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A FRAMEWORK FOR DEVELOPING USER-BASED ADAPTIVE GAMIFIED SYSTEMS

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ABSTRACT

Gamification, which is the use of game elements in a non-game context, has become a trend in many industries. It is used as a means for motivating and engaging users and influencing their behaviors. Thus, during the last few years, many researchers have attempted to find a way to design and implement gamified systems that are adaptively personalized based on user types. This paper proposes a framework that aims to aid software engineers in systematically designing adaptively personalized gamification applications of any context type by adapting the appearance of gamification elements based on each user type. The framework introduces a method that provides a systematic means to modify the system at runtime (i.e., while the system is in use) based on the user's preferences and behavior by changing the existing elements based on the usage of each user. The researchers validate the proposed framework using a case study conducted with employees of a large-scale software development company. By applying all their practical comments, the methods of the proposed framework were enhanced. Moreover, to formalize the proposed framework the researchers develop an ontology that implements the mappings between game elements and user types by defining rules that govern their usage. In this paper, an ontology validation is presented including the use of Reasoner, Instances, SPARQL queries, and requirements model implementation. Also, a sample prototype is presented on one of the most used applications and show how the researchers apply this framework to it.

Index Terms: *Gamification; Adaptive Gamification; Software Development; User-based Adaptation; Game elements.*

I. INTRODUCTION

In 2010, the term "gamification" was coined in the software industry, and it was quickly recognized as one of the most important trends in software engineering [1]. The implementation of game design features in non-gaming environments is known as gamification. [2]

There are various advantages and benefits to incorporating gamification into

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software systems. It improves end-user happiness and participation. It also inspires people to finish daily and tedious tasks with zeal. Many businesses and organizations are gamifying their systems to give their staff and users a better experience.

Not all users have the same types and approaches for completing tasks/goals in different circumstances. In other words, in the software development field, the "One size fits all" approach of typical gamification no longer works because different people are motivated in different ways utilizing distinct mechanics and dynamics tailored to their requirements and personalities [3] [4].

Personalization of software systems based on user types is one of the most investigated subjects in gamification literature nowadays [5] [6] [7] [8] for a variety of disciplines (e.g. health [9], learning [10] [11], crowdsourcing [1] [9] and Enterprise Information Systems [1]). Traditional software design requirements can no longer be used to create gamified software applications since gamification must search for what motivates the software's intended users. [2] [12].

Most of the researchers applied their frameworks with the concept of "One size fits all" by using the same elements for all types of users. This way does not suit the design of a fully personalized system which is not motivating because users do not have the same thinking and same behavior, especially regarding the gamification elements [3].

The "Design principles for designing gamified software" outlined in the prior literature was one of the attempts made and described in [2]. The offered ideas, on the other hand, did not integrate software customization notions in a way that allows software engineers to create an adaptable gamification system depending on user types.

In addition, numerous studies in the literature have attempted to personalize the gamification elements, such as in [5] [6] [7] [8]. However, they only consider how to adjust game mechanics and dynamics such as the value of the points a user may earn, the suggestions the system can make to each user, and the reward process. There is no mention, however, of how the software can regulate the elements that show to different user types.

Also, the adaptive gamified system is one of the top research topics nowadays. Lots of the researches created frameworks for very specific kinds of systems which cannot be used as a general idea for the different fields and contexts.

Some researchers applied their proposed framework in real-life work environments from the user perspective and not from the software engineers perspective as it lacks comