Like in SimCity or Minecraft, users can create new structures based on blocks. But this element is closely related to games as they require a virtual world to be the container of the user' actions. This element may have a limited or no presence in the final gamification platform, but actions towards maximizing the creativity of the users will be taken seriously in mind during gamification design.	

GE22	Race	☒
Description	The player must reach a place before the opponent does. The enemy as a "timer" can be slowed down by the player's actions, or there may be multiple enemies being raced against.	
Appropriateness for CMMD	This element is considered not applicable to this domain of gamification. A race could create unwished reactions to such a competition and also maybe negative feelings for the gamification platform itself.	

General Purpose Gamification Elements

GE23	On-boarding / Tutorials and Signposting	☑
Description	User manuals are not used any more. Instead users prefer tutorials to understand how everything works	
Appropriateness for CMMD	An extensive use of Video tutorials is proposed for CMMD. Also, signposting of next actions and cues will help users during standard procedures.	

GE24	Progress, Feedback and Status Information	☑

Description	Feedback from the system include many forms like progress bars, hints and the use of color to indicate progress made, current status or at risk conditions.
Appropriateness for CMMD	Progress and feedback from the system will come in many ways. Some types of feedback mechanics may work better in certain types of users. The use of a color code for example is more appropriate for doctors to estimated risk conditions.

GE25	Theme and Narrative Story	☑
Description	Gamified environments can have a background story to create atmosphere and share roles among end users.	
Appropriateness for CMMD	A background story and digital narration is not excluded from this project. But it will need a careful design in order to emotionally 'touch' end users, especially PLWD. A wrong story may cause negative results if introduced in the gamification platform. Little fantasy will help users make sense of the story and their role in it.	

GE26	Curiosity, Mystery and Exploration	☑
Description	Along with the narrative story, designers may insert some mystery in the story and make it explorative. Actually, curiosity is the expected feeling for users and it can be the result of the mystery.	
Appropriateness for CMMD	A little curiosity can be a strong force towards user's participation and long lasting experiences. In this direction, not all aspects of the background story have to be explained.	

GE27	Space and Time Pressure	☒
Description	Pressure when applied to users may, result a stronger experience. Space and time pressure refer to limited resources, either to enough room to move or use and the available time to complete certain actions. Most common in performance-oriented gaming experiences.	
Appropriateness for CMMD	Although some kind of space and time pressure will be present by default, not additional design actions towards pressure will be performed. This is due to health risk issues (heart attacks, strokes, stress).	

GE28	Collect, Trade and Share	☑
Description	Collection of 'expensive' or important elements can motivate users. Trading can also give users a way to make profit and build relationships and feelings of purpose and value.	
Appropriateness for CMMD	Allow gifting or sharing of items to other people to help them achieve their goals. While sharing knowledge is a rewards, trading may not be eligible for CMMD. There will be no currency and no virtual economy. Partially approved (Collect and share, but not trade)	

GE29	Virtual Economy	☒
Description	Virtual economy allows users to gain and spend money expressed in a virtual currency on virtual or real goods. Usually designers face legal issues and aim at long term financial benefits.	

Appropriateness for CMMD	Not eligible for CMMD gamification platform.

GE30	Rewarding System	☑
Description	Reward systems are used in competitive processes to create motivation to users and players. In business climate, it is used to get more from employees. Similarly, in almost all gamified environments there is a rewarding system which drives user's participation.	
Appropriateness for CMMD	A reward and recognition system is required in the gamification platform to reward wished user's behaviour, create external motivation and strengthen user's loyalty. Rewards can be random, fixed or time dependent. Random rewards may disorientate users, but it is expected that some unexpected rewards will cause a positive effect on users, especially PLWD. On the other hand, fixed rewards based on defined actions can play an important role. Celebrating milestone events for example is appropriate form of reward for CMMD users. In addition, some time-dependent rewards like birthday celebrations or everyday come back rewards can play a complementary role like in most social networking environments. Rewards related to performance in testing processes and overcoming challenges will contribute the most to the feelings of participants and the recognition by self and others. Achievements can be connected with certificates and privileges (e.g. access rights to more features of the platform). The rewarding system, apart from driving user's behaviour and motivation can track progress on PLWD and provide valuable information to doctors and other professionals. It is proposed to be a simple scoring system without complicated algorithms or formulas. The users, either as learners or performers, should be able to directly link their actions and activities to a score so they know what they need to do to be successful [Kapp, 2014]. In overall certificates, points, stars, privileges and badges will work as visual symbols of mastery for PLWD and other user groups. Lottery is forbidden.	

GE31	Learning & skills development	☑
Description	Learning and developing skills through gaming is one of the best ways to let users achieve mastery. This gamification element gives users opportunity to learn and expand.	
Appropriateness for CMMD	Dyads need to learn about cognitive decline and dementia conditions, treatment, symptoms, clinical procedures and how to use the platform itself. All user groups which support PLWD need to know best practices and need to develop new skills for giving the best. Thus, learning and skills development should not be missing from the gamification platform.	

GE32	Branching Choices	☑
Description	Choice offering on users can give them a feeling of freedom in choosing their own way of doing things.	
Appropriateness for	Multiple paths can make users choose their path and destiny. Multiple learning paths for example could be proved more effective and appreciated	

CMMD	than fixed paths.

GE33	Unlockable / Rare Content	☑
Description	Unlockable or rare content can offer to the users a feeling of self-expression and value. This is usually reached by exploration and achievement.	
Appropriateness for CMMD	CMMD users can be offered unlockable and/or rare content as an additional reward for exploration. Achievement may be better rewarded by more predictable and obvious rules. 'Easter eggs' hidden in educational material could be a way to implement this gamification element of the platform.	

GE34	Creativity	☑
Description	This refers to the possibility to allow users to express themselves by creating their own content material.	
Appropriateness for CMMD	Self-expression is already included in the CMMD platform's requirements. A real patient-centered approach will allow content in the platform to be expanded by users themselves, including PLWD, not only doctors and professional.	

GE35	Customization and Personalization	☑
Description	Personalization and customization is a key-element in gamified social networks. Accommodation of specific user groups or individuals based on profiles can let people to customize their experience. This includes how they want to present their profile to others, avatar appearance, UI designs (i.e. accessible interfaces) and personal collections.	
Appropriateness for CMMD	Designers can give users, especially the elderly and people with cognitive decline, tools to customize interfaces, profile sharing and the content creation and presentation. Based on the user's profile the platform may use a different interface design. Customization can also include personal preferences in platform functionality and appearance. This element can be used in the platform to improve treatment adherence results, improved platform metrics and end user satisfaction. It is one of the most important features and a whole task on WP2.	

Socializing Gamification Elements

Some elements depend or are closely related to the social dimension of the platform. Elements used for socialization are presented in here as a separate gamification elements category. CMMD will be designed as a social gamified environment and the following elements can outline the game mechanics usually implemented in social games [Hamari & Järvinen, 2010].

GE36	Team Making	☑
Description	People feel the need to belong in a team, especially in multiplayer games or environments with a critical mass of users. Team making is not only about constructing a shared identity but for team competition also. Team play can be fun.	
Appropriateness for CMMD	Small users groups can be more effective than larger groups. This concept fits well with the 'Circle' metaphor of the CMMD platform. Team making will allow PLWD to feel they are part of something bigger than themselves.	

GE37	Social Status, Visibility and Discovery	☑
Description	Those three elements work closely together to help users discover other users, build new relationships with them and apply rules on those relationships. Anonymity is an option.	
Appropriateness for CMMD	All three elements as a group are mandatory for the CMMD platform. Also, matchmaking in user profiles based on interests and status is quite common in social networks and a must have feature in this platform.	

GE38	Social Pressure	☒
Description	Social pressure (or Peer pressure) influence a group of users to change their behaviour or attitudes and values to conform to those of an individual or influencing group.	
Appropriateness for CMMD	Users may feel different than others, especially PLWD and their caregivers. This phenomenon may appear naturally or made in purpose to some extent. In order to make users feel good with their identity and status we may avoid social pressure to avoid demotivation, especially when expectations are unrealistic. On the other hand it is inevitable that minor social pressure may be applied to some user groups. For example, users may feel a minor pressure to participate in the Forums. Anyway, Social Pressure is more often related to negative social phenomena, so it is proposed that this element will not be used in purpose.	

GE39	Competition	☑
Description	Competition can be created naturally between user groups or individuals, especially when time and space is limited or when user groups face conflicts. Competition is used by users to win rewards and prove themselves against others.	
Appropriateness for CMMD	Competition and cooperation are opposites. CMMD gamification platform needs both to motivate people, help them win awards and make teams. People will be encouraged to cooperate with their friends to compete other teams. This may be used to take advantage of the benefits friendly competition has to offer. It can be described as friendly competition as the result in not critical and there is no money involved, only symbolic rewards.	

GE40	Care-giving	☑
Description	By caregiving in here it is meant to offer help to others in their in-platform activities, not daily living. In that sense, the caregiving element refers to those design choices and actions which will allow some user groups to provide help to others regarding online activity.	
Appropriateness for CMMD	Apart from being fulfilling, looking after other users may be derived from specific user's roles like caregivers and helpers. Caregiving can be provided by all user groups but for some will be systematic. In a dyad for example, the caregiver will normally provide help and take after if needed all issues related to the PLWD he/she is responsible for.	

Miscellaneous

GE41	Voting System	☑

Description	A standard feedback collection tool is voting. A voting system is all rules to describe the way voting will be performed by users. When and how may rise administration issues and also the results may affect in various ways the decision making.
Appropriateness for CMMD	Self-expression can be fulfilled by a voting system to give voice to users on issues of common interest. Those issues may refer to the community, best practices or clinical processes. It is advised that the voting system will not be allowed to be used for issues related to politics and other issues not related to the community.

3.3 Gamification Technologies and Development

3.3.1 Gamification Platforms

Gamification solutions are designed and implemented either from scratch or using a gamification platform. The technologies used in web development can be used for the development of the gamification platform. The very same techniques can be applied in back-end and interface design. Since gamification has become a trend, a lot of 'baked gamification platforms' have been proposed. Those platforms can be used over existing or new web platforms to offer gamification services.

Below an extensive list of gamification platforms are presented along with some short evaluation results. From the plethora of gamification solutions, we can give focus on low price and open source platforms. Most of gamification platforms on offer are targeted to customer's and employee's loyalty and thus they may not be eligible for CMMD. Evaluation criteria include the pricing and the size of the targeted organization.

From the list of gamification platforms in **Table 6**, those which may have characteristics to be used In the CMMD platform and should be taken into consideration for the design of the gamified environment are indicated by bold style. This is the results of a first pass of the evaluation (screening) of the existing solutions. A more detailed evaluation, including technical aspects, will be performed in the design section (*3.2. Gamification Design and Development*).

Table 6. Gamification platforms

Name/Logo	Description	Pricing	Works best for	Pros and cons
preferred PATRON	Preferred Patron is a customer loyalty and rewards solution which offers a gamified platform with interactive surveys, email marketing, integrated SMS and more.	Average	Any size industries	Targeted to customers only
Hooptap	Hooptap makers develop mini games, leaderboards, points, badges, etc. for customer loyalty programs of global corporations in consumer brands, hospitality, entertainment, travel, food and beverage.	Average	Mid-sized Businesses or Enterprise	Suitable for a wide range of application domains
adr ALL DIGITAL REWARDS	All Digital Rewards' software offers a gamified information collection tool and multiple games operation and promotion services for rewarding members of organizations for a desired behaviour.	High-end	Mid-sized Businesses or Enterprise	High pricing
dataga.me	The Dataga.me is an online platform to create and publish engaging gamified surveys for customers and employees. Marketers and researchers use the platform to enhance their existing surveys, online communities, websites, and social media presence.	Low-end	Any size, all industries	Limited to feedback collection. Supports a generic JavaScript embedded version
(Launchfire logo)	Launchfire is a digital engagement solution used in B2C gamification to improve consumer interactions with the brand's online assets, recall rates and more.	Average	Mid-size	Targeted to customers only
Perkville	Perkville provides small businesses with gamified loyalty rewards programs that integrate with point of sales (POS) systems, utilizing point-tracking systems	Low-end	All enterprises	Targeted to sales
CROWDTWIST GIVE MORE. GET MORE.	CrowdTwist is a cloud-based gamification software that comes with out-of-the-box integration with social media sites like Facebook, Twitter and Foursquare.	High-end	Enterprise	Expensive and targeted to existing social networks
hull	Hull's platform is a user management and gamification solution used to engage users with points, voting, currencies, badges, rewards, leaderboards and games. Hull assists brands with creating rich user experiences quickly and efficiently.	Average	Any size, all industries	**Good in integration Positive user reviews**
influitive	Influitive provides gamification services to develop a community of advocates consisting of previous customers	Low-end	Any size, all industries	Limited to services to the B2B marketers

	Captain Up is a gamification solution to increase user engagement, website traffic and on-page engagement. Help businesses gain greater insight into their most frequent users' behaviour.	Free version	Small-Medium Businesses	**Free, Support lot of languages (all of pilot sites), online, mobile**
	Hopskoch is a trans-media marketing collaborative gamification platform used by brands to create, track and analyze users and viewers. It incorporates game mechanics into marketing campaigns by rewarding visitors for clicking selected elements on the website.	Average	Med-sized Businesses or Enterprise	**Good solution**
	Friendefi is a gamification platform for consumer engagement through social loyalty programs. It is used to create brand ambassadors and channel engagement programs using gamification. Suitable for both customers and employees.	Average	Med-sized Businesses or Enterprise, all industries	More suitable for brand naming
	Social Annex's gamification platform augments the online marketing experience by adding customer loyalty, social login, and contests to eCommerce sites	Average	Med-sized Businesses or Enterprise	More suitable for eCommerce sites
	Gamification offers cross platform social media and ecommerce tools used to create customer communities for branding with emphasis on sales, customer loyalty, and new user engagement.	High-end	Med-sized Businesses or Enterprise	High pricing
	Pomegranate is a gamification solution which combines gamification techniques, user experience, and visual design to create engaging customer experiences for mobile devices and the web and enrich customer loyalty with the goal of long term customer retention.	High-end	Med-sized Businesses or Enterprise	Complete solution, but in high price
	Playbasis is used to encourage customer interaction by providing loyalty rewards, recognition and incentivizing social media engagement. Also designed to increase customer engagement and loyalty while providing them with insights into customer behaviour. Designed for use by both start-ups and established companies.	Average	Med-sized Businesses or Enterprise	Real-time tracking and analytics tools
	Pluck is a community platform to gamify customer engagement and loyalty and it can transform customers into brand ambassadors. It is ideal for large enterprises	High-end	Enterprise	Suitable for large enterprises and quite expensive
	The NextBee gamification platform is designed to engage customers and employees, to increase brand loyalty, training results and encourage referrals.	Average	Med-sized Businesses or Enterprise	

	Description		Size	Notes
	This tools help in raising brand awareness by creating large online social media contests. Hashtag'd can be used in a variety of ways: Gamifying Social Engagement, Crowd-Sourcing New Creative, Showcasing Audience Creativity and Leveraging Audience Ambition Via Contests.	Average	Med-sized Businesses or Enterprise	Good solution with many features
PERFECTPOST	PerfectPost combines gamification principles to help businesses better shape their content and to maximize social media marketing. PerfectPost uses badges, achievements and levels on company's followers and on social media sites. Those can then be used for generating engagement like in contests and competitions.	Low-end	Med-sized Businesses or Enterprise	Good integrated solution and low price
PunchTab	PunchTab's track and measure consumer behaviour, both online and offline to help increase customer loyalty and engagement, reward loyalty across platforms and create branded contests and campaigns.	Average	Med-sized Businesses or Enterprise	Targeted to the market
	FiveStars is a gamification solution which specializes in building gamified customer loyalty programs for various industries. It can be used for consumer brands, hospitality, entertainment, travel, food and beverage.	Average	Any size	Suitable for a wide range of application domains
customeradvocacy.com	Customer Advocacy offers a solution to follow customers who can promote their brand. Offers services for providing customers with "challenges" such as writing company reviews and posting case studies about the company's services.	{Unknown}	Med-sized Businesses or Enterprise	More suitable for brand-naming
Fanplayr	Fanplayr offers gamified services for visitor's behaviour analysis to help determine optimal times and offers based on aggregated data. Game elements are customizable on-the-fly in order to catch customers at the right time to encourage a purchase.	Low-end, eCommerce	Med-sized Businesses or Enterprise	Targeted to customers
mplifyr Rewarding in so many ways	Mplifyr builds gamified loyalty and engagement programs for businesses, schools, charities, and nonprofits, growing engagement through customized programs.	Low-end	Med-sized Businesses or Enterprise	**Good price and suitable for a wide range of application domains**
Litmos by CallidusCloud	Litmos is a web-based gamified learning management system (LMS) from CallidusCloud that allows the creation of entire courses.	Average	All sizes	Targeted to learning management

PLAYGEN	PlayGen offers gamification solutions for companies who are seeking to increase customer loyalty and engagement. AddingPlay is a brainstorming toolkit used in the heart of its gamification engine used to allow brands to create custom gamification solutions adapted to their business goals.	Average	Med-sized Businesses or Enterprise	Suitable for a wide range of application domains
conteneo	Conteneo offers a Software-as-a-Service (SaaS) gamification platform that provides insight into the specifics of behaviour, engagement, and strategy development. It can be used for customer behaviour insight or for friendly employee competition in the office.	High-end	Enterprise	High pricing
mindspace	Mindspace is gamification platform that helps companies to engage their audiences through interactive communication channels.	High-end	Enterprise, all industries	High pricing
SAICON	Saicon Games helps brands to establish an online community of customers and is specialized in gamification for brand awareness, customer loyalty and community-building and social engagement.	High-end	Med-sized Businesses or Enterprise	High pricing
Rise	Rise is gamification software that combines business and social data to score individuals and rank them against their peers using company criteria.	Low-end	Med-sized Businesses or Enterprise	Requires social data to perform most of its functionality
eMee	eMee is a gamification solution which helps to address employee engagement, low morale and low productivity that are designed to match the specialty of each client.	Average	Any size, all industries	Targeted to employees
doods	Double Doods is a gamification solution which uses social media campaigns, sweepstakes and market research to offer clients several options across 3 platforms, which promote a business's brand, increase customer loyalty, engage audience members and help build customer profiles.	Low-end	Med-sized Businesses or Enterprise	Applied on social networks
gametize	Gametize is targeted to employee engagement, provides a range of in-game challenges and can set custom rules and rewards to increase competition. It brings psychology-based game-like experiences to the workplace.	Average	Med-sized Businesses or Enterprise	More targeted to Asian markets

	Description			
	Playlyfe is a web-based gamification platform which enables companies, organizations and individuals to design and develop gamified applications quickly. Playlyfe is primarily a Platform-as-a-Service (PaaS) provider and it offers a user friendly design interface to allow app development from the beginning to the end.	Average	Any size, eCommerce, Education and Training, Sales	**Good user reviews, good integration thanks to its REST API**
	Pilgrim Consulting is gamification solution designed both for customer and employee-facing. It can be used to motivate specific user behaviour and it is suitable for businesses of any size and operating in any industry.	Average	Any size, all industries	Moderate
	Monitae's software boosts employee motivation and increases productivity by using contests, competitions, and challenges. It uses an intuitive interface which promotes team collaboration and competition.	Average	Any size, all industries	Targeted to employee engagement
	Bunchball's combines big data and behavioural science to provide cloud-based gamification services. This solution can help companies to gain new customers and improve current customer loyalty.	High-end	Enterprise	High pricing
	The Behaviour Platform is a cloud-based gamification platform which allows the collection and analysis of behavioural data for valuable customer insights.	High-end	Enterprise	Targeted to employees
	SuMo for Salesforce combines game mechanics and behavioural science to motivate employees, customers and partners.	Average		Targeted to customer-service, call centers and sales
	Exago uses a gamification system to help organizations engage both internal and external user communities. It is used for improving customer engagement, achieve real results and for the purposes of addressing key business challenges.	Average	Med-sized Businesses or Enterprise	
	Yambla's innovation management platform uses game elements to inspire employees to submit their ground-breaking ideas that will solve company problems.	Average	Med-sized Businesses or Enterprise	Targeted to employees

	Hero Points is an integrated customer loyalty system which helps merchants to retain customers and increase sales. Hero Points is a cash-spent based loyalty program which rewards customers with a configurable number of points per item purchased.	Free	Small-Medium Business	Targeted to sales
	Plyfe gives consumer the ability to be rewarded for their digital, social and mobile activities. It can be used to design social challenges such as answering trivia questions, watching a youtube video, or tweeting and to win real prizes and experiences by that.	Low-end	Small-Medium Business	**Online platform, free with limitations**
	BadgeOS is a plugin to WordPress that lets web designers and webmasters to easily create achievements and issue sharable badges for their users and visitors. Designers define the achievement requirements and choose the assessment options. The resulted BadgeOS sites can be customized to organization or company goals.	Free	Small-Medium Business and Large Enterprise	Plugin for WordPress
	Zurmo is an Open Source Customer Relationship Management (CRM) application that is mobile, social, and gamified. We use a test-driven methodology for building every part of the application. It can be used to create and maintain a custom-built CRM system.	Free, Open Source	Small-Medium Business	**It is free, online, on Premise and suitable for mobiles**
	Userinfuser is a popular open source platform that provides customizable gamification elements designed to increase user interaction on websites through badging, points, live notifications, and leaderboards.	Free, Open Source	Small-Medium Business	Free, Open source and popular but very basic
	Mambo.IO is (a partially) open source gamification solution for customer and employee engagement.	Free, Open Source	Small-Medium Business	**Open source (parts of) and popular but not free**

3.4 Gamification Design and Development

The list of the winner gamification elements for the CMMD platform is presented in **Table 7**. Those engines will provide ideas for the CMMD gamification functionality. The game elements presented earlier in this deliverable will be implemented based on the functional characteristics of the most advanced gamification engines. Regarding the gamification technology found on the market (gamification engines), most of the free solutions are either very simple, or discontinued. Others appear to be available for free use as long as they are not used to make profit. According to CMMD exploitation plans, our gamification approach and technology will be developed from scratch to better meet the project objectives and the special characteristics of CMMD target audiences without any barriers in future use as a final product.

A second major outcome of the state of the art analysis was that not all gamification elements are eligible for all user groups. After those elements have been selected to be inserted into the platform, a design framework may help in the implementation of those elements and the merging with other important design issues. A lot of games and gamification design frameworks have been proposed in the literature to describe various aspects of gamified environments. The gamification design of the CMMD will be based on Mechanics-Dynamics-Aesthetics (MDA) Framework proposed by LeBlanc and Hunicke [LeBlanc *et al.*, 2005; Hunicke *et al.*, 2004]. MDA is a tool used to analyze and game designs by breaking them down into 3 components: Mechanics, Dynamics and Aesthetics. Those three components are used by the theory behind MDA to explain how they relate to each other and influence the player's overall experience. More specifically [Wikipedia for MDA]:

- Mechanics: the base components of the game. Refers to its rules, every basic action the player can take in the game, the algorithms and data structures, etc.
- Dynamics: the run-time behaviour of the mechanics acting on player input and "cooperating" with other mechanics.
- Aesthetics: the emotional responses evoked in the player.

The three elements described above are closely related according to the background concept that the mechanics generate dynamics which generate aesthetics. This underlying relationship between the main components creates challenges for designers because they can only influence mechanics and the rest appear as outcomes of the design process. In the other way around, end-users perceive only experiences attributed to aesthetics which the game dynamics provide, which emerged from the mechanics. In **Table 8** the Gamification Model Canvas[16] for the CMMD gamification platform is presented.

Table 7. List of winner Gamification Elements to be included in the platform

#	Gamification Element	Targeted User Categories	Comments
GE1	Endless loops	All	The gamified user experience will stop only by external interruptions
GE3	Repeat Pattern	All	Most actions will repeat series of given steps
GE5	Block Puzzles	PLWD,	Combined with GE2 by using blocks in drag and drop

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		Caregivers	actions to perform patterns
GE9	Disinformation	PLWD	Disinformation will be used to create fun and skills development on selective attention
GE10	Switch Modes	Caregivers	Caregivers will participate as players over-the-soldier of PLWD (dual role with switching modes)
GE14	Squad	Professionals, Social Workers	Supported user groups will control multiple patient profiles which must work together to achieve a team objective
GE15	Hidden Image (object)	PLWD & Caregivers	PLWD will be asked to look at a wide virtual spaces for particular items and clues, or patterns.
GE16	Timed	All	Timed actions by dyads will be used for treatment adherence. Social prof. will have to update social status regularly.
GE17	Protect a Target	All except PLWD	The whole gamified environment will be constructed around Patient protection
GE18	Undirected Exploration	PLWD, Caregivers	Dyads will be free to explore
GE20	Dialogue Tree	All	For trans-nation trans-cultural interactions, ready-made text messages will be used
GE23	On-boarding / Tutorials and Signposting	All	Eliminate dependencies on user manuals
GE24	Progress, Feedback & Status Information	All	Multiple feedback mechanics will inform and guide users in performing standard tasks
GE25	Theme and Narrative Story	All*	A background story will create an atmosphere
GE26	Curiosity, Mystery and Exploration	PLWD, Caregivers	Having exploration allowed for all, Curiosity and Mystery will be used mostly for Dyads
GE28	Collect and Share	PLWD, Caregivers	Dyads can pride themselves for achievements and found cues
GE30	Rewarding System	All	Extensive Point and Badges system
GE31	Learning & skills development	PLWD, Caregivers, Professionals	PLWD will develop cognitive skills, caregivers will learn better methods and clinicians will develop professional skills
GE32	Branching Choices	All	User's choices will be and feel meaningful to be most effective and appreciated
GE33	Unlockable / Rare Content	PLWD	A set of secret responses will occur as a result of an undocumented set of user actions and rare content will be used to foster curiosity and reward long exploration
GE34	Creativity	All	Self-expression will be used and required by all users
GE35	Customization and Personalization	All	Customization will be supported for all user categories, while personalization will be mostly preferred for PLWD and Caregivers
GE36	Team Making	All	The feeling of belonging in a team will be required for dyads and recommended for other user categories
GE37	Social Status, Visibility & Discovery	PLWD, Caregivers, Social prof.	People search, share of status and opportunities to create new relationships will be required
GE39	Competition	All	All actions and intentions should be completed under reasonable effort and time according to user's category
GE40	Care-giving	PLWD	Caregiving is the main target of the gamified environment
GE41	Voting System	All	Important decisions can be made

Table 8. Gamification Model Canvas for the gamification platform

PLATFORMS	MECHANICS	DYNAMICS	AESTHETICS	PLAYERS
The platform in which the gamification will be implemented is the CMMD platform. This contains the social network of the community, the accessible interfaces and the personalization component. VADEMECUM platform used to collect pharmaco-logical information is not included, thus pharmaco-logical interactions and other relevant information will not be gamified.	All gamification elements of the **Table 7**. Mechanics will be explained in user manuals and intro videos. Also in reminders. • Develop Circles (Contact points) for team belonging and shared identity development • Answer surveys for treatment adherence • Participate in conversations in the Café for socialization • Search and read for discovery • Share experiences and self-expression	Dynamics which can describe the run-time behaviour of the mechanics over the users include: • Appointment • Status • Progression • Reward • Productivity* • Identity • Creativity • Altruism Scarcity may not be included in this list. * Productivity will be used only in professionals.	Desirable emotional responses evoked in the users include: • Challenge • Fellowship • Discovery • Expression • Fantasy • Sensation • Submission Colourful badges and progress reports are expected to grab the attention. Users should play to conquer a social environment, self-express and obtain a fellowship.	Users are PLWD, caregivers, social workers and professionals (doctors and other clinicians). It is expected that PLWD are elderly people and they can be further divided into two sub-categories: a. Mild and b. Moderate Neurocognitive Disorders. PLWD like sharing experiences and want support and treatment adherence Caregivers like advice and want to improve treatment adherence. Professionals like tools to monitor and report
	COMPONENTS Components for awarding: • Points • Badges • Achievements • Leaderboards • Countdown Levels and Dice not implemented		**BEHAVIOURS** Wished behaviours include: • Read content (posts, readings) and reply • Create content and recommend to others • Participate in questionnaires	

COSTS	REVENUES
The investment for the development of the gamified environment is already covered by the H2020 program. The main costs of the gamification platform are the development of features not offered by the available gamification platforms and the adjustment of the level of difficulty based on personal profiles.	Results we hope to achieve from the game are a better treatment adherence and a better cohesion on the community. Success will be measured by the loyalty of end users and the better clinical and social outcomes.

3.4.1 Best Gamification Practices and Visual Components

Known websites of professional social networking implement simple gamification techniques to encourage users to share professional information. Those techniques include progress indicators (progress bars or gauges). Users receive awards for being active (**Figure 5a)** and short reports on their overall activity **Figure 5b.** Profile completion is important for some background platform actions (like matchmaking) and thus additional motivational actions are taken to make users keep updated profiles. In **Figure 5d** for example, users receive notifications that they have completed their profile by 90% and the platform propose some actions to take in order to cover the distance to the upper limit of 100% (full profile).

In social networking the power of the community can be used to give statistics on actions performed by other users to a given profile. The number of connections, profile views and article reads are common examples of community activity (**Figure 5c)**.

A novel way to endorse connections for professional skills has been proposed by LinkedIn (**Figure 5e)**. According to this, users receive invitations to share short skills assessment in their network (circle).

Community reviews are one of the most successful ways to engage users. Customer's reviews about a product or service made by a customer who has purchased the product or service are the most successful example used in online stores. Some of the best examples are presented in **Figure 5f&g**. Those reviews may be graded themselves for sincerity or usefulness by other users, so reviews themselves can be reviewed.
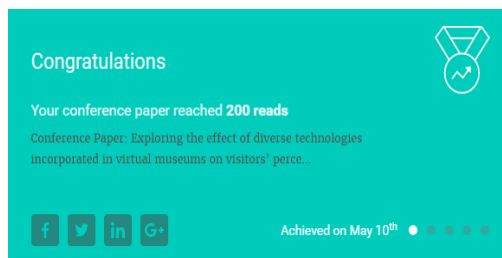
a. Certification and Badge for reaching a milestone in article reads (ResearcGate)
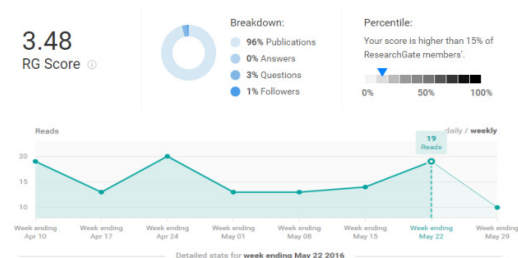
b. Statistics on overall activity and profile reputation (ResearchGate)
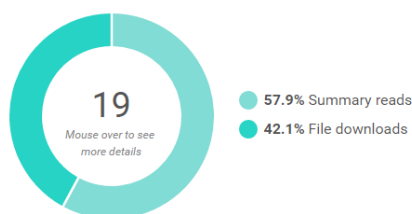
c. Statistics for specific elements (e.g. Article reads and downloads in ResearchGate)
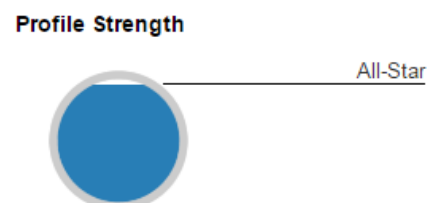
d. All profile parameters are used by an internal pltform function to calculate the profile strength (In LnkedIn)
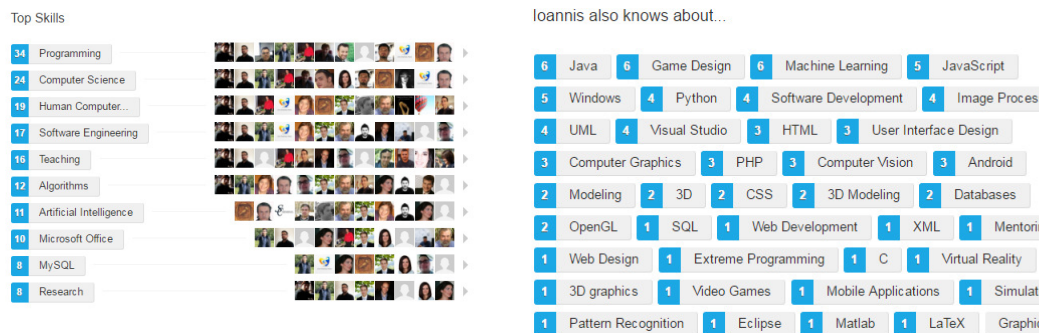
e. Skills and Endorsements (LinkedIn)
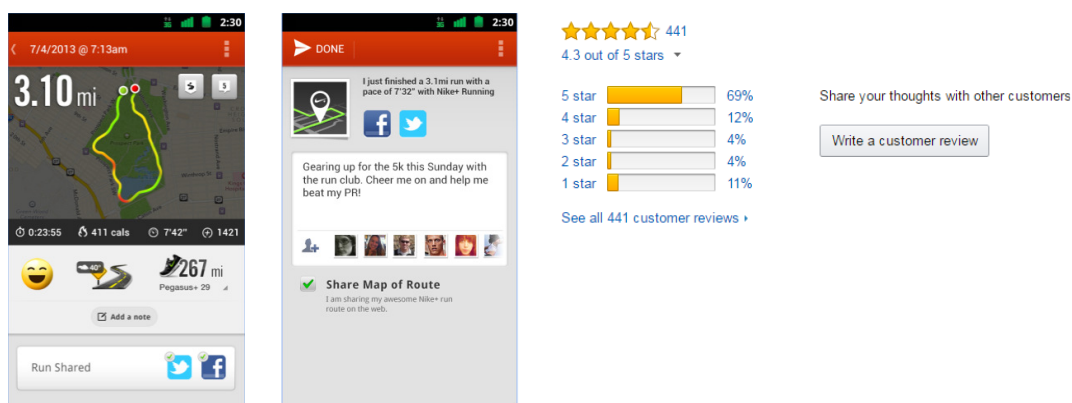
f. Achievement (left) and sharing of this
achievement with others (Nike+)[17]

g. Customers review (Amazon)

Figure 5.Best visual gamification elements used by existing social networks[18]

All of the above can be used in the gamified CMMD platform. Starting from certifications and points earned for profile completion, one of the very first actions users will be prompted to take are giving more information about themselves. Real-time notifications will prompt users to process their personal profile, including medical profile, and decide which information will be public and which will be kept confidential. This process will contribute to both points earned and profile percentage completion (**Figure 5.d**). Profile reputation and overall activity (**Figure 5.b**) will be visible to the user itself and the caregivers and helpers if the user participates as a Patient. Personal skills and achievements will be public by default (**Figure 5.e & f**), as well as badges and other awards.

3.4.2   Game Definition Languages

In most cases users are not aware of the rules of the gamified environment before they participate. Rules are communicated and become fully understood at runtime, thus textual descriptions should be available in order to give chances of equal participation. Those rules

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[17] Nike+, https://play.google.com/store/apps/details?id=com.nike.plusgps&feature=search_result
[18] Copyright © Linkedin Corporation. All Rights Reserved. Used without permission under the Fair Use Doctrine.

should be predefined at design phase and implemented into the heart of the gamification engine.

To describe those rules in a technical manner, various rule description languages are used. The Game Definition Language (GDL) designed by Michael Genesereth as part of the General Game Playing Project at Stanford University is a typical example of such a formal rule-description language. As a logic programming language it describes the fundamental building blocks of the game or gamified environment, the state of the game as a series of facts, and the mechanics as logical rules. According to the GDL specification [Love *et al.*, 2008], GDL holds the class of games used for General Game Playing and describes the mathematical models underlying general game playing to compute the legal actions of all players for every possible state and from the actions of all players to compute the forthcoming states. For gamification purposes the use of GDL raises some limitations. GDL for example supposes that there is a termination state. In non-leisure settings like gamification in a social network a termination description may not be defined. But not all games are well-formed and not all rules are known to players at the beginning. In CMMD not only intentions and strategies of other users cannot be assumed, but also complete information on the gamification rules.

On the other hand, the gaML [Herzig et al., 2013] is a language proposed to provide a mechanism for the precise definition of gamification concepts and recently was merged in game-development tools [Matallaoui et al., 2015]. GaML can be used to formalize conceptual gamification requirements (syntax and static semantics) and it is readable by both gamification experts and wider audiences.

The intention is to find a way to express and investigate (recurrent) game structures methodologically. *Machinations* [Dormans, 2009] offer a new lens on the intuitive and delicate practice of game design and balancing. *Machination* is a visual modeling language used to express and investigate game structures methodologically. *Machinations* mainly communicate gamification rules by game feedback diagrams. They can describe emergence effects of game mechanics and they offer a theoretical framework and an interactive, dynamic, graphical representation to describe dynamic systems and their closed feedback loops. Thus, *Machinations* are used in design phase (**Figure 6**) to study and validate gamification mechanics on a theoretical level even before its final implementation.

At first stage, the gamification platform will be methodologically described as a dynamic system with focus on feedback loops within sub-systems. This will allow to non-technical readers to follow the proposed gamification rules based on intuition and balancing. At WP3 in which the platform will actually be developed (*D3.3. APIs for integration of gamification service, treatment adherence service and clinical report service*), this material can be expressed in programming languages which is more suitable to implement the whole gamification systems.

3.4.3   Resulted Scenarios, Gamification Rules and Recommendations

Gamification as a conceptual and design approach will be applied to specific domains/areas of the platform. This section comes as a result of the previous analysis and presents areas of intervention within the CMMD platform and a description of the gamified functionality with direct links to the gamification elements studied earlier in this document. The following

table summarizes areas for gamification, while specific rules of the reward system are presented in **Table 9**.

Table 9. Parts of the platform in which gamification will be more intensive

Intervention area	Description
User Profiles	Profiles in CMMD are quite complicated because they combine personal preferences, demographics, medical data and social network data. In addition, most services require a good knowledge of the user's profile before taking action. The matchmaking mechanism will require complete profiles to perform well, and so ideally profile completion has to be close to 100% for all users. Motivation for making strong profiles and keeping them updated is required for all user categories.
Gamification Elements to be implemented with	GE1, GE3, GE10 (switch modes between profile editor and profile viewer), GE16 (profile must be completed after a grace period), GE18 (free exploration to other user's profiles), G3E23, GE24 (achievements visible on profile), GE25 (participate as a 'character' or 'role' in a narrative story), GE26 (curiosity for other user's profiles and roles), GE28 (collect awards and share them in team profiles), GE30, GE33 (rare objects visible on the personal wall), GE34 (self-presentation), GE35 (priorities in profile elements, visibility, range of visibility, styles), GE36 (teams visibility), GE37 (Social Status visibility). Especially for GE39 completion will be a requirement for some additional actions like treatment adherence monitoring for PLWD. With uncomplete patient's profile, treatment adherence will make no meaning. It is expected that Caregivers will help PLWD in some cases to complete their profile and thus this is a GE24 (Caregiving) element which will be implemented in here.

Intervention area	Description
Bibliography	
Gamification Elements to be implemented with	Bibliography is an important part of the platform because GE1, GE3, GE5 (articles will be handled as blocks to share, read, as pieces of profiles, etc.), GE14 (team work publications for professionals), GE15 (for finding hidden information), GE16, GE18 (search and follow publications), GE23, GE24, GE28 (paper collections), GE30 (publications are rewarded), GE31 (reading is learning and thus reading will be rewarded), GE32, GE33 (unlock publications of high importance or interest after achievements), GE34 (author's creativity), GR35 (notifications is new articles match my interests), GE36 (team bibliography exploration), GE39, GE41 (vote for best article, give stars to personal preferences, etc.),

Intervention area	Description
Evaluations & eSurveys	The basic idea behind the gamification of surveys and questionnaires applied to CMMD platform is that participants who perceive a questionnaire as an enjoyable activity are much more likely to give more valuable feedback and

	devote effort to its completion.
	The mechanics behind gamification of surveys involve game-like aesthetics, richer responses and challenges for greater time spend on the questionnaire, greater attentiveness and lower abandonment rates. Rewards can be offered to users for participation on surveys and point earned can be directly linked to the overall participation awarding system. The back story used in other parts of the gamification platform will be expanded to the surveys area.
	The approach of Puleston can be followed to improve questions of surveys through game elements [Puleston, 2013; Sleep & Puleston, 2011]. For example instead of using a list of words or short phrases to give test takers enough options, use icons or pictures. Actually, surveys can by turn into games before integration into the gamification platform. To be noted that In such an approach the improved surveys may need to be validated again.
	Surveys in the existing CMMD platform may contain already some minor gamification elements like the emoji, but this is not enough. Multimedia elements will be inserted into multiple choices to replace text when possible and each question answered will be rewarded by one point. The whole questionnaire will be part of the gamification platform sharing the same background story and visual elements like avatars, styles and themes. Interactive elements will be inserted in questions (images, animated gifs, etc).
Gamification Elements to be implemented with	GE1 (some eSurveys will be repeated endlessly), GE3, GE10 (Caregivers will participate sometimes as independent users and sometimes to help PLWD as the other half of a dyad), GE15, GE16 (some questionnaires may have time limit), GE23, GE24, GE25 (optional), GE28, GE30, GE31, GE33, GE35, GE37 (can see other user's scores and feedback if allowed, average scores also), GE39, GE41,

Intervention area	Description
Gamification in the Cafe	The Forum stands for the forum of the community. As place designed to help users relax, met each other and share experiences, the Café will inherit typical properties of the social networks. Gamification will be applied on typical user actions and the reward system (point-based) will cover social network expansion (number of contacts, size of personal circle), new posts (number of answers/replies to posts of others) and content expansion (number of tickets, questions or topics raised). A visual status indicator will notify other users for recent activity: 'Sleeping' for inactive members of the Café, 'Look bored' for minor activity, 'Walking' for active members and 'Running' for users with outstanding participation in the Café and on discussions.
Gamification Elements to be implemented with	GE1, GE9 (Disinformation on personal or team's achievements may create fun), GE15, GE18, GE20 (in cross-cultural communication), GE23, GEE24, GE25 (Optional to continue the story or to take off masks), GE26 (same as previous), GE28 (rare elements may be shared or traded in the Cafe), GE30 (participation in the Cafe will be rewarded), GE31 (for social skills development), GE32 (natively users will be free to follow their own way),

GE33 (rare content hidden in Café discussion rooms), GE35, GE36, GE37, GE41.

Intervention area	Description
Presentation of the community Presentation of the circle	Team (or group) profiles will allow users to present their shared identity to others. Group profiles should be considered as a gamification intervention area within CMMD platform as in personal profiles. There is room for more intensive use of gamification elements mainly because shared profiles can present to others teamwork, as a matter of the summary of the badges, points and other forms of achievements by all members of the team.
Gamification Elements to be implemented with	{Same as in User Profiles}

Intervention area	Description
Background story	Users will participate in the gamified environment using custom avatars, but a comic-like 'Neuron' characters will be available In advance. By definition, Neurons (or Nerve Cells) are the core components of the brain and spinal cord of the central nervous system. Their functionality is to process and transmit electrical and chemical information (signals). The transmission is implemented through Synapses, specialized connections with other Neurons. The most important thing Neurons can do is to connect to each other in order to form neural networks. Thus, the Neuron metaphor serves a dual objective: a. personal goals to make the Neuron strong and healthy (collect performance points and awards) and b. team goals (make new connections with others, grow the circle, and share group awards). Human brain, the organ mostly affected by the dementia conditions (as a brain disease which causes the symptoms of neurocognitive disorders) is illustrated by a huge number of Neurons and Synapses. This perfectly matches the game background story by allowing users to participate as Neurons that is the smallest units of a big brain (the community). Each user will differentiate him/herself with visual metaphors (e.g. clinical instruments to indicate doctor's privileges), colour code (users will choose their favourite colour for their Neuron) and emotional states (strong and happy, normal, sad, weak, etc.). Especially for the last element, emotional states will be controlled partially by user's feedback ('How you feel today?') and partially by the system (how active this user was in the last few days?). Group identities, that are personal circles and clubs the user is participating in the Forum, will be represented by groups of Neurons and their in between connections (Neural Networks). The icons in the profiles of such groups will be like a group of happy comic-like neurons tied hand in hand. Also, the health status of the whole brain (the community) will be used as a reference. This will be computed as the summation of all activities and achievements by all user profiles and all groups of users. Visual elements like timelines will present personal, group and community status.
Gamification	GE1, GE3, GE10 (switch between personal, group and community status),

Elements to be implemented with	GE14 (achieving group targets), GE18, GE20 (communicating progress & achievements), GE23, GE24, GE25, GE26, GE28, GE30, GE35, GR36, GE37, GE39.

According to the above, and most specifically to the background story, avatars of users as game-like characters, will interchange between states. Those states can be controlled by end users after passing through filters of loyalty and treatment adherence evaluation. In others words, the visual appearance of the avatars will be controlled by the artificial intelligence of the system based on their participation evaluation. Participation metrics include almost anything users can do in the platform, starting from login times, number of messages exchanges, personal social network growth (circle), posts in the café, filling up questionnaires, taking actions for profile completion, etc.

The Reward System will be mainly positive Points and badges will not be removed from user's profiles, but some emoticons in the user's graphical representation may change according to the overall activity. All those actions will be sensed and be rewarded by the system according to a set of rules (**Table 10**). This ruleset described what the end user is aware off according to his/her role in the gamified platform. Those rules will be known in advance and described in the user manual. In addition, visual changes in the avatar's visual appearance and/or new award arrivals on the user's personal wall will be properly announced to the user. Those announcements will make emphasis on the winning award and at the same time will explain the reasons it was attributed to the user. The first time an award is attributed to the user, an animation will be presented during the award time, just like in 'Strike animations' used on Bowling.

Table 10. Rules of the Rewards System per User Category (to be updated if needed)

Rules	User Category	Description
R1.1.	**All**	**Get points for each new connection (Synapse)**
R1.1.1.	Get 10 points for each new contact request you answer back	
R1.1.2.	Get 10 points for each new contact request answered back by someone else	
R1.2.	**All**	**Get points for each new message exchange**
R1.2.1.	Get 1 point for each new message to someone else	
R1.2.2.	Get 1 point for each new message you receive by someone else	
R1.2.3.	Get 5 points for each new post to personal circle	
R1.2.4.	Get 5 points for each new post to group in the Forum	
R1.3.	**All**	**Get points for each new recommendation**
R1.3.1.	Get 5 point for each new recommendation you make to others for an article	
R1.3.2.	Get 1 point for each reading (click by someone else) on your recommendation	

R1.3.3.	Get 1 point for each reading you make after someone else's recommendation to you		
R1.4.	**All**	**Get points for each new test you take**	
R1.4.1.	Get points for each new test you take (questionnaires & eSurveys), 1 point for each question you answer		
R1.4.2.	Get 5 extra points for each questionnaire you complete		
R1.5.	**All**	**Complete your profile**	
R1.5.1.	Get percentage units for each new action you take to complete your profile (personal info, additional info like interests, groups you are active member, etc.)		
R1.6.	**All**	**Overall activity**	
R1.6.1.	Recent activity: Defend your 'Strength' Badge for each week by getting more than 10 points by any activity (Strong-happy face). In other case back to normal.		
R1.6.2.	In no access to the platform for more than 2 week, then 'sad'. In other case back to normal.		
R1.6.3.	In no access to the platform for more than 1 month, then 'weak'. In other case back to normal.		
R1.6.4.	Mid-term activity: Win a 'Champion' Badge for performing outstanding performance in group activities (more than 75% of the activity of others for a period of one month). Leader Badges are indicated in the profile icon as a feather (Strong-happy face with daphne). In other case back to previous state.		
R1.6.5.	Long term activity: Win an 'Experienced' Badge for earning more than 100 points by any activity (golden coin)		
R1.7.	**Doctors & Professionals**	**Scientific Contribution (articles, reviews or cases)**	
R1.7.1.	Get 50 points for each new original article you post		
R1.7.2.	Get 2 points for each article you share with others (as a recommendation or repost)		
R1.7.3.	Get 10 points for each new review		
R1.7.4.	Get 15 points for each new case you create		
R1.7.5.	Get 1 point for each badge your PLWD get		
R1.7.6	Win a 'Master' Badge for earning 100 votes of trust from your supported PLWD		
R1.7.7	Win a 'Golden Pen' for outstanding scientific performance in writing articles. This award is attributed by the administrator or scientific board.		
R1.7.8.	Most popular and award winning articles will be noted by a star mark. The total number of reads will be used as a metric and after a threshold of 100 reads, an		

R1.8.	PLWD & Caregivers	Dyad's Bahaviour and Status
R1.8.1.	Win a 'Happy Face' Badge for bringing in good psychometric test results (above threshold)	
R1.8.2.	Every 10 hours of total participation time (Logout time-Login time) gives 1 point	
R1.8.3.	Win a 'Silver Star' for having one of the top 10% scores of your community (circle) or in the Café. This award is not dropped by time.	
R1.8.4.	Win a 'Golden Star' for having one of the top 5% scores of your community (circle) or in the Café. This award is not dropped by time.	
R1.9.	Professionals	Regulator
R1.9.1.	Can transfer or attribute a number of points or badges to PLWD and caregivers for their loyalty. This is used as a safeguard to fix things when needed. Normally a prior agreement between platform administrators, doctors, caregivers, social workers and helpers is needed.	

Figure 6 graphically represents the whole internal economy of the gamification platform in a machination diagram. The main pools (circles) of award units are points, profile completion percentage (%) and Badges. The user's actions (doubled lined circles) trigger a number of transactions between pools and finally the profile completion is reaching 100% and point wallets (sets of 100 points) become badges and they are added to user's profile. This is the main functionality common for all user categories (focus groups), while additional rules may be applied to specific profiles according to what has been presented in **Table 10.**

Figure 6. The internal economy of the basic user profile as a Machination diagram[19]

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[19] Created by an online flash-based machination tool (http://www.jorisdormans.nl/machinations/).

3.4.4   Development Process

Gamification design will take as input the results of the PACT analysis performed in T2.1 and reported in D2.1 (*PACT Analysis and Focus group reports*) business concept models and use cases to start conceptualizing the implementation of the winning gamification elements of **Table 7**. Those will be inserted into the overall schema as *Gamification Components*, which are processed and verified gamification elements. In addition, rules derived from the **Table 10** and some technical constraints derived from existing technological solutions, as well as the findings of the D1.1 (*Accessibility Report*) and D1.2 (*Dementia and psychiatric comorbidity symptoms assessment handbook*) are inserted into the design approach. After provisioning, implementation and testing processes, the unified gamified platform will be deployed according to generic gamification principles and State of the Art, the requirements and design priorities given by the preparation phase described earlier in '*Gamification in eHealth*' and especially in section '*Design Approach for CMMD Gamification Services*'.

In **Figure 7** the overall approach in gamification development is presented based on the approach of Herzig [2014]. The gamification development phase may be separated from the development of the rest of the CMMD platform, although it is quite close to it. It is expected that it will be clearer for designers to study the gamification development starting from the Business and eHealth modelling to conclude in special or additional requirements.
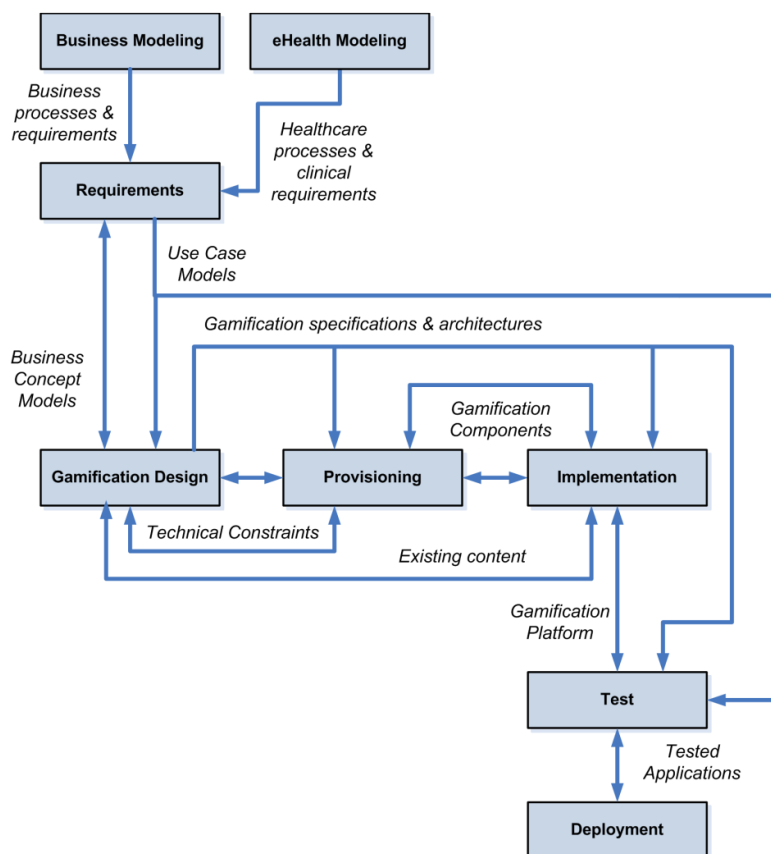
Figure 7. Overview of the Gamification development in CMMD

On the business modelling phase, all participants including designers share a common understanding of the business processes and limitations. The eHealth modelling will be performed based on the outcomes of user's conditions (*T1.1. Relevant conditions for usability*), T1.2 (*Identification of dementia and psychiatric comorbidity symptoms*) and the treatment adherence level (*T2.3. Treatment Adherence Service*).

3.5 Gamers' Models and Mechanisms

Not all players behave the same in any given environment, not all users prefer the same kind of interaction and challenges types. A classification of multiplayer online game players was proposed by **Bartle taxonomy of player types** [Bartle, 2003] according to their preferred actions within the game, but later it was expanded to single player video games too. This taxonomy was based on a user models theory which includes four types of characters: Achievers, Explorers, Socializers, and Killers (**Figure 8**).
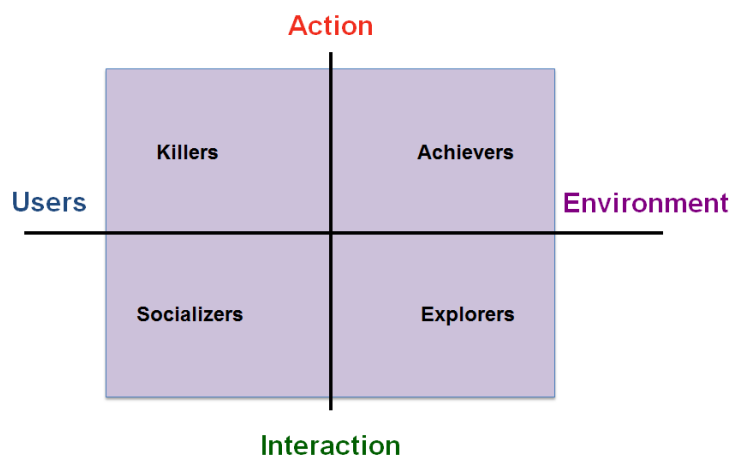
Figure 8. Player types [Bartle, 2003]

According to the target of the interaction, users may cooperate with others (Socializers) or they may eliminate others in order to win the prize (Killers). Similarly, according to the opposite point of view users may like to explore the environment by reading learning materials and search discussions (Explorers), or they may like to be more active in relation to other users (Achievers).

Some types of this theory may not be appropriate for CMMD, like the Killers for example, but others can be taken into account when designing the gamification mechanisms. **Table 11** presents an overview of the gamification mechanisms chosen to be part of the gamification component. According to this, an achiever for example would be more interested in gaming mechanism closely related to avatar evolution and the social platform.

Table 11: Overview of gamification mechanisms

Mechanism	Description	Motivator	Application
Fast Feedback	Immediate feedback or response to actions	Mastery Progress	Upon performing a certain task, the user will be able to view his/her updated points immediately via the

			personal wall.
Transparency	See where everyone stands, quickly and easily	Progress Social Interaction	The PLWD and caregiver will be able to view his/her individual points via the tablet app. The cumulative team points can be viewed via the group wall.
Goals	There are short and long term goals to achieve	Purpose Progress Social Interaction	Every game created using the gamification framework has a "Maximum Score that can be achieved", which may vary for each game. Individually, it is one of the goals of the user to reach this score. Regarding team effort, the dyads and the user groups have the goal to beat their previous score.
Badges	Display evidence of accomplishments	Mastery Purpose Progress Social Interaction	Badges are mandatory for avatar evolution and for grouping user profiles according to their matureness and reputation. Points will be translated into badges (and intangible achievements).
Levelling Up	Status achievement within community	Mastery Purpose Progress Social Interaction	Each game has different levels. Upon completing a certain level, the user is moved up to the next level (Avatar Evolution)
On boarding	Learn in an engaging and compelling way	Mastery	Depends on the external system.
Competition	See how a user is doing against others	Mastery Social Interaction	The concept of competition is applied with caution as not all users have equal chances to winning situations by default. Users can compete: a with their own yesterday score or b. with others.
Collaboration	A user can work with others to accomplish goals	Purpose Social Interaction	Team games (user groups). It will be possible for a user to participate in team games and in games for individuals at the same time.
Community	See what the community is doing and vice versa (the community can see what an individual is doing)	Social Interaction	The sense of community is maintained by maintaining a single instance of gamification for all the external systems. So everyone contributes to the same collective

			score of all the users of the community by performing any task related to any of the external systems linked with the gamification framework (e.g. social network, Survey engine, eLearning component, etc).
Points	Measureable evidence of accomplishment will be visible	Progress Social	Points are awarded upon performing tasks of different games created by the external systems. Each user will be able to view his/her individual points via the online app.
Lenses	Sense of Equality	Progress Social	Avatar evolution will be mastered by the 'lenses' concept. This is a personal agent which will translate personal performance into equal awards to equalize the game
Visibility	User and system visibility	Control	The Visualization Component will visualize: Personal and group Social Graphs, Treatment Adherence Evaluation Results, Scales Results, Profile Statuses, Leaderboards, Personal Walls (point wallet, badges for achievements, short animations) and states of avatars progress.

According to the user psychological state model of Radoff [2011], the level of challenge and the user's skills can define the state of the player (**Figure 9**). The key to success in gamification is to define a fair balance between challenge and the user's skills. According to this model, when experienced users face a moderate challenge, this leads to the state of having the control. On the other hand, a high challenge level may cause anxiety to the less skilled users. The positive user's emotional states for CMMD are from Relaxation to Arousal, which means that we need a challenge level from moderate low to high given a varying user skills level.

Challenges related to the avatar evolution (e.g. Levelling Up & mastery), as well as social interaction should be designed with caution to avoid unwanted states. There seems to be a gap on the left part of the diagram on **Figure 9**: Low skill users move from apathy to worry and anxiety when the level of challenges they take is going higher. It looks like there is no fair balance for users of low skills. This is a risk the gamified CMMD has to address by letting users to develop first some skills before taking challenges as 'missions'.

Such safe challenges could be the creation of a personal circle using personal contacts. This will transform existing social structures into digital social structures (personal social network) in a controlled way. This process will give the time users need to get familiarized with the platform. After newcomers have proved they have some experience with the platform the social component of the CMMD, the system can suggest to them some social challenges afterwards. Similarly, after dyads have a proven treatment adherence history on

the platform they can be safely invited to a group of users who aim to maximize their treatment adherence scores.
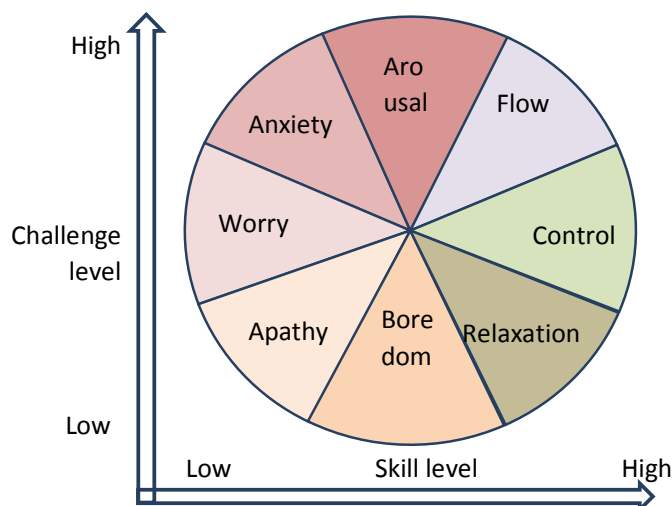
Figure 9. Gamer's states according to their skills and faced challenge (balance) [Radoff, 2011]

Other aspects of the so-called **Social Network Theory** which will be used in the development of the internal economy of the gamified platform (user monitoring & awarding system) is:

- **Connection Analysis**, e.g. the number of nodes connected to a node (personal circle's size)

- **Distribution Analysis**

  – **Degree** (the number of nodes a certain node is directly connected to)

  – **Betweennes Centrality** (the likeliness of a node being the most direct route between two other nodes)

  – **Closeness Centrality** (the minimal number of nodes one has to pass before reaching everyone in the network)

  – **Eigenvector Centrality** (the influence of a node in a graph, measured according to its relative position

- **Segmentation analysis,** e.g. finding clusters or communities in a network

3.6   The Gamification Engine

The knowledge collected from user requirements, PACT analysis and focus groups on WP2 helped in designing gamification platform in CMMD. User's needs were analyzed and prioritized in requirements specification. Gamification in CMMD was implemented in an IDE engine (see Annex) using PHP and MySQL for managing the database. The gamification database has been designed according to what tasks take place in a social network and a community of people sharing the challenge living with Dementia. Initially, some basic entities were created in order to have an overview of the database. Connections between these entities as well as their relationships are shown in the picture below (**Figure 10**).
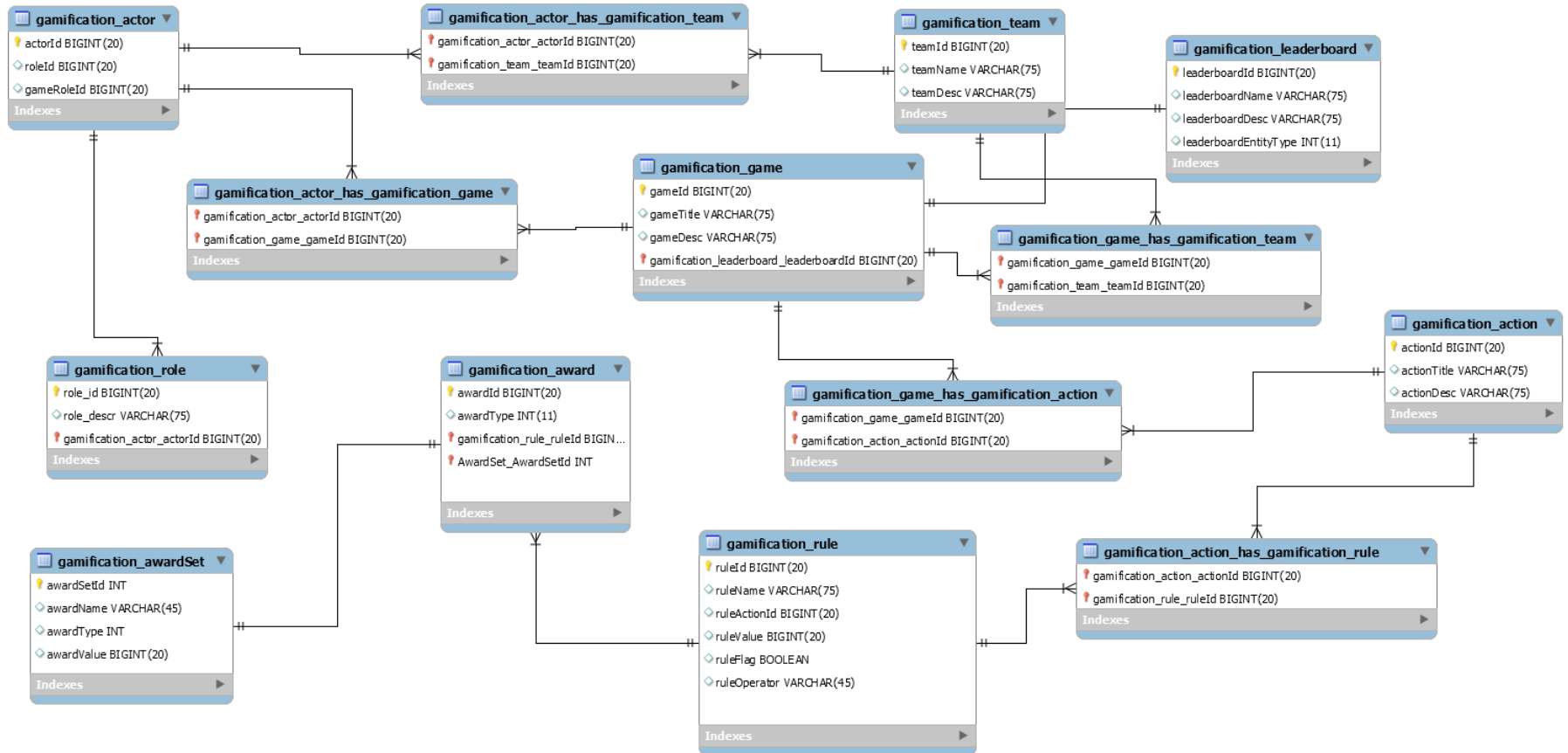
Figure 10. The architecture of the Gamification database

The CMMD gamification engine will allow gamification administrators (the 'puppet masters') to create and run multiple games simultaneously. Each game is defined as a set of targeted actions made by user groups and individuals. The games can be proposed to users as 'missions' or 'challenges' to take over. Each game will implement and run its own set of rules according to the aims of the game creators. Also each game will have its own awarding system (points, badges, leaderboards, etc.).

Usually, database architecture has three levels:

Conceptual Data Level: is the subtractive description of the database which identifies the high-level relationships only. Thus, it includes the set of basic entities and their relationships without denoting attributes or primary keys.

Physical Data Level: This structure represents how data is going to be stored in the database. This described the table structures including column name, datatypes primary keys relationships between tables and any constraint that may exist.

External Data Level: Entities are converted into tables and relationships into foreign keys in order to make a physical data model. Above this, the external data level will be responsible for making connections with all other resources not considered internal to the gamification system, including the CMMD social network database and platform.

The following table summarizes the basic entities of the In CMMD gamification platform (**Table 12**). Each entity is a table whose columns describe the elements of the entity. Supplementary tables describe the relationships between them like when one entity is connected with more than one different entities.

Table 12. Rules of the Rewards System per User Category

Entity	Fields	Description
User	user_id, name, surname, role_id	The users table
Role	id, description	The Roles table stores a description of the user's id according to the roles in physical life and the health conditions
Game	game_id, title, description	This is the table containing the games.
Metrics	metric_id, name_metric, type_metric, description	The table of metrics lists all kinds of metrics used to monitor user's activity and awarding back
Process	process_id, title, description	Contains the list of processes and basic descriptors
Task	task_Id, task_name, task_description, task_LoopCount	This table defined the set of tasks and their repetitiveness
Rules	rule_Id, rule_name, rule_metric	Each game has a number of rules associated with a metric.

Leaderboard	leaderboard_Id, leaderboard_name, leaderboard__description, leaderboard_entity_type(players/team)	List of leaderbords, their details and their range in players and teams
Rewards	Reward_id, reward_type, reward_verb, reward_condition	The types of rewards to be applied in the game
Action	action_id , title, description, action_type	List and Type of actions (user-driven) which have an impact on the game flow
Values	value_id, value, verb, probability	Table of game values
Team	team_Id, team_name, team_description	The table of user teams, discussion groups, national-wide regions, etc.

The game is characterized by the rules and the metrics used to link tasks. Taking 10 points for each post in the social network for example, requires that the gamification administrator has created a new game for the social network first and then has created a new rule to connect the metric (points) to the activity of posting a message (process).

In the server side, a set of web services have been implemented which cover the aforementioned requirements. More information on the gamification API can be found on the D3.3. deliverable.

The Gamification Administration Tool

The administrator of the gamification component is responsible for creating the game and setting its rules. Due to the enough work-load a gamification administrator will have, a separate tool for interfacing the gamification engine was required. **Figure 11** presents a screenshot of the gamification administrator tool (entry point).
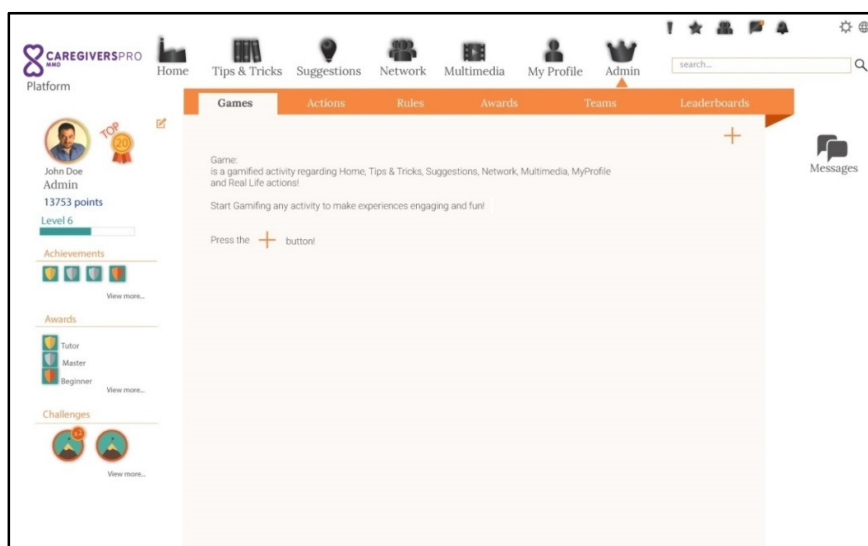
Figure 11. Entry screen for gamification administrator tool

After a new game has been created (**Figure 12**), the administrator can create user groups, rules (**Figure 13**) and rewards (**Figure 14**).
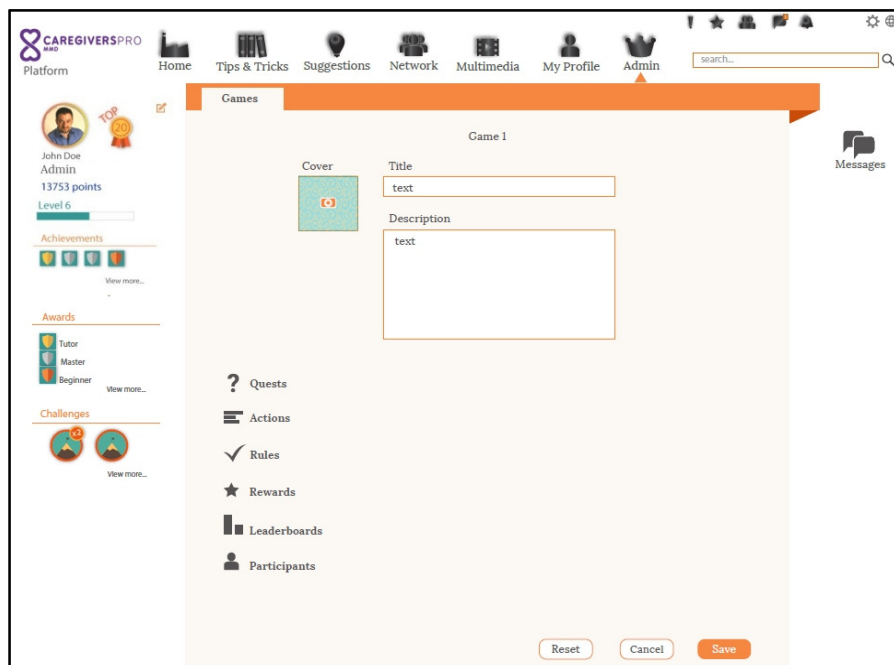
Figure 12. Creation of a new Game for the gamified platform
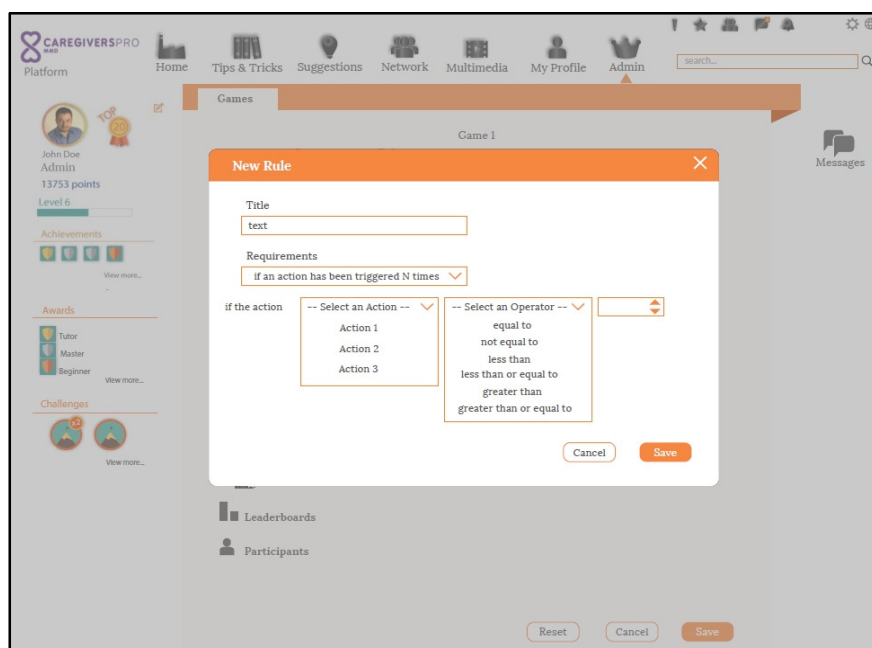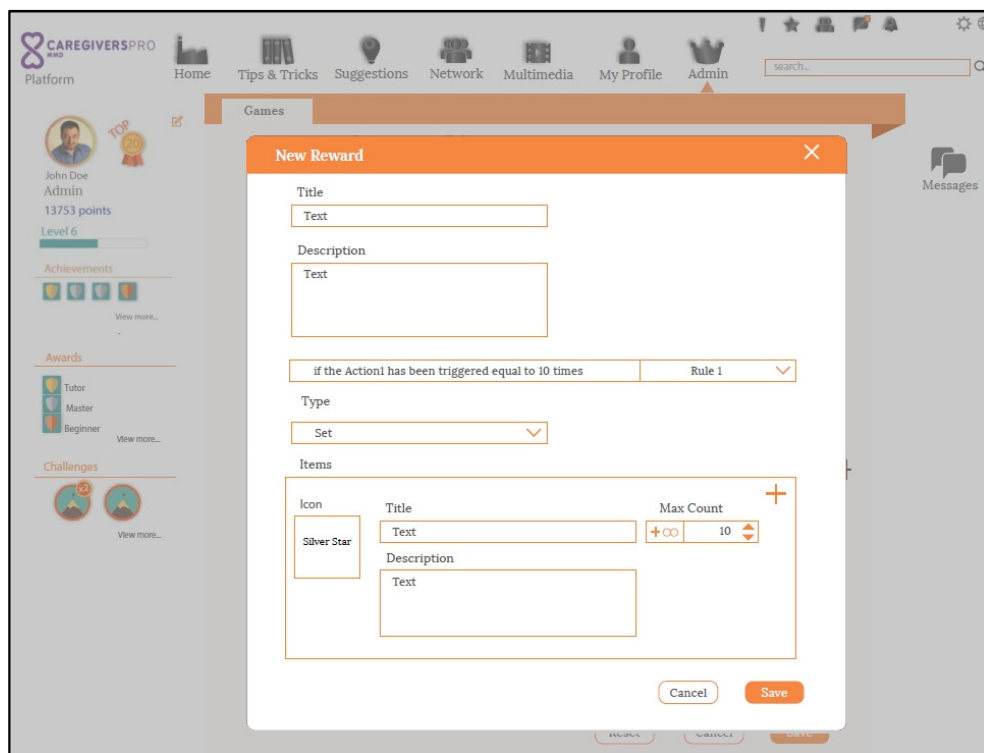
Figure 13. The 'create new rules' interface

Figure 14. The interface for creating a new reward

3.7 Conclusions on Gamification

The gamification paradigm of CMMD starts from a model which moves around medical personnel (physician-centred, or clinic-centred model) towards a de-centralized model in which caregivers and PLWD –together as a unit- are given more responsibility for the health conditions and treatment planning.

Future characteristics to be included in the final version of the gamification engine would be:

- **Quests or Missions:** highly personalized and can combine quests, combinations of actions and discrete steps in achieving game goals. Also Linear vs Random, timed events with expiration

- **Multilanguage support** (additional languages will be inserted into the gamification back-end as an extra table for translation)

- **Security:** Cool off period for each action (e.g. unlimited votes, time between 2 votes, reduce action spamming)

- **Levels:** Game elements used to split the level of difficulty and share objectives in groups. Levels functionality will be implemented according to the following rules:

    - Each game will have one or more levels. Even if the game-master (creator) will not define levels, at least one default level will be applied in each new game.

- Levels on the Front-end are to be featured at the left side of the screen (among awards, actions etc.) and will be located just after rules.

- Each rule will be applied differently in each level: the effort to win points will be different by using **multipliers**.

- In overall, each level will have the properties: **Title** (String), **Description** (LongString), **OrderId** (Integer), **Requirements** (Integer), **Avatar** (picture)

- The progress for k level will be presented to the end-user as a **progress bar** having in left-side the requirements for k, in right-side the requirements for k+1 level and current value: gaugePosition = totalPoints-kRequirements

4 Treatment Adherence

Given the prevalence of the problem, especially among patients with chronic conditions, minor improvements in Treatment Adherence (TA) among groups of people should yield significantly better health outcomes for CRs (Care Receivers) and CGs (Caregivers), and savings for hospitals and health systems.

We will measure TA in order to better informing the assessment of an intervention (as unrecognized non-adherence may lead to an underestimation of possible treatment effects), determining influences on adherence to treatment in people with dementia and/or with psychological comorbidities and identifying CG and CR requiring education or support to improve medication use (*e.g.* recipient of C-MMD tailored intervention).
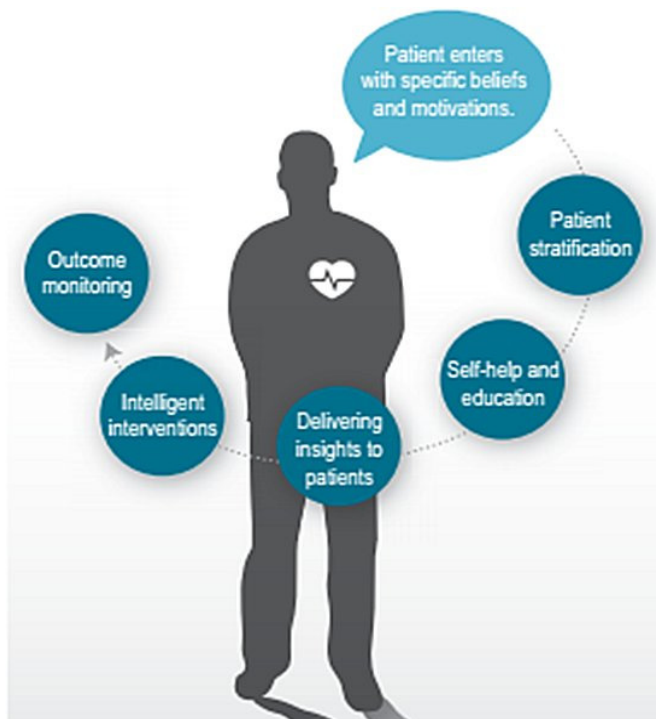
Figure 15. High concept of treatment adherence

One of the C-MMD gold objectives is to reduce the functional decline of CRs recently diagnosed by improving the treatment adherence from 50 to 70% [Brady & Weinman, 2013], and to improve also treatment adherence for CG.

A clear first step is the early identification of potential problems with adherence among person with dementia because of cognitive or physical limitations. Due to the high of CG involvement in the care of patients with AD, strategies that address CG concerns may improve adherence.

A key question is when to change from self-management to having another person assume responsibility for medication administration.

4.1 Existing validated self-reported scales for adherence

Self-report adherence scales can (i) measure medication-taking behavior, where use of the scale either complements objective measures, or is used as an alternative to objective measures and/or (ii) identify reasons for a patient's non-adherence, by identifying patient-specific barriers or beliefs that impede adherence. Recently, a systematic review [Nguyen et al., 2014] proposes a list of 43 validated self-reported scales for adherence.

4.2 Medication Management

Medication management is defined as patient-centred care to optimize safe, effective and appropriate drug therapy through collaboration with patients and their health care team.

Medication self-management is defined as "the extent to which a patient takes medication as prescribed, including not only the correct dose, frequency and spacing, but also its continued, safe use over time".

Known risk factors for adverse drug reactions include non-adherence, drug interactions, and polypharmacy [Maidment et al., 2011]. The primary goals of medication regimens for CRs include preservation of cognitive and functional ability, minimization of behavioural disturbances, and slowing of disease progression.

AHRQ's 2012 comparative review of 62 evidence-based interventions to improve TA suggests little is known about the effectiveness of these interventions for dementia patients. The review found that interventions reducing out-of-pocket expenditures and combining case management and education was most likely to promote medication adherence.

The majority of dementia patients experience multiple comorbidities and must manage those conditions, and associated medications, concurrently.

4.3 Treatment adherence interventions

Based on the scenario, (MCI, Mild dementia, moderate dementia), we will first assess the TA for the CR and CG and define treatment adherence interventions. These interventions will differ according to the level of dementia (our scenarios). Medication management in early stage dementia may be characterised by patients' desire to maintain independence, denial of issues or disease, and a refusal to take medications owing to feeling angry. In late-stage dementia, older adults often refuse medications owing to delusional or suspicious thinking,

which results in caregivers assuming responsibility for managing their medications [Kaasalainen et al., 2011].

Scenario 1 (MCI):

Based on the assessment result, we will build tailored intervention based on the following model of medication self-management:

Fill	fill and pick up their prescriptions
Understand	learn how to take the drug safely and appropriately
Organize	organize and plan their medications around their daily schedule
Monitor	Potential side effects, risks, and warnings
Sustain	Throughout the duration of the prescription (persistence)

Scenario 2 : (mild dementia)

Mixte between scenario 1 and 3.

Scenario 3 : (moderate dementia)

Denys T. Lau et al propose that effective medication management is linked to caregiving skills in the following five domains: teamwork skills, organization skills, symptom knowledge skills, medication knowledge skills, and personhood skills [Lau et al., 2009].

Teamwork skills	Ability to communicate and coordinate
Symptom knowledge skills	Ability to recognize and respond to common symptoms.
Medication knowledge skills	ability to apply the basics of pharmacology
Personhood skills	ability to assess the patient's symptoms and administer medications given the patient's individual needs, preferences, and ways of communication
Organizational skills	ability to acquire, store, track, and discard medications

The goal of the C-MMD TA interventions is to improve TA for CRs and for CGs. Based on assessment's results, C-MMD will generate online tailored interventions for CG only, CR only and shared between CG and CR. These tailored interventions will also differ based on the scenario.

While self-reporting data is essential to tracking and measuring patient outcomes and behaviours, self-reporting rates are usually very poor due to low patient motivation levels. C-MMD Gamification will also provide a driving force for CRs and CGs to involve themselves in the process and benefit from it.

4.4 Medications adherence analysis

In summary, the analysis of the literature results in a compendium of scales to be used that are collected in the following list grouped in different situations:

Medication-taking behavior

Title/acronym	Brief Adherence Rating Scale (BARS)
Created by	Byerly et al 2008
Purposes	Based on CATIE trial The BARS is a recently developed clinician-administered adherence assessment tool consisting of a) three questions (adapted with permission from a questionnaire used in the CATIE trial) about the patient's knowledge of their own medication regimen and episodes of missed medication taking, as follows: 　　1. number of prescribed doses of medication per day 　　2. number of days in the past month when the patient did not take the prescribed doses 　　3. Number of days in the past month when the patient took less than the prescribed dose. b) A visual analogue scale (VAS) used to assess the proportion of doses taken by the patient in the past month (0–100%). The visual analogue scale rating is the key measure of adherence provided by the BARS.
References	Byerly MJ, Nakonezny PA, Rush AJ. The Brief Adherence Rating Scale (BARS) validated against electronic monitoring in assessing the antipsychotic medication adherence of outpatients with schizophrenia and schizoaffective disorder. Schizophr Res 2008;100:60–9.

Group 2: Medication-taking behaviour and barriers

Title/acronym	Adherence to Refills and Medications Scale (ARMS)
Created by	Kripalani
Purposes	- Correct administration - Forgetfulness - Prescription refill ability Based on Literature review, MAQ and Hill-Bone Compliance Scale
References	Kripalani S, Risser J, Gatti ME, Jacobson TA. Development and evaluation of the Adherence to Refills and Medications Scale (ARMS) among low-

	literacy patients with chronic disease. Value Health 2009; 12: 118–23.

Title/acronym	**Adherence Starts with Knowledge-12 (ASK-12)**
Created by	Matza LS
Purposes	- Patient-perceived barriers - Inconvenience - Forgetfulness - Medication beliefs The ASK-12 demonstrated adequate reliability and validity, and it may be a useful brief measure of adherence behavior and barriers to treatment adherence
References	Based on ASK-20 Matza LS, Park J, Coyne KS, Skinner EP,Malley KG,Wolever RQ. Derivation and validation of the ASK-12 adherence barrier survey. Ann Pharmacother 2009; 43: 1621–30.
Availability online (web address)	http://stage.wapatientsafety.org/downloads/Ask12-articles-Annals.pdf

Title/acronym	**Morisky Medication Adherence Scale (MMAS)**
Created by	Morisky DE - 2008
Purposes	- Forgetfulness - Medication-taking behaviour - Adverse effects and problems Based on MAQ and behavioural aspects Self-reported questionnaires have frequently been used because they are low in both cost and time expenditure. Early studies found that the self-report method was underestimating non-adherence when compared with pill counts or biological assays. However, subsequent research suggests that the self-report method may provide a reasonably accurate estimate of adherence. Among structured, self-reported scales, a four-item self-reported questionnaire (the Morisky Medication Adherence Scale-MMAS-4) to assess medication adherence was developed by Prof. Morisky. An eight-item self-reported scale has been developed (MMAS-8) and widely use in different kind of studies. The MMAS-4 and MMAS-8 are not in the public domain and a license agreement may be obtained from Prof. Morisky.
References	Morisky DE, Ang A, Krousel-Wood M,Ward HJ. Predictive validity of a medication adherence measure in an outpatient setting. J Clin Hypertens 2008; 10: 348–54.

Title/acronym	Simplified Medication Adherence Questionnaire (SMAQ)
Created by	Knobel H
Purposes	- Forgetfulness - Adverse effects Based on MAQ
References	Knobel H, Alonso J, Casado JL, Collazos J, Gonzalez J, Ruiz I, Kindelan JM, Carmona A, Juega J, Ocampo A. Validation of a simplified medication adherence questionnaire in a large cohort of HIV-infected patients: the GEEMA Study. AIDS 2002; 16: 605–13.

Group 3: Barriers to adherence

Title/acronym	Adherence Attitude Inventory (AAI)
Created by	Lewis SJ - 2002
Purposes	- Cognitive functioning - Patient-Provider - Self-efficacy - Commitment Based on Health Belief Model, Health Promotion Model, Reasoned Action - The Adherence Attitude Inventory is a 28-item Likert-type scaled rapid assessment instrument that consists of four distinct constructs (cognitive functioning, patient-provider communication, self-efficacy, and commitment to adherence) that are related to adherence to medication.
References	Lewis SJ, Abell N. Development and evaluation of the Adherence Attitude Inventory. Res Soc Work Pract 2002; 12: 107–23.

Title/acronym	Medication Adherence Questionnaire (MAQ)
Created by	Morisky et al, 1986
Purposes	- Forgetfulness and carelessness - Adverse effects and efficacy Based on 5-item questionnaire by Green et al
References	Toll BA, McKee SA, Martin DJ, Jatlow P, O'Malley SS. Factor structure and validity of the Medication Adherence Questionnaire (MAQ) with cigarette smokers trying to quit. Nicotine Tob Res 2007; 9: 597–605.

Title/acronym	Medication Adherence Reasons Scale

Created by	Unni EJ - 2009
Purposes	- Managing issues - Beliefs - Multiple medication issues - Availability issues - Forgetfulness Based on Literature review Objective measures of non-adherence such as prescription claims and pill count, while quantifying non-adherence, do not provide the reasons for non-adherence, hence making it difficult to develop intervention strategies. Self-reported measures are helpful to determine reasons for non-adherence;
Submitted by	Self-administered
References	Unni EJ, Farris KB. Development of a new scale to measure self-reported medication nonadherence. Res Social Adm Pharm 2009.
Availability online (web address)	http://www.ncbi.nlm.nih.gov/pubmed/21272524

Title/acronym	The Self-Efficacy for Appropriate Medication Use Scale (SEAMS)
Created by	Risser J - 2007
Purposes	- Specific problem areas - Self-efficacy Based on Literature, expertise and patient interviews. Self-efficacy scale for medication adherence in chronic disease management that can be used in patients with a broad range of literacy skills. The Self-efficacy for Appropriate Medication Use (SEAMS) was developed by a multidisciplinary team with expertise in medication adherence and health literacy
Submitted by	Self-administered
References	Risser J, Jacobson TA, Kripalani S. Development and psychometric evaluation of the self-efficacy for appropriate medication use scale (SEAMS) in low-literacy patients with chronic disease. J Nurs Meas 2007; 15: 203–19.

Group 4: Beliefs associated with adherence

Title/acronym	Beliefs about Medicines Questionnaire

Created by	Horne R - 1996
Purposes	- Medication necessity beliefs - Medication concerns Based on Health Belief Model and Patient Beliefs - This paper presents a novel method for assessing cognitive representations of medication: the Beliefs about Medicines Questionnaire (BMQ). The BMQ comprises two sections: the BMQ-Specific which assesses representations of medication prescribed for personal use and the BMQ-General which assesses beliefs about medicines in general. - Patients with hypertension, diabetes mellitus, hypercholesterolemia, hypothyroidism or condition requiring HRT.
References	Horne R,Weinman J, Hankins M. The Beliefs about Medicines Questionnaire: the development and evaluation of a new method for assessing the cognitive representation of medication. Psychol Health 1999; 14: 1–24.

Title/acronym	Drug Attitude Inventory (DAI)
Created by	Hogan et al, 1983
Purposes	- Attitudes towards medications - Beliefs on medications The DAI consists of a questionnaire that is completed by the patient. It includes a series of questions, each with true/false answers, pertaining to various aspects of the patient's perceptions and experiences of treatment. The original scale consists of 30 questions, but a short form consisting of 10 questions has also been validated. The patient should be asked to read each statement in the questionnaire and decide whether they believe it to be true or false (or mostly true/false) as applied to their own experience with medications (only those medications used for the patient's mental health needs). They should circle their answers in ink on the form. The DAI-10 was derived by means of stepwise discriminant analyses applied to the responses of 150 schizophrenia patients to the DAI-30 (Awad, 1993). The DAI-10 contains six items that a patient who is fully adherent to prescribed medication would answer as 'True', and four they would rate as 'False'. Scores are allocated to each answer and the total score is calculated in the same way as for the DAI-30. Similarly, a positive total score indicates a positive subjective response (adherent) and a negative total score indicates a negative subjective response (non-adherent).
Evaluated by	Self-Administred
References	Based on Literature review and patient reports

Group 5: Barriers and beliefs

Title/acronym	Beliefs and Behaviour Questionnaire (BBQ)
Created by	Georges J – 2006
Purposes	- Beliefs - Experiences Based on Qualitative interviews with Chronic Obstructive Pulmonary Disease (COPD) patients
References	George J,Mackinnon A, Kong DC, Stewart K. Development and validation of the Beliefs and Behaviour Questionnaire (BBQ). Patient Educ Couns 2006; 64: 50–60.
Availability online (web address)	http://www.ncbi.nlm.nih.gov/pubmed/16843634

Title/acronym	Brief Evaluation of Medication Influences and Beliefs (BEMIB)
Created by	Dolder 2004
Purposes	- Forgetfulness - Access to medications - Support network - Benefits of medication Based on Health Belief Model and Patient/Investigator feedback, designed to identify patients who are more likely to be nonadherent to their antipsychotic medication.
References	http://www.ncbi.nlm.nih.gov/pubmed/15232332

Title/acronym	Medication Adherence Report Scale (MARS)
Created by	Thompson et al, 2000
Purposes	- Forgetfulness - Adverse effects - Value of medication - Behaviour and attitudes Thompson et al (2000) identified several deficiencies in the DAI as a measure of adherence and proposed a new inventory, the MARS scale, that incorporates features of both the DAI and the MAQ (Morisky et al, 1986) but which they claimed to have greater validity and clinical utility. They concluded that it was a valid and reliable measure of adherence to psychoactive medications. The patient should be asked to respond to the statements in the

	questionnaire by circling the answer which best describes their behaviour or attitude towards their medication during the past week.
References	Based on MAQ and DAI

Other adherence scales

Title/acronym	**Measure of Drug Self-Management (MeDS)**
Created by	Stacy Cooper Bailey -2015
Purposes	The MeDS seems to be a valid and reliable tool that can be used to assess medication self-management skills among diverse patients, including those with limited literacy skills. Overall, 88.6% of the participants interviewed believed that this tool could help them or other patients to take their medicines safely.
References	Development and evaluation of the Measure of Drug Self-Management Stacy Cooper Bailey, Izabela E Annis, Daniel S Reuland, Autumn D Locklear, Betsy L Sleath, and Michael S Wolf

Title/acronym	**Personal Evaluations of Transitions in Treatment; PETiT**
Created by	Voruganti and Awad, 2002
Purposes	PETiT is another self-administered patient questionnaire. It was developed with the aim of producing a tool that could monitor changes perceived by a patient receiving therapy based on antipsychotic drugs, and particularly to measure the effects of atypical antipsychotic drugs on outcomes such as subjective well-being.
Evaluated by	Self-administered
References	Voruganti LN, Awad AG. Personal evaluation of transitions in treatment (PETiT):a scale to measure subjective aspects of antipsychotic drug therapy in schizophrenia. Schizophr Res 2002;56:37–46.

Title/acronym	**Clinician Rating Scale; CRS**
Created by	Kemp et al, 1996; 1998
Purposes	The CRS uses an ordinal scale of 1–7 to quantify the clinician's assessment of the level of adherence shown by the patient. Higher numbers represent greater adherence. The CRS has been used in two controlled trials of 'compliance therapy', in which it demonstrated sensitivity in detecting differences in outcomes among patients receiving compliance therapy versus non-specific counseling (Kemp et al, 1996; 1998).

Evaluated by	Self-administered
Availability online (web address)	http://bruceliese.com/documents/blpubs/Clinical_Rating_Scale.pdf

Title/acronym	**Composite Self Report Measure**
Purposes	Homecare patients over 65 years of age – Assessment with the 4-item self-report scale developed by Morisky et al and A composite estimate of adherence was made utilizing all available recorded self-report data. This measure was derived by cross-referencing subjects' responses to the individual scale items (Morisky) with their responses to an open-ended question regarding reasons for non-adherence
Evaluated by	Self-administered
Availability online (web address)	http://bruceliese.com/documents/blpubs/Clinical_Rating_Scale.pdf

Title/acronym	**Drug Regimen Unassisted Grading Scale; DRUGS**
Created by	Edelberg HK, Shallenberger E, Wei JY (1999)
Purposes	The DRUGS tool uses a performance-based measurement to assess the individual's ability to identify, access, and determine the dosage and timing of their medications. This tool may take about 35 minutes to administer, and is preferred for higher-functioning, community dwelling individuals.
References	Edelberg HK, Shallenberger E, Wei JY. Medication management capacity in highly functioning community-living older adults: detection of early deficits. J Am Geriatr Soc. 1999 May;47(5):592-6

Strategy of treatment adherence evaluation in the CAREGIVERSPRO-MMD platform

To carry out an evaluation of the treatment adherence, the platform will collect the following parameters:

- Medication name (free text)
- Anatomical, Therapeutic, Chemical classification system (ATC) (https://www.whocc.no/atc_ddd_index/)
- Dose (a quantity of medicine prescribed to be taken at one time)
- Duration of treatment (date - date)
- Indicated for… (Pathology, comorbidity …)

- Administration route (Oral, Intravenous, Nasal, Respiratory (inhalation), Transdermal, Other)

This information will be complemented with a subjective appreciation of adherence to the drug following the following questions (MMAS-4 scale) [Morisky et al., 1986]:

1. Do you ever forget to take your medicine?
2. Are you careless at times about taking your medicine?
3. Sometimes if you feel worse when you take the medicine, do you stop taking it?
4. When you feel better do you sometimes stop taking your medicine?

Results (score interpretation):

Adherence MMAS-4	Score
High Adherence	0
Medium Adherence	1-2
Low Adherence	3-4

5   Personalization and User Interface Adaptation

5.1   Introduction

Personalization of software is the content of the task T2.4. The general objective of this task is to customize the platform to each user categories, especially to the PLWD and their caregivers. According to this aim, a rule-set need to be defined in order to successfully adapt user profiles based on context features. Those rules will describe how specific user profile characteristics and current status will cause changes in the context and the appearance of this context in the platform. Personalization and customization will be defined by a set of parameters to be controlled by PLWD, caregivers, doctors and other medical professionals.

Matchmaking algorithms will be used for conditions and adaptation rules. The algorithmic content of the personalization component will be completed by the development of algorithms for auto-adjustment of user profiles.

In the following sections, a brief definition of the terms personalization and customization will be provided. A literature review will shed more light into the priorities and implementation issues behind personalization on healthcare systems. Results derived from the above will lead the personalization strategy definition for CMMD platform?

5.2   Definition of Personalization and Customization

Personalization and customization are two terms both used to describe user experience issues. Although they have been used as synonyms, personalization is closely related to the ability of a system to adapt to individual users and their behaviour. In a hotel reservation site for example, a user receives notification on others users viewing the same hotel for the same period of time. In addition, personalization can be used to serve the needs of groups or segments of individuals. Today personalization is used by organizations to improve customer

satisfaction, marketing and advertising results and to improve web visibility metrics. In healthcare, it is used to personalize healthcare services, improve treatment results and maximize satisfaction for PLWD and their caregivers. Personalization is also featured as a key element in social media.

On the other hand, customization is closely related to conscious user actions towards a change in the interface. Those changes can be in font size, background colour, layout, etc. In this way an end-user can explicitly change things and customize their experiences. In the latter case, the user can accept, decline or ignore the suggestion. This makes the personalization component more user-friendly because it is less restrictive and interventional.

5.3 Categorization of Personalization Approaches

There are two major categorization families: a. User-driven and b. system-driven personalization, each one with its own pros and cons.

User-Driven Personalization

When personalization is initialized and performed by the user him/herself on numerous features of the interface or content to best fit user's personal needs and preferences. It is often mentioned as customization by system designers and it is closely related to the visual characteristics of an intervention, no too much on the functional characteristics. Appearance selection in an avatar performing in a virtual world for example can influence user's behaviour. In non-immersive environments User Interface (UI) elements like menu-bars can change position in the screen (working area). In Operating Systems (OS), smartphones and elsewhere users can create their own shortcuts to favourite application. All of the above are examples of customization used for stimulating users and make them feel unique.

System-Driven Personalization (SDP)

Systems automatically monitor user's status and behaviour using interaction tracking (e.g. log files), input from surveys and data from social networks in order to 'learn' the user and predict what would be supportive and comfort. SDP makes use of big data analytics and user modelling technologies to present the intelligent systems they are hosted in as 'personal systems'. The system-driven personalization often operates in the back-end, under no user's control or awareness. SDP can easily handle groups of users who share similar characteristics and have a high profiles' similarity and they are considered ideal for information overload reduction and for offering proactive services. From a designer's point of view it is all about balancing user autonomy and applied control.

The problem is when SDP makes not the right adaptations: users lose their trust because they sense that the system treats them as they were someone else. Advanced user modelling and detailed user descriptions are required (complete and detailed user profiles and relatively long interaction history) in order to make safe conclusions on users interests, preferences and limitations.

5.4   CAREGIVERSPRO-MMD Advances on Personalization

It should be noted that the design of CMMD services and the platform interface will take into account people who experience disabilities and health conditions, but this should not be confused with the process of personalizing the services, because personalization is different than accessibility. Actually personalization and customization will be applied after accessibility design.

Based on the challenges and limitations of personalization approaches explained before, CMMD aims to address:

Mixed User- and System-Driven Approach

Personalization will be the result of a hybrid matchmaker which will make use of both the statistical and the rule-based matchmaking processes. To be noted that apart from the system-driven recommendations, user preferences will have the highest priorities. In overall the output of the rule-based engine which will be based on health conditions and the user category will be given the lowest priority. Next the output of the statistical matchmaker will have a higher priority than the rule-based because it is expected to have achieved a better clustering of user profiles. Lastly, the personal preferences will have higher priority than the previous two. This will be the method for the conflict resolution to be used in the hybrid approach (**Figure 16**).
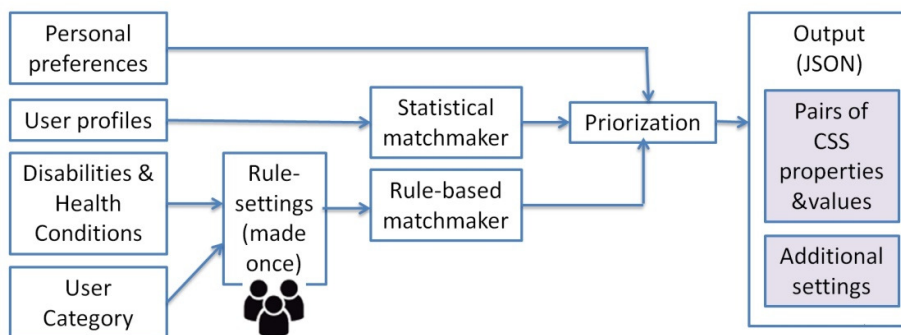
Figure 16. Block diagram of the hybrid matchmaker and basic functionality

Dynamic personalization

Research on dynamic personalization is limited and we have to deal with changing adaptation rules and techniques as a result of people's changing experiences over time. This could be also applied in changing contexts or medical conditions over time. Thus, one of the major challenges for CMMD platform is to provide personalization services according to: a. the progress of the MMD symptoms and b. changes in priorities, preferences and behaviour or users.

Collaborative Personalization

Instead of letting only one person to apply personalization in his/her profile or the system, Collaborative Personalization (CP) is a collaborative process. Groups of people will be able to co-create the rules and apply them into their profiles. CP has been previously applied in other fields like learning and web search [Inthiran et al., 2012]. According to the principles of

CP an information retrieval strategy will be designed to provide users with relevant results based on group statistics. The results will be valuable inside the members of the group and thus CMMD communities can undertake such initiations. The outcomes can be reported as group profiles and be available as options (among others) in the personal preferences editor of the CMMD platform.

Recovery Strategy

Personalization service breakdowns may influence the overall end-user's experience and thus evaluation results, not to mention that service breakdowns make the system less functional or impropriate. Unlike other attempts, attention will be paid on recovery strategies to eliminate side effects and maximize the trust people have to the CMMD platform. The aim is to continuously guarantee high quality in services on offer for the different groups of users.

5.5   Similar Work

CultureAll

This was a Canadian network project which developed technology and strategies for inclusive design as components of Web 2.0 technologies (Fels et al., 2006). To ensure that everyone could participate in the Canadian cultural exchange by web offers. A variety of free accessible web tools were created to improve access to cultural content and activities. In particular, the *TransformAble* project is mentioned here because it included a personalization component for user interfaces. It proposed a set of web services that could modify the user interface of a website, along with its contents, in order to accommodate the individual needs and personal preferences of individuals. The project exported 3 open source Java-based services (Colin, 2008):

- **PreferAble:** A web interface used by users to edit and save a set of preferences like language preferences, colour schemes, screen enhancement, control preferences and alternatives to multimedia.
- **StyleAble:** Used to perform a range of display and structural transformations on any well-formed webpage. These are 2 types of transformations: a. generation of custom style sheets and b. document transformations.
- **SenseAble:** This worked alongside rich-media content repositories. A set of metadata was used to describe the accessibility characteristics of particular resources (including potential alternatives). A video resource for example could appear with captions or possible available sign language resources in case the user profile indicated hearing problems. Thus, the matching engine of SenseAble determined the availability and appropriateness of content alternatives.

The Fluid Project

The Fluid (Flexible User Interface) Project created an interface architecture which could enable the creation of modular, reusable, and swappable UI components and highly personalized apps using Web 2.0 Technologies (Markus et al., 2014). UI could be customized based on personal profiles during configuration or at runtime.

The GUIDE project

As one of the 4 projects which formed the VUMS (Virtual User Modelling and Simulation Standardisation) cluster, the GUIDE (Gentle user interfaces for elderly people) project developed personalised and adaptive user interfaces for the elderly (Biswas & Langdon 2010). Here, the adaptation engine of UI components was based on the VUM which controlled the relationship between the user characteristics and the interface configuration.

It is worth to mention some key-outcomes of the GUIDE project:

- **GUIDE Framework:** software components which automatically perform adaptation on legacy & future Web/TV platforms. In addition, this framework could be used by software and web developers to create adaptive web interfaces (HTML-based)
- **GUIDE Tools:** tools for application development within the GUIDE Framework (GUIDE Simulator).
- **GUIDE User Model:** proposed a new VUM (Virtual User Model) that reflects impairments & preferences of the elderly. The VUM is the enabling technology for the GUIDE framework & tools.

The MYUI project

The MyUI (Mainstreaming Accessibility through Synergistic User Modelling and Adaptability) project aimed to make user interfaces to self-adapt to evolving user models (Edlin-White et al., 2012). Series of interactive TV, digital physiotherapy and socialisation services were developed. In this project, user and context related information were collected in real-time by an ontology-based context management infrastructure. The personalisation process was the result of a loop in which user's interaction motor, cognitive and environmental factors were taken into account for feedback. Decision patterns were matched with user and content models before the composition of selections to feed the UI adaptation mechanism.

Personalization Standardization

Some Personalization standards taken into account were introduced by the World Health Organization (WHO, 2001-05) for measuring health and disability, also known as International Classification of Functioning, Disability and Health (ICF)[20]. But this standard was mostly used to describe body functions of individuals in medical contexts. EU projects like the MyUI have successfully adopted this approach for UI adaptation.

The IMS AccessForAll Meta-data Specification (AccMD) 1.0[21] and the IMS Learner Information Package Accessibility for LIP (AccLIP) were based on the Web-4-All approach to include the content and display characteristics, as well as the control of digital resources. Finally, this approach became known as the Access-For-All (AfA) approach to accessibility. More specifically, the AccLIP described the type content, the way to be rendered and the

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[20] *Available at: http://www.who.int/classifications/icf/en/*

[21] *Available at: http://www.imsglobal.org/accessibility/*

way to be interacted with. This representation followed a hierarchically-structured XML schema to augment the IMS specification of Learner Information.

The ISO/IEC 24751-2:2008 (Information technology -- Individualized adaptability and accessibility in e-learning, education and training - Part 2: "Access for all" personal needs and preferences for digital delivery [22]) divide properties into 3 groups: a display, b. control and c. content. It follows a multi-level structure in which each feature can occur multiple times (each time under a different application or display). This way, complex human-computer interaction systems which consist of multiple display and control units can be modelled. Also, an individual may have multiple user profiles for various contexts or application-specific settings. This is of particular importance for CMMD as the personalization component defines personalization modules for various social and physical contexts (see Personalization Design section).

In addition, the ISO/IEC 24751-2:2008 can support priorities for various features. Those priorities define that each feature can be required, preferred, optionally used, or prohibited. The ISO/IEC 24756:2009 is a framework for a Common Access Profile (CAP) specification of user needs and capabilities, as well as specification of the system and the environment (by the notion of "channels" and "filters"). It can help to determine if a specific system, service or setup can fit specific individuals.

5.6 The CMMD Approach

5.6.1 Introduction and Expected Benefits

It is not necessary to have new features in order to offer personalization services; making use of existing features is also a common practice. Platform designers are meeting user's needs more effectively and efficiently by offering alternative ways to make interaction faster and easier. Especially in web personalization unique content can be delivered to each individual based on user's profile, current status, personal preferences and the context of the platform use.

Table 13. Personalization and Customization approach

Customization	Personalization
Personal profiles of PLWD	
PLWD specify what they want and take control on the contents, way of use and appearance of the interfaces. Customization will be applied to: - Font sizes (main text and headings) - Font colors (main text and headings) - Background colour or outlined line weight for buttons and active visual controls	The system uses implicit personal interests and user monitoring components to collect information on current user purposes and status. Personalization will be based on: - Regular in-platform activities - Personal treatment (drugs, treatment program, physical and mental exercises, etc.) - Treatment adherence evaluation status

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[22] Available at: http://standards.iso.org/ittf/PubliclyAvailableStandards/index.html

	- Profile status (normal, active, champion, inactive, sad, etc.)
Personal profiles of Social Workers, Doctors and Medical Professionals	
Customization for the rest of user categories will rely on personal preferences on content presentation. Collections of articles, layout status and monitoring are examples of components which will be affected by customization actions.	• Adaptation to user type (access to additional layouts for professionals). • Define rulesets for adaptation for PLWD and caregivers
Personal Profiles of Caregivers	
Caregivers explicitly specify what they want for themselves or for the PLWD they are responsible for. Caregivers can take control on the contents, way of use and the layout of the interfaces of the PLWD depending on the state of the dyad. Self-customization will be applied to all mentioned before (for self) plus (for PLWD): - Access to medical data and diagnostic materials - Visibility of visual elements like settings button, treatment adherence assessment, neuropsychological surveys	Adaptation to user type, plus adaptation to user profile as described earlier for PLWD, but applied to both PLWD and caregivers for: • UI • content • recommendations

5.6.2 Expected Benefits

In the field of user satisfaction, literature evidence implies that initial user's experience differs from long term-experience [Karapano et al., 2009]. Targeting to long-term benefits, CMMD personalization approach will offer to its users [Fan & Poole, 2006; Lee , 2013]:

• Liking towards the offered services
• Motivation for participation
• User Loyalty
• Efficiency
• Easy learning routes
• Help to sting the attention
• Reduced information overload (memory and selecting attention)
• Improved persuasiveness of messages and recommendations:
• Improved trust and emotional responses

5.6.3 Hybrid Personalization Models

There are two main model structures used by the personalization component of CMMD: a. the User Model and b. the Interaction Class Model.

To improve the CMMD experience we need to develop a mechanism for understanding the user. The User Model (UM) is an internal representation of the user, including modelling of their health conditions, knowledge and experience, purposes and roles in the platform. An instance of a UM is a collection of personal data associated with a specific user.

The UM in CMMD will have two parts, one static and one dynamic. Starting with a basic kind of user modelling, main data -not be changed again in future- is captured and saved as a *static* model. Such data is the demographics of users (e.g. year of birth, gender, disabilities, role in the platform, etc.). The *dynamic* part of the user model will consist of up to date representation of the users. Changes in interests, treatment adherence, dementia progress and user-system interactions will be parts of the dynamic UM. Although quite stereotyped, this UM will be able to perform most actions required by the CMMD personalization approach. Statistics on activities and preferences of other similar users can provide valuable information or the only information in case of new users (collaborative personalization). Thus, the system will be able to propose a personalization approach even in cases of limited knowledge about a user (**Figure 17**).
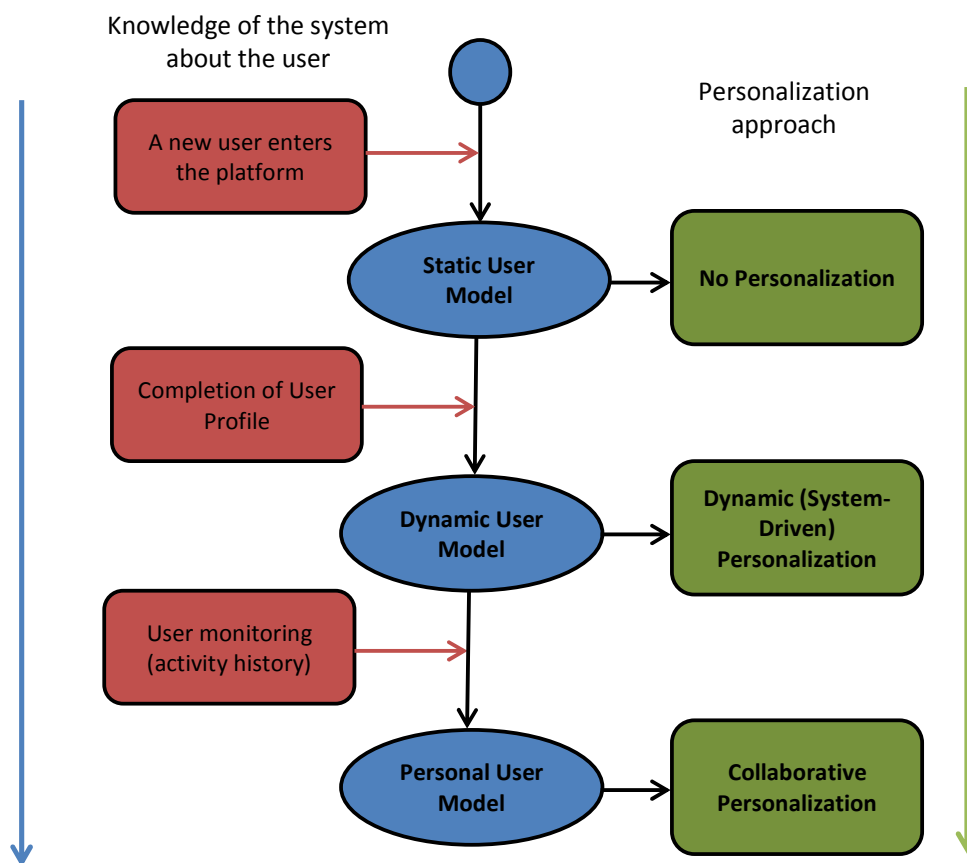

Figure 17. Maturation of the adaptation process

In addition, old user profiles who have a long history on the platform may contribute with a lot more information about their users. User modelling based on specific users is highly

adaptive and do not have to rely only on statistics (study of what other users of similar profiles do).

This hybrid CMMD approach tries to combine the advantages of other existing user modelling methods. In 'cold start' conditions for a new user, the personalization component will be based on the static user model. Based on user categories, pre-defined personalization and customization preferences work as a starting point. Later on, users are expected to complete their profiles by giving information about themselves. This is where the dynamic part of the user modelling is getting activated to take into effect the dynamic adaptation of content, functionality and interface. After getting mature enough, a user model will reach the highest level of its ability to describe a specific user and thus the collaborative personalization process is triggered (after machine learning techniques have been used to classify users). Based on these assumption rules, the platform will be able to perform changes in the personalization approach.

Personalization will penetrate horizontally all other components of the CMMD platform: namely the recommender system, the intelligent tutoring and the gamification component.

5.6.4 Participation through Lenses

Those lenses will work like distorting mirrors for offering equal chances to all users, especially those facing disabilities and cognitive decline (**Figure 18**). The system will take into account user profile information and will adapt missions and actions accordingly. The integration of these Lenses approach will be made using performance multipliers. This kind of personalization (equalization) is most applicable to gamification. According to this, a small improvement in depression test results made by a caregiver in high risk for depression may lead to more points earned than in another user who face no risk of depression. Similarly, the system will equalize a person with mild cognitive decline with other PLWD who have moderate cognitive decline. Normally, those Lenses will be implemented as rules in the gamification component (ruleset) by gamification masters at the time of the game creation.

Figure 18. Hall of mirrors ("A mirror labyrinth", ŠJů, Wikimedia Commons, CC BY-SA 3.0). CMMD platform users will appear to others differently than in reality. The performance of the 'poor' user profiles will be corrected by using amplifiers when needed to ensure the fair play in gamification component and equal chances of participation and socialization in the social component.

5.6.5 Profile Similarity Calculation

Social networks involve users as actors of the social interactions. Usually people organize their contacts (friends) on their own, according to personal criteria of their relationship (closeness). On the other hand, a user model is used to store all the information related to users and their activity in the network (reputation, communication activity, etc.). This user model may be used by the system to discover similar profile information throughout the network and propose to users contacts they may be interested in, for example based on common interests. The same approach can be applied on personal profiles, as well as on group profiles.

Without an engine to calculate profile similarities it would be impossible to create groups of users (clusters) in order to feed the statistical matchmaker. The process of finding profile similarities is explained in the following section.

A lot of distance/similarity measures have been proposed in the literature for calculating similarity score between two entitles. Filtering of information and text mining using cosine similarity in high-dimensional positive spaces (normalized dot product of the two attributes), string or distance similarity using Euclidean or Manhattan distance and probability density functions for measuring document similarity [Cha, 2007] are few examples.

Especially for calculating user profile similarity in CMMD, we need a measure of how much alike two user profiles are. The distance will be measured based on dimensions representing features of the user profiles like age, type of user, role on the platform, nationality, preferences, etc. If the distance is found to be small, then two user profiles share commonalities and the system may propose the one to the other. A large distance would mean less similarity between the two user profiles and thus low probability the two users to have an interest to be friends in the CMMD platform. Similarity will be expressed as a score in the range [0, 10].

Starting with a simple similarity index like the 'simple matching coefficient' [Sokal & Michener, 1958] (the number of matches divided by the total number of variables), up to Jaccard Similarity (the length of the sets intersection divided by the length of the sets union) used when characteristics come as sets, like in preferences, individual and group profile similarities will be tested to find the most effective method. For interaction history similarity comparison of sequences will be used [Needleman & Wunsch, 1970], e.g. the Spearman rank correlation just like in Biology. There are numerous categories of matching methods to be applied in the User Profiles defined in T1.6. An extensive list is presented in **Table 14.**
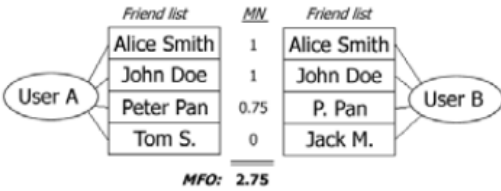
Table 14. Matching methods to be used and use cases

Matching Method	Description	Use cases
Exact Matching (Simple Comparison)	Check for equality in user profile data fields to produce a Boolean result.	Role types (e.g. Caregiver) Nationality or language matching (e.g. Italian, Spanish) Member of a user group or
	$$M(A,B) = \begin{cases} 1, if\ A\ equals\ B \\ 0, if\ A\ is\ not\ equal\ to\ B \end{cases}$$ Where A and B are two terms (e.g. primary language)	

		personal circle
Partial Matching [Vosecky *et al.*, 2009]	Partial matching methods allow checking for matching in part of data fields $$S(C_1, C_2) = \sum_1^n w_i M(f_{iC1}, f_{iC2})$$ Where: $$M(A,B) = \begin{cases} \dfrac{length(B)}{length(A)}, & if\ A\ contains\ B \\ \dfrac{length(A)}{length(B)}, & if\ B\ contains\ A \\ 0, & otherwise \end{cases}$$ Where f_{iC1} is the i_{th} field of the user profile C1, W_i is the weight of the f_i element	Especially useful in: • Profile data given in the system by users themselves • Cases of missing data • Data which contain misspellings
Scales Matching [Nguyen & Nguyen, 2015]	Feature whose value can be expressed as a single number $$s_{ij}^k = 1 - \frac{|a_i^k - a_j^k|}{Max - Min}$$ Where: a^k is the feature Max, Mix of the value range	In cases of scale variables: • Age • Scale scores • Points earned from games • Birthdates
Fuzzy Matching [Vosecky *et al.*, 2009]	Complex data $$S(w_1, w_2) = \frac{\sum_{k=1}^{|w_2|} max w_2[1] \in w_2(Part(w_1[k], w_2[l]))}{max(|w_1|, |w_2|)}$$ Where: $Part(C_1, C_2)$ $$= max \begin{cases} 1, & if\ C_1 = C_2 \\ 0.5, & if\ C_1\ is\ an\ initial\ of\ C_2 \\ 0.5, & if\ C_2\ is\ an\ initial\ of\ C_1 \\ \dfrac{LCS(C_1, C_2)}{max\,[l(C_1), l(C_2)]}, & if\ LCS(C_1, C_2) \geq 3 \\ 0, & otherwise \end{cases}$$	In cases of complex logic: • Special characters (symbols) • Initials • Swapped wording (e.g. 'John Smith' and 'Smith John') • Additional words in fields • Zero similarity (e.g. completely different names should have similarity equal to zero)
Query-based Similarity Kim MC., Choi KS. (1999).	Jaccard Similarity: $J(A,B) = \left|\frac{A \cap B}{A \cup B}\right|$ $$S(q_1, q_2) = \frac{KN(q_1, q_2)}{Max(kn(q_1), kn(q_2))}$$ Where: Kn(): the number of keywords in a query KN(q$_1$, q$_2$): the number of common keywords in two queries	In cases of predefined terms: • Participation in common user groups and discussion rooms • Similarities in awarding performance (Badges)

Comparison of sequences	Shannon definition of entropy $$H(x) = \sum_{i=1}^{n} P(x_i)\, I(x_i) = -\sum_{i=1}^{n} P(x_i)\, log_b P(x_i)$$	Interaction action sequences: • Entropy of the interaction profile (sequence of interaction types)
Reputation Similarity	Where: b is the base of the used logarithm (e.g. 2, e, 10) H(x) is the entropy P(X) is the probability mass function	Find similarities in the position of users in the social network
Circle Similarity	Vector-based profile matching A high mutual contacts overlap (MCO) value means that user profiles share a lot of friends 	Applied in personal networks of friends and direct connections
Matching of interval of numbers [Nguyen & Nguyen, 2015]	Features expressed as intervals of numbers $$s_{ij}^{k} = \frac{2*(z_2 - z_1)}{(x_2 - x_1) + (y_2 - y_1)}$$ Where: $a_i^k = [x_1, x_2]$ and $s_i^k = [x_1, x_2]$ are two interval values of the a^k feature and $[z_1, z_2]$ is the intersection interval of the other two.	In cases of: • Duration of participation (e.g. total number of hours in the platform, or in a specific game) • Dates of registration • Game objectives measured as ranges (e.g. treatment adherence targeted ranges)
Ordered discrete numbers [Nguyen & Nguyen, 2015]	Similarity function for features given as a set of ordered discrete numbers (vectors) $$s_{ij}^{k} = 1 - \frac{\sum_{v=1}^{n}|x_v - y_v|}{n(Max - Min)}$$ Where: a_i=(x_1, x_2, … x_n) and a_j=(y_1, y_2, … y_n) are two vector values of the feature a of two objects I and j. The value in each dimension of the vector in limited in the range [Min, Max].	In cases of: • Ordered scale scores (e.g. neuropsychological tests)
Non-ordered	Similarity function for sets of numbers	In cases of:

discrete numbers	$$s_{ij}^k = 1 - \frac{1}{m}\left(\frac{\sum_{v=1}^{n}|x_v' - y_v'|}{Max - Min} + (m-n)\right)$$ Where: $a_i=(x_1, x_2, \dots x_n)$ and $a_j=(y_1, y_2, \dots y_n)$ are two set values on the a feature of two objects I and j n,m are the sizes of the sets The value of each element is limited in the interval [Min, Max].	• Similarity of user performance scores from different games
Set of Strings Comparison	Similarity function for sets of strings $$s_{ij}^k = \frac{2 * size_{ij}^k}{size_i^k + size_j^k}$$ Where: a_i and a_j are two sets of strings on the feature a^k, of two objects i and j respectively. $size_i^k$ and $size_j^k$ are the size of the set value of the features a_i and a_j.	In cases of: • Similarity of user's interests (e.g. hobbies) • List of tags attributed to articles authored or uploaded by users in the platform

After all similarities on each feature have been calculated based on the above table and after weights have been associated with each feature (**Table 15**), then the similarity between object I and j is then given by the formula:

$$s_{ij} = \sum_{k=1}^{n} w^k * s_{ij}^k$$

Where:

$\sum_{k=1}^{n} w_k = 1$, for weights.

Table 15. Matching methods to be used and use cases

Field Name	Data Type	Weight
Surname	String	0.02
Given name	String	0.01
Country	Short string (Country ISO identifier)	0.10
Registration date	Date	0.02
Role	Nominal String (M, F, O)	0.02
Gender	Nominal Char (M, F, O)	0.05

Age	Integer in the range [0..100]	0.02
Spoken language	Non-ordered discrete strings	0.05
Living status	Short int	0.05
Education	Short int	0.02
Computer Use	Short int	0.02
Hobbies	Non-ordered discrete strings	0.04
NDType	Short Int	0.05
Year of first diagnosis	Integer	0.05
Impairments	Non-ordered discrete strings	0.05
Self-managing treatment	Boolean	0.02
Groups membership	Non-ordered discrete strings	0.02
Social circle (Friends)	Non-ordered discrete strings (user ids)	0.05
Closeness centrality	Float	0.05
Eigenvector centrality	Float	0.02
Game names	Non-ordered discrete strings	0.02
Game points	Integer	0.02
Number of badges	Short int	0.01
No of tangible objects	Short int	0.02
No of posts	Integer	0.02
No of likes	Integer	0.02
No of reviews	Integer	0.02
No of article views	Integer	0.02
No of articles authored	Integer	0.02
No of scales taken	Integer	0.10
Scale scores	Non-ordered discrete numbers	0.02

5.6.6 The User Profile Classifier

The process of learning users by observing their interaction history is called user classification and the only correct way to model behaviour is by observation of user's interaction history [Gaikwad & Sane, 2014].

The classifier of user profiles in CMMD is performed just before the matchmaking and recommendations output. Measuring user profile similarity using the methods previously presented in Table 14 is a core requirement for matchmaking. The next step is to calculate the density of the user profile data that surrounds a certain user profile k by using the following equation [Gaikwad & Sane, 2014]:

$$D_k(Z_k) = \frac{1}{1 + \sum_{i=1}^{k-1} \frac{dist(x_k, x_i)}{k-1}}$$

Where k-1 is all the other user profiles in the platform, D_k is the density of the data (Z_k) that surrounds user profile k

This formula was simplified and calculates simply the distance instead of the square of distances because the data are represented by a set of positive support values. A new user profile is classified after its comparison with all the other user profiles in the platform. The smallest distance determines the higher similarity. Finally, the new user profile is classified to the class of a user profile prototype with closest similarity. The computational effort, as well as the time needed for calculations, depends on the number of user profiles available on the platform and the total number of user profile attributes (User profile data model as explained in D1.4

5.6.7 User Model

The user model (**Table 16; Figure 19**) was developed to enable the personalization of CMMD platform services. SHA-2 (Secure Hash Algorithm 2) is a set of cryptographic hash functions designed by the National Security Agency (NSA) and the SHA-256 is a novel hash function of the SHA-2 family consists of hash functions computed with 32-bit words.

Table 16. User Profile Properties and detailed description

Property	Description	Data Type	Nullable	Unique	Range
Personal					
User_Id*	A unique Identifier (auto-increment)	Longint	FALSE	TRUE	-
HonorificPrefix	Prefix for user names	String	TRUE	FALSE	0-8
SurName	Surname (family) name	String	FALSE	FALSE	8-64
GivenName	Given (First) name	String	FALSE	FALSE	8-64

Property	Description	Data Type	Nullable	Unique	Range
NickName*	A user identifier to appear in public	String	FALSE	TRUE	8-64
Email*	The primary email address of user validated by the RFC 5322 Section 3.2.3	String	FALSE	TRUE	8-64
Phone	Primary phone number including international code	String	FALSE	FALSE	0-24
Address	Full home or work address, including postal code	String	FALSE	FALSE	8-256
CountryCode	International country code validated by the ISO 639	String	FALSE	FALSE	2-3
SHA256*	Secure Hash Algorithm Code	String	FALSE	TRUE	256
SALT	The salt key for the one-way hashing of password	String	FALSE	FALSE	8
RegistrationDate	Date the user account was created validated by ISO 8601	DateTime	FALSE	FALSE	10
Role	Nominal expression of the user type (e.g. Caregiver)	String	FALSE	FALSE	6-24
Demographics					
Gender	'M' for Males and 'F' for Females. 'O' used for other or null.	Char	TRUE	FALSE	1
Age	Age in years	Byte	FALSE	FALSE	0-110
[PreferredLanguages]	List of languages of the interface and content (when possible). The first element indicates the primary preferred	Array of Strings	FALSE	FALSE	2-3 each element

Property	Description	Data Type	Nullable	Unique	Range
	language. Languages are validated by the RFC 7231 Section 5.3.5				
LivingStatus	Standardized choices validated by the PACT analysis questionnaire in D2.1	Byte	TRUE	FALSE	1-5
EducationLevel	Level of education validated by the ISCED 2011	Byte	TRUE	FALSE	0-8
ComputerUse	Subjective estimation of computer driving skills	Byte	TRUE	FALSE	1-3
Hobbies	Array of comma separated words or phrases	String	TRUE	FALSE	0-256
Medical					
NDType	Type (Level) of Neurocognitive Disorder validated by the PACT analysis questionnaire in D2.1	String	TRUE	FALSE	0-64
YearofDiagnosis	First diagnosis date in YYYY format	Number	TRUE	FALSE	4
[Impairments]	List of Impairments	Array of Strings	TRUE	FALSE	-
SelfManagingTreatment	Indicates if the person manages treatment on his/her own. Zero means treatment is made by caregiver	Boolean	TRUE	FALSE	1
[ScalesScores]	Array of pairs [psychological, medical and behavioural scales and scores]	Array	TRUE	FALSE	-
Social					
PrimaryCaregiver_Id	Id of the user who has	Longint	TRUE	FALSE	-

Property	Description	Data Type	Nullable	Unique	Range
	the responsibility of the caregiving. Negative values means no caregiver.				
[GroupsNames]	Array of objects: group names the user participates in and registration dates	Array of Objects	TRUE	FALSE	-
[Friends_Id]	Array of Id of other users who are directly connected to this user	Array	TRUE	FALSE	-
ConnectionDegree~	The number of nodes directly connected to this node (personal circle's size). Claculated based on the size of the [Friends_Id] list.	Integer	TRUE	FALSE	-
[Centrality]	Array of social network centrality metrics as triplet vectors of: [GroupName, CentralityType, CentralityValue] (See below for details).	Array	TRUE	FALSE	-
OtherSNMetric	Unused field for Social Networks	-	-	-	-
Gamification					
[GameNames]	Array of game objects the user participates in	Array of objects	TRUE	FALSE	-
Game Object		Complex object (Vector)			
GameName	Name of the game	String			
Points	Points earned	Integer			
[Badges]	Badges earned	Array of objects			

Property	Description	Data Type	Nullable	Unique	Range
[Privileges]	Privileges earned	Array of objects			
TotalPoints~	The sum of all points earned in all games (wallet)	Integer	TRUE	FALSE	-
[TangibleObjects]	Array of pairs: object name and quantity	Array	TRUE	FALSE	-
Interaction					
NoOfPosts	Number of message posts	Integer	TRUE	FALSE	-
NoOfLikes	Number of Likes	Integer	TRUE	FALSE	-
NoOfReviews	Number of Reviews	Integer	TRUE	FALSE	-
NoOfArticleViews	Number of articles viewed by the user	Integer	TRUE	FALSE	-
NoOfArticleAuthored	Number of articles authored by the user	Integer	TRUE	FALSE	-
NoOfScalesTaken	Number of Scales taken by the user	Array	TRUE	FALSE	-
Other					
UnusedField1	For future use	String	TRUE	FALSE	-
UnUsedField2	For future use	String	TRUE	FALSE	-
UnUsedField3	For future use	String	TRUE	FALSE	-
UnUsedField4	For future use	String	TRUE	FALSE	-

~ Those fields are products of other fields

A type is said to be nullable if it can be assigned a value or can be assigned null, which means the type has no value whatsoever.

The user profiles will be exported and shared between the platform components according to the JSON API (JavaScript Object Notation (JSON) [RFC7159]) latest specification (v1.0) (can be found on http://jsonapi.org/format/).
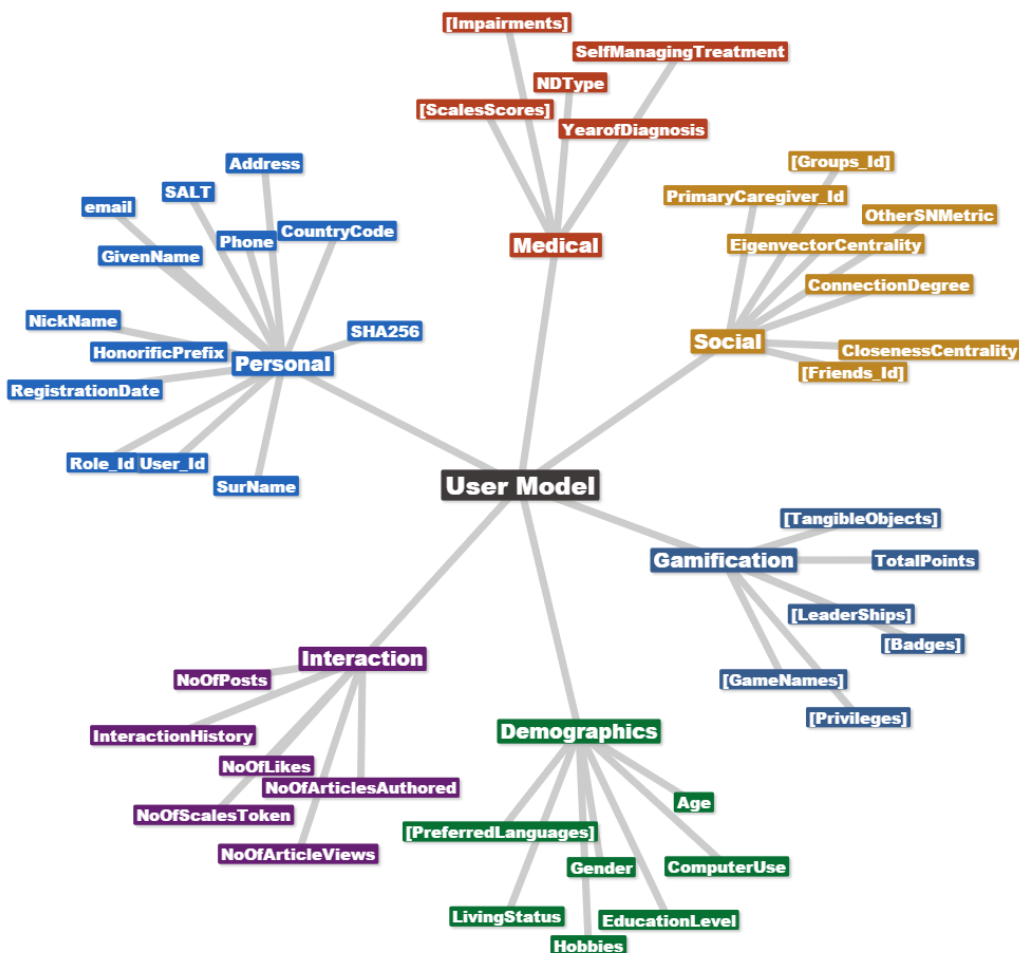
Figure 19. The User Model of CMMD

5.6.8   Recommendations based on User Conditions

We need to identify which conditions are relevant to the patient and define the adaptation strategy for each condition. Accessibility experts can use a tool like the one presented in the following image in order to make connections between the health conditions and disabilities to specific UI adaptation rules. The right part of the screen will be used to define values for each of the supported UI style variables like font sizes, colours, etc. as explained earlier.

Moreover, a short report on the history of rule-creation will be offered to people who will responsible for maintenance of the UI adaptation rule-set (lower part of the screen). Those rules will be based on the international accessibility guidelines and the contents of the D1.1 deliverable (Accessibility Report. but will be standardised after statistical analysis of the data collected during the pilot studies.

All the data collected using this method will be expressed into a computer-readable format (JSPN Object) used to feed the rule-based matchmaker. The final output will be further processed by the hybrid matchmaker and finally a settings file will be posted to the CMMD platform to update the UI according to the medical status and disabilities of each individuals.

Figure 20. Design example for making rules to connect medical conditions with UI adaptation rules

5.7   Implementation

The human centred approach for UI adaptation implies with the Accessibility report (D1.1), the DIN EN ISO 9241-210 standard, the IMS Learner Information Package Accessibility for LIP Information Model, the ISO/IEC 24751-1:2008 and the CEN EN1332-4 standard. In addition, the Section 503 of the Rehabilitation Act was taken into consideration.

5.7.1 High Impact Variables

A set of adaptable user interface variables have to be defined in order to be the basis for preference set parameters. The customization component must be clearly defined and separated by the personalization component. It should be noted that although customization will have a relatively lower UI adaptation strength compared to personalization, it will have a higher priority. That means that if the system recommends a specific font size for the interface of a user with visual disability and the user has set a bigger font size in his/herself personal preference, then the UI adaptation should respect the personal preference. For the vice versa the system could ask the user for confirmation.

Having in mind that the set of adaptable user interface variables could be easily become very large and unmanageable, it is important to keep the size small enough. Those predefined set of adaptable user interface variables will be managed in the settings page (preference management editor) by visual controls like up/down menus, sliders, combo-boxes selectors etc. In general, there are two major groups of adaptable user interface variables:

- Variables used to maximize user satisfaction: PACT analysis findings reported in D2.1 can provide valuable information in selecting those variables. In addition, user interviews during the pilot testing will confirm and extend this set.
- Widely accepted accessibility guidelines, as well as the accessibility report (D1.1) is the main source for selecting the user interface variables related to accessibility.

According to the above process we concluded in the list presented in **Table 17**. Those variables will ensure that the UI will be better to see, feel and interact.

Table 17. Adaptable user interface variables

User Satisfaction	Accessibility
Colour Theme	
Background color	Background color
Font Color	Font Color
Opacity	{No opacity}
	Text highlight color
	Cursor pointer color
	Link color
Images & Icons	
Images min-width	Images min-width
Images min-height	Images min-height
	Cursor pointer size
	Icons size
	Scrollbar size
Text & Paragraph	
Font family	Line height (line spacing)
Regular text font size	Regular text font size
H1 heading size	H1 heading size
H2 heading size	H2 heading size
H3 heading size	H3 heading size
H4 heading size	H4 heading size
Magnification	
	Zoom
Miscellaneous	
Background image	Background image
Background repeat	Animated cursor

Additional Content visibility	Additional Content Visibility
Language (En, Esp, It)	Language (En, Esp, It)
Form of reminders	Form of reminders
	Custom cursor
	DOM element selection highlight
	CSS animations off

The above list will be used as the set of variables used to make UI of the CMMD platform accessible and adjustable to user profiles and personal preferences. In general, manual adaptation drives customization, while automatic adaptation drives the personalization and both will work together in order people with disabilities to be able to perceive, navigate around and interact with the content of the platform. Platform accessibility and personalization will benefit others, including elderly people (PLWD or caregivers) who may have changing abilities due to age-related perception issues. In addition, selecting the wished form of reminders will help in adjusting the settings of the notifications component. Few optimal options appear to be:

- popup windows to appear within the platform at run-time
- email notifications in registered emails
- SMS to mobile phones

The output of the personalization component in either care will be a collection of adaptable user interface variables structured as a JSON object. This will be send to the CMMD platform to adjust the UI dynamically. Technical details on how to call the personalization component is presented in D3.2.

5.7.2 Customization and Personalization Process

A screen-flow example of how personalization and customization is working is presented in **Figure 21.** After user registration it will be checked if the user has a complete user profile. This step is mandatory for taking the personal information into account and apply the accessibility rules (rule-based matchmaker). Next, personal preferences are collected in order to have a set of values for UI adaptation variables of higher priority. The final outcome will be a computer-readable file which will contain the settings for the personalized UI adaptation.

5.7.3 The Personalization Component Architecture

The matchmaker is built on a lightweight distributed architecture in which stateless RESTful (i.e. HTTP-based) services exchange data in the JSON format. All preferences are stored and retrieved from a Preferences Server. This server will update user personal profiles on demand (to be consumed by any other CMMD component) and will send recommendations for UI, game and content adaptation to the CMMD platform as seen in the following figure.
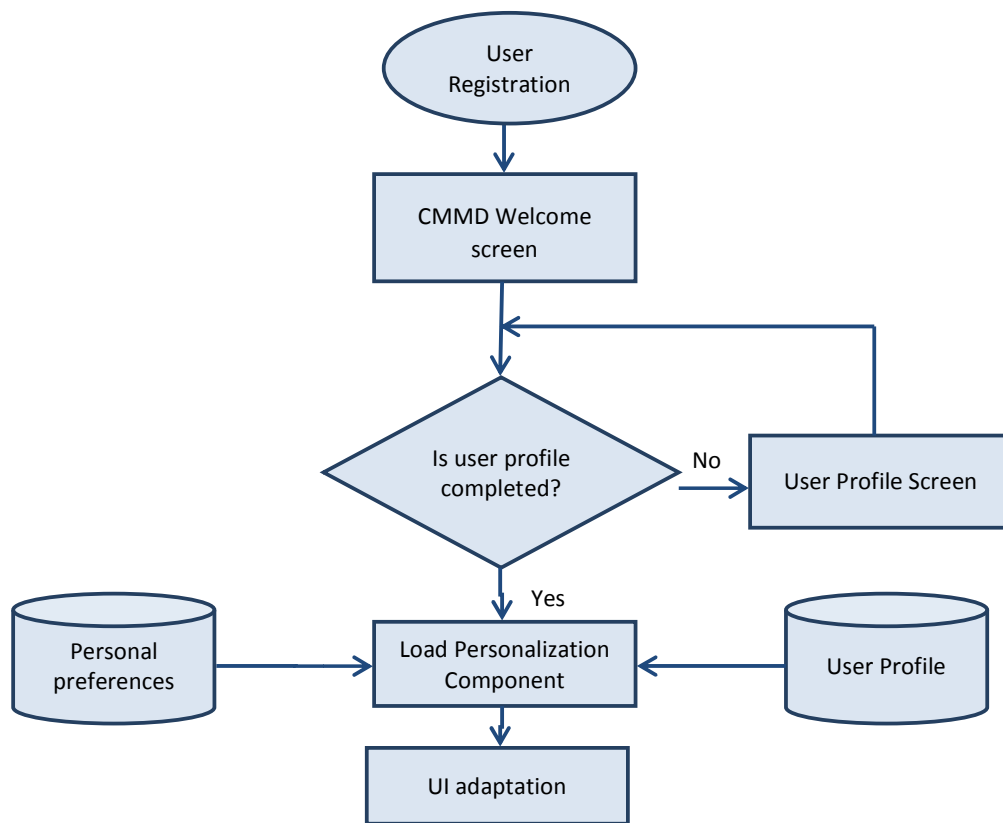
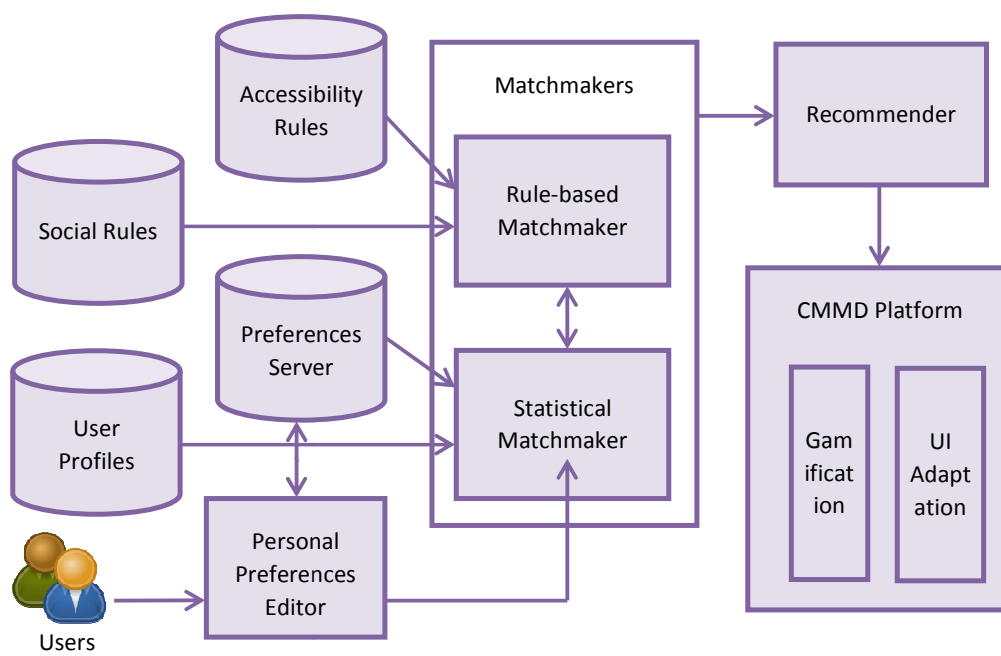**Figure 21.** The UI and content adaptation as result of the personalization component

Figure 22. A lightweight architecture for the Personalization Component

The Personal Preferences Editor

Users will be able to insert their personal preferences using the customization editor in which UI elements will represent the adaptable user interface variables. The editor will both inform users about the current settings and will accept new values for the adaptable user interface variables if wished. The variables will be presented in groups and will be explained with clear human readable comments. The preference settings will be saved in the CMMD server along with the rest profile information.

It is important to note that in order to have a starting point, a default set of preferences will be applied at the time of registration. Those default values will be presented at the first time the user opens the personal preferences editor. Those default settings can be different for each user group and also in case of mesh or inappropriate settings, the user will be able to restore default settings and select his/her personal settings form the beginning. A save button will validate settings, will save personal preferences in the CMMD server and will apply settings. An example of the editor can be seen in **Figure 23.**
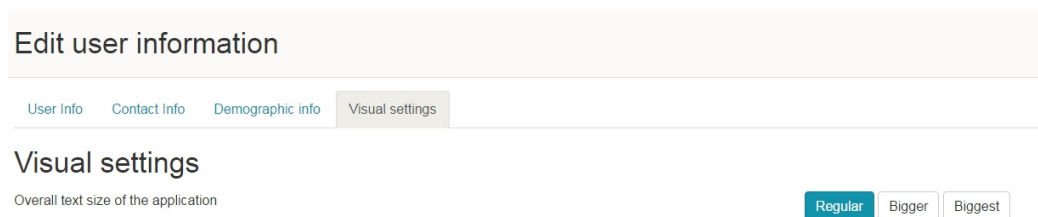
Figure 23. Main screen example of the personal preferences editor

An important feature in the personal preferences editor is the Preview Area (according to the WYSIWYG principle). This is a mock area used to display the current settings before they are saved and applied in the platform. This preview functionality will demonstrate expecting UI changes and will maximize the user's confidence on their own settings.

Internal & External Formats of the Preferences and Recommendations Data

The internal format of the personal preferences and the recommendations data will consist of a name-value pairs set saved as an .ini file. The .INI file format, as an informal standard for configuration files, are ASCII files with a very basic structure composed of sections, properties, corresponding values and commends (optional and ignored by the machine). There will be no hierarchy of sections within sections (**Listing 1**).

```
; This file is in the UTF-8 encoding
[Colour Theme]
Background-color   = rgb(10,10,10)
Font-color = rgb(0,0,0)
Opacity = 100%
Text-highlight-color = rgb(0,255,255)
Cursor-pointer-color = rgb(255,255,0)
Link-color = rgb(0,255,0)

[Images & Icons]
Images-min-width = 200px
Images-min-height = 200px
; Cursor size in range [0.0 – 1.0]
```

```
; where
; 0.0 = "standard"
; 0.5 = "large"
; 1.0 = "extra large"
Cursor-pointer-size = 0.5
Icons-size = 50px
Scrollbar-size = 2em

[Text & Paragraph]
Font-family = Arial
Line-spacing = 130%
Regular-text-font-size = large
H1-size = normal
H2-size = normal
H3-size = normal
H4-size = normal

[Miscellaneous]
Magnification = 150%
Background-image = url(somepath/somefolder/bg.jpg)
Background-repeat = yes
Animated-cursor = no
Additional-Content-visibility = yes
Language = It
Custom-cursor = url('some-cursor.ico')
DOM-element-highlight = yes
CSS-animations = off
```

Listing 1. Internal representation of personal settings and automatic styles recommendation

The internal format (INI format) for name-value pairs will be used by the statistical matchmaker. The result of the personal preferences and the automatic CSS recommendator will use the following JSON format for output (presented in **Listing 2**) which actually describes the same data. To be noted that commends are not allowed in the JSON format, so they will be skipped when converting the INI settings into a JSON object. In contrast, the INI format can entirely represent the JSON format.

```
{
  "User Logon Page": [{
    "value": {
      "Background-color" = "rgb(10,10,10)",
      "Font-color" = "rgb(0,0,0)    ",
      "Opacity" = "100%",
      "Text-highlight-color" = "rgb(0,255,255),
      "Cursor-pointer-color" = "rgb(255,255,0)",
      "Link-color" = "rgb(0,255,0)",
      "Images-min-width" = "200px",
      "Images-min-height" = "200px",
      "Cursor-pointer-size" = "0.5",
      "Icons-size" = "50px",
      "Scrollbar-size" = "2em",
      "Font-family" = "Arial",
      "Line-spacing" = "130%",
      "Regular-text-font-size" = "large",
      "H1-size" = "normal",
      "H2-size" = "normal",
      "H3-size" = "normal",
      "H4-size" = "normal",
```

```
        "Magnification" = "150%",
        "Background-image" = "url(somepath/somefolder/bg.jpg)",
        "Background-repeat" = "yes",
        "Animated-cursor" = "no",
        "Additional-Content-visibility" = "yes",
        "Language" = "It",
        "Custom-cursor" = "url('some-cursor.ico')",
        "DOM-element-highlight" = "yes",
        "CSS-animations" = "off"
      }
   }]
}
```

Listing 2. Example of user's CSS settings

Transaction Messages

The connectivity between the personal preferences editor and the CMMD platform will be in the JSON API format. A CSS to JSON Converter for JavaScript can be used (like the https://github.com/aramk/CSSJSON) to transform the personal settings.

The Statistical Matchmaker

Traditionally, the typical approach for a statistical matchmaker is to exploit existing information related to user profiles and personal preferences in order to propose settings which can maximize user acceptance and minimize the need for manual changes in the personal preference settings.

The statistical matchmaker identifies similarities between sets of preferences coming from user profiles which have a limited distance to the current user profile. The expected outcome is a set of game and content preferences, style (UI) preferences and/or textual recommendations for a certain user based on what other similar users expressed as their personal preferences. Similar user profiles are being identified by the distance functions declared in **Table 14**.

The matchmaker which is based on statistical analysis takes as input two important factors that can influence its performance: a. the summary of the personal preferences of all the existing user profiles and b. the statistical methods and algorithms to be applied on this data.

A statistical matchmaker requires limited human maintenance, but it may perform poorly if limited information is available. In this case the critical mass of active users may not have been achieved and thus, the available number of personal preference sets is limited.

In the core engine of the statistical matchmaker will be a set of machine learning algorithms. In addition, it will be required that those algorithms should be adaptive to the running scenarios and also be capable of handling a large number of personal user preferences and use contexts.

The Hybrid Matchmaker

Other non-functional requirements include the consideration of individual user conditions. A successful adaptation after recommendations can improve user satisfaction, the consumption of CMMD services on offer and for longer times. However, there are negative

aspects possible caused by mismatches between the wished content and settings and the personalization recommendations produced by the matchmaker. Negative consequences can be caused by such mismatches with inability of the user to performed tasks being the worst case. Thus, content, gamification and UI adaptation settings/recommendations should guarantee that every use of the CMMD platform can manage tasks. Secondary, the matchmaking process should result in a set of settings/recommendations that do not disorientate, distract or frustrate users.

Functional requirements for the hybrid matchmaker include the implementation of different matching techniques to address different matching problems. Both matchmakers (rule-based and statistical) will be general –purpose matchmaking engines for finding optimal solutions to given user's needs and context of use.

Finally, the results of the statistical matchmaker with be compared with those of the rule-based matchmaker in order to unify results, to resolve possible conflicts and make final decisions. The outcome will be transferred to the platform for content, gamification and UI adaptation.

5.7.4 The matchmaker Input and Output Data

The main input for the hybrid matchmaker is the user class (type like caregiver for example) and a set of user preferences. The profile similarity calculator will have previously given a maximum distance (similarity value). All user profiles which satisfy those two requirements will be taken into account:

  a. Have distance to the given user profile less than the maximum distance, and
  b. Have been completed at a degree higher than the minimum allowed

In other words, similar but completed user profiles should be given to the hybrid matchmaker in order to generate recommendations. Following ISO/IEC 24751 CMMD proposes a set of user preferences delivered as a flat ordered list of user preferences. This flat ordered list is defined by the following triple: a. property, b. value and c. condition. The property is an identifier associated with a style, game or content specification. The value is a numerical or textual expression for the property and the condition describes the used context (the social or physical context in which the preference is valid). To be noted that some properties are meaningful only within the context of a specific module like the *CMMD-Home*. For example the recommendation may be like this: *Let the font size to be 20pt during the day, but after evening let it be 16pt when in CMMD-Home mode.*

The previous example describes the property font size under different time-zones and user-controlled modes. The recommendation for 20pt font size is valid for the time condition 06.00 to 18.00 under all modules apart from CMMD-Home (based on his/her manual setting on mode). The alternative recommendation for font size is 16pt for the time zone 18.00 to 05.59 while the user is at home where the reading glasses are always available.

```
{
  "type": "font-size",
  "settings": [
    {
      "value": "20pt",
      "conditions": [
```

```
        {
          "type": "time",
          "values": [
            "06.00.00",
            "17.59.59"
          ]
        },
        {
          "type": "modules",
          "values": [
            "CMMD-Mobile",
            "CMMD-ForAll"
          ]
        }
      ]
    },
    {
      "value": "16pt",
      "conditions": [
        {
          "type": "time",
          "values": [
            "18.00.00",
            "05.59.59"
          ]
        },
        {
          "type": "modules",
          "values": [
            "CMMD-Home"
          ]
        }
      ]
    }
  ]
}
```

Listing 3. Example of recommendation output

5.7.5 The Matchmaking Process and Scenarios

The matchmaking process is straight forward: after receiving input, it is required to best match the target context of a user with the preference set. Consider the example scenario presented in Listing 4. This scenario presents the need to combine user preferences, both matchmaking types and finally recommendations on the platform content, on the gamification component, accessibility and the UI adaptation.

```
John is a 65 years old Englishman and he is giving care to his
wife who is 62 years old and recently she was diagnosed with
MCI in 2015. The couple have two children but both they are
living with their families in London and can visit them once in
a few months. The couple enjoy cooking and playing card games
with a few friends and neighbours.

The couple do not know enough about MCI conditions and progress
and both they face difficulties in using a tabled or other end-
```

device because of their visual problems. In addition, John has
acoustic problems in the one of his year.

Although his wife conditions are not severe, John is quite
stressed about the situation and he worries about the future.
Doctors think that he is at high risk of depression.

John was registered in the CMMD platform a couple of months ago
(October, 2016) and he became a member of three caregivers
clubs (groups) within the platform, but he actively
participates in the 'HULL Care Group' –a local group– mainly
because he knows some people there in person. He afraid of not
being able to provide care to his wife and he expect to find
answers in the learning content of the platform and in
discussions with other caregivers.

John is able to read test in the tablet under daylight when the
font size is 20pt or higher. The effects of his low vision are
lowered in the night or in dark environments and he can read
text in smaller font size like 16pt when in home where his
reading glasses are always available.

The personalization component found out that similar user
profiles choose a white font colour over a dark background
after evening. The recommendator will finally mix John's
personal preferences (customization) with the results of the
matchmaker in order to propose a user–accepted solution that
maximizes comfort in reading test in the tablet.

The second field of intervention for the personalization
component is the content. According to John's profile, a new
game with learning objectives (caregivers training) is
proposed. Thus a new message appears in his personal wall and
in the recommendations area. In addition, more articles related
to MCI conditions and the risks of progress to Dementia are
coming up as recommendations in his personal wall.

Listing 4. An indicative scenario based on the user profile of Listing 1.

6 Overall Conclusions

This deliverable has successfully established the necessary strategy for the design of the
CMMD platform and its components, including the gamification, the treatment adherence,
the personalisation and the interface adaptation components. The contents of this
deliverable touches the major functionalities of the CMMD platform and outlines the desired
user experience. This was achieved by benchmarking and state of the art on relative to
CMMD standards, design guidelines and recommendations. After summarizing the outcomes
of the T2.1 task, a systematic review on similar platforms was performed at first to give an
overview of the existing functionalities for elderly people and for PLWD when possible. Next,
an extensive overview of the gamification elements was presented in order to evaluate them
against the objectives of the CMMD. The age of the target populations, as well as their
medical conditions were taken into account before carefully design the gamification

mechanics to be used as motivators for the CMMD users. The gamification engine (back-end), as well as a gamification concept, design elements and layouts of the front-end were described in detail.

In order to better inform the assessment of an intervention, determine influences on adherence to treatment in PLWD and identify user's requiring education or support to improve medication use, the treatment adherence concept was introduced. Moreover, the sensing of the treatment adherence was defined according to numeric approach (Adherence MMAS-4) in order to be connected with other CMMD components like the gamification (e.g. give awards for a good treatment adherence bevaviour) and the clinical reporting component described in the deliverable D1.5.

The Personalization and UI Adaptation concepts came later as an answer of the CMMD to the requirements for accessibility and adaptation of both software and contents. A hybrid matchmaker lies behind the mechanism used to combine all available resources like the user's profiles, personal preferences and heath conditions to provide recommendations for UI adaption. Moreover, additional dimensions of the personalization concept were provided in relation to other CMMD services like the gamification (personalized gamification recomendtions).

Overall, the processes and mechanisms outlined in this report reflect the CMMD spirit to make the foreground as accessible and usable as possible. The concepts, methods and design ideas are to be integrated into the CMMD platform according to the tasks described in WP3. As this is the first version of the Customization Guidance Document, all future work to be done will be reported in the second version of the deliverable (D2.3) to be delivered by M24.

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ANNEX A: CMMD Gamification Elements

In this annex, a description of the used gamification structures is presented. The gamification tables and properties are described in the first section. An application programming interface (API) was developed, as a set of calls for building the gamification functionality and applications.

User (user_id, username, password, firstname, surname, role_id, account_creation_date)

User_Game_Status (gstatus_id, user_id, ADC, social_network_points, communication_points, scales_points, avatar, badges, team_memberships)

Comments:

Avatar can be in one of the following states: happy, normal, sad, weak

User_Medical_Status (mstatus_id, user_id, disorders, medication)

Comments:

-Disorders is a set of ordered Boolean indicators:

- Vision Disorder [0 or 1]
- Acoustic Disorder [0 or 1]
- Motor Disorder [0 or 1]
- Cognitive Disorder [0, 1 or 2]

e.g. a person with Mild to Moderate Cognitive Disorder with non-corrected vision problems is referred as: '1002'

User_Personal_Profile (profile_id, user_id, role_id, age, gender, language, medical_status, work_status, education_level, people_in_household, living_status, job_title, PLWD_responsible_for, caregiving_place, years_of_prof_exp)

Comments:

-Properties not applicable remain null, e.g. years_of_prof_exp for a patient

Role (role_id, description)

Comments:

Role types are derived from user categories:

- Patient_Mild_ND
- Patient_MildtoModerate_ND
- Caregiver
- Medical_Professional

- Helper
- Social_Worker

Metrics (metric_id, metric_name, metric_type, description)

Comments:

The following metrics will be used:

- Social_Points
- Communication_Points
- Scales_Points
- Total Points*
- Social_Badges (sized_social_network_badge)
- Communication_Badges (active_neuron_badge, inactive_neuron_badge)
- Performance_Badges (treatment_adherence_badge)
- Overall_Avtivity_Badges (champion_neuron_badge, normal_neuron_badge, weak_neuron_badge)

* Will be computed based on the previous point metrics

Group (group_id, group_name, group_description, group_creation_date)

Comments:

Some team types will be predefined like those which group together all user categories:

- People with Neurocognitive Disorders*
- Caregivers*
- Medical_Professionals*
- Helpers*
- Social_Workers*

Some other team types are created by users:

- Personal circles (identified by patient's id)
- Café (all Café users)
- Café table (sub-group)

Finally, two additional user teams will be global:

- Local_Region (country and language)*
- Community (all cmmd users)*

* System-generated invitation after registration

Group_Status (tstatus_id, team_ADC, team_social_network_points, team_communication_points, team_scales_points, team_icon, team_badges)

Comments:

Each team has a team status updated every day

Rules (rule_id, rule_name, rule_tag, rule_metric, requirements, action_id)

Comments:

- Team inclusion criteria
- Rewarding system (Badges and points)

Leaderboards (lboard_id, lboard, name, lboard_description, lboard_metric)

Comments:

The following Leaderboards will be supported (leaderboard metric in parenthesis):

- Total_Personal_Activity_Leaderboard (higher scores in collected points)
- Total_Group_Activity_Leaderboard (higher point scores in social groups)
- Greatest_Personal_Social_Networks (number of connections per user)
- Greatest_Group_Social_Networks (number of connections per social group)
- Highest performance scores in various scales (treatment adherence, psychological and medical scales)
- Personal_Wall (collected points, number of social connections, names of groups involved, scales performance)
- Group_Wall (group collected points, group size, group badges, average group scales performance, group logo and mission statement)

Invitations (invitation_id, invitation_title, invitation_text, sender_id, receiver_id, invitation_date)

Comments:

-Invitations can refer to:

- Invitation to join a personal circle
- Invitation to join a team

-When the invitation will be send from the AI, the sender_id will be 'system', otherwise it will be a user_id.

Missions (mission_id, mission_type, mission_title, mission_text, sender_id, receiver_id, start_date, end_date, mission_metric, mission_objective, mission_creation_date)

Comments:

Missions will be created by abstract mission types which will be personalized before posted to PLWD and caregivers:

- Grow your network (make X new connections)

- Share your ideas with others and be more active in conversations (X posts per week)
- Improve your Treatment Adherence (PDC over 80%)
- Improve your Scales (X scale by Y points or percentage)*
- Complete your profile (by XX%)

* All missions are mandatory expect scales improvement which is optional and it is made after invitation or proposal of a mission

Actions (action_id, action_type, description, mission_id, metric_id, timestamp)

Comments:

-Action Types:

| Action name/type	Action description
User's initiated actions	
Search user profile	Search for someone on the social network (formulate a search string, apply filters on results, apply tags, update search, save search)
Search article	Search for an article on the platform contents (formulate a search string, apply filters on results, apply tags, update search, save search)
Search post	Search for a post on a discussion room (formulate a search string, apply search string on results)
Make contact invitation	Invite someone in your personal circle or team (invite_id, user_id or team_name)
Accept contact invitation	Accept invitation
Reject contact invitation	Reject invitation
Send message	Send a private message or broadcast a message to a circle, a team or the whole community
Develop profile	Give profile information
Share profile	Share profile information
Share achievements	Share profs of achievements and outstanding performance
Cash out	Cash out points in Personal Wall (buy medals, badges and accept gifts)
Create group	Create a new team/group of users and share a common identity

Make invitation to join a group	Invite someone to join your personal circle or shared group
Apply to join a group	Ask the group leader to be part of the community of users
Accept membership invitation	Accept an invitation to be part of a community
Reject membership invitation	Reject an invitation to be part of a community
Propose a mission	Propose to someone else to take a challenge for a template-based mission. This includes personalization of a mission for someone specific.
Accept a mission	Accept/Undertake the challenge for a mission
Reject a mission	Ignore/Reject the challenge for a mission
Give a test	Give a neurophychological test, take part in a survey or medical scale
See Leaderboard	Check the status of a leaderboard
See Personal Wall	Check your Personal Wall
Vote	Give vote to a person, an article, a post
Gallop	Answer to a gallop question
System initiated actions	
Authenticate user	
Get user's profile	
Search, find and propose OTHER USERS with similar profiles (weekly)	
Give award/apply rule	Award users based on their interactivity, achievements and performance (rewarding system) or apply other known community rules.
Update team's status	Update the status of a team and share achievements with others
List members	List all members of a team (team_id)
Discard someone (kick off) from a team	Discard member from a team (user_id, team_id)**

* After invitation by the AI or other user

** creator of the team only

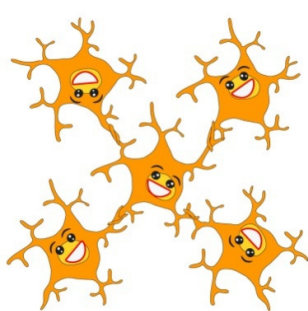# ANNEX B: Gamification Visual Elements

This is a collection of icons and images created to be used in the CMMD gamification component, either as initial user's avatars, or as icons for gamification titles (icons to accompany game titles in the game-master's front-end).
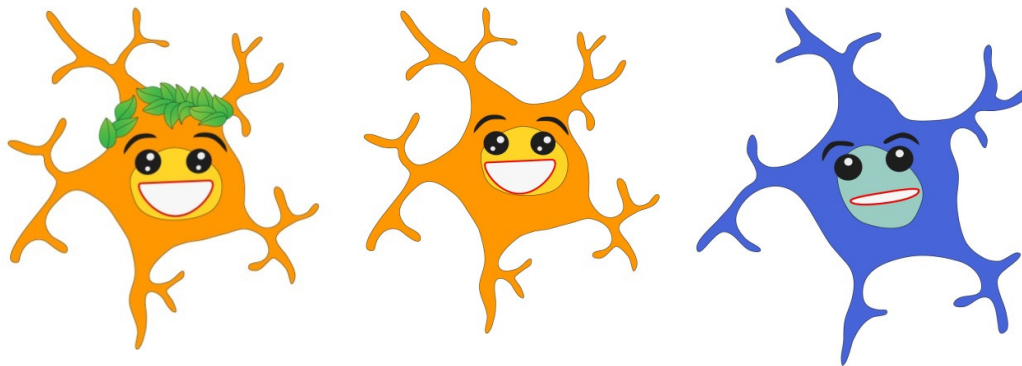
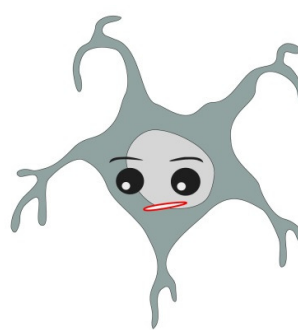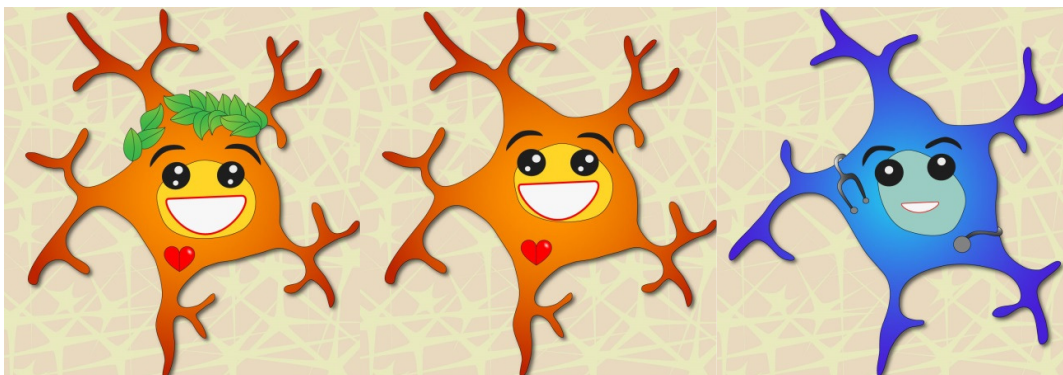| a. Champion | b. Happy and strong Neuron | c. Normal Neuron (Initial state) |

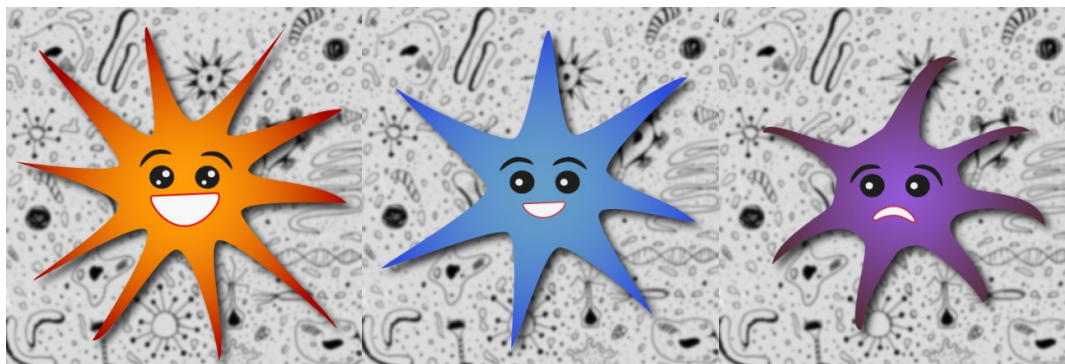| d. A Neuron network | e. Sad Neuron (inactive for more than 2 weeks) | f. Weak Neuron (inactive for more than one month) |

Figure 24. Avatar states (Neurons) according to the user's activity in the platform

a. Champion

b. Happy and strong Neuron

c. Normal Doctor Neuron (Initial state)

d. A Neuron network

e. Weak Neuron

f. Inactive neuron

Figure 25. More avatar states

a. Champion

b. Happy and strong Neuron

c. Normal Doctor Neuron (Initial state)

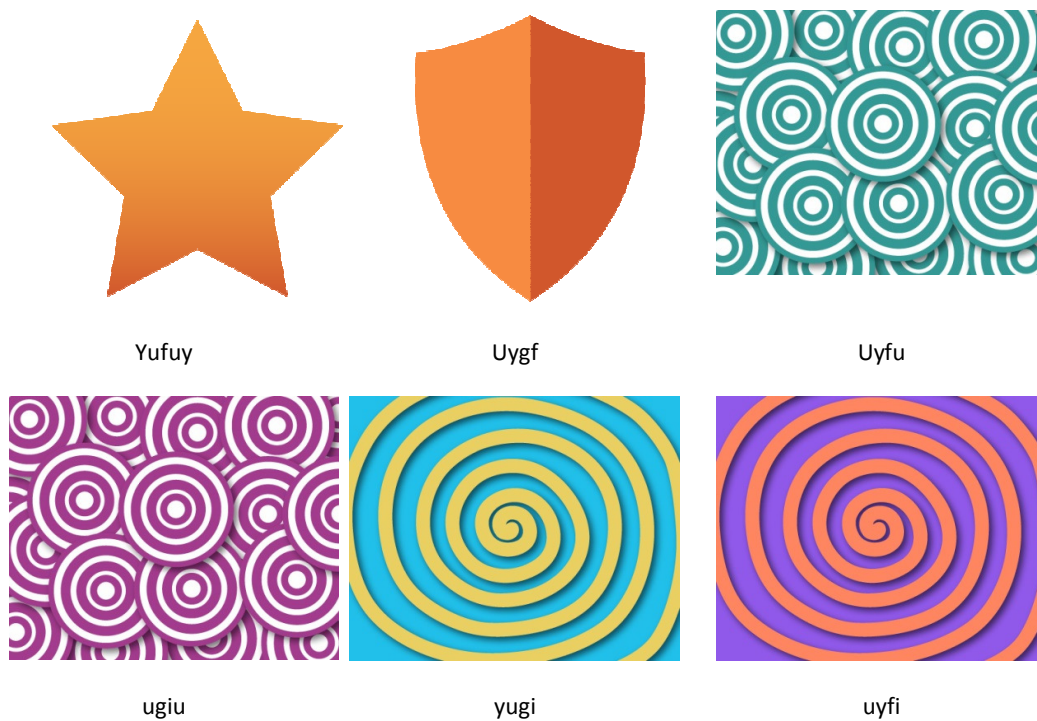
d. A Neuron network

e. Weak Neuron

f. Inactive neuron

Yufuy

Uygf

Uyfu

ugiu

yugi

uyfi

Figure 26. Badges and abstract themes to be used for gamification icons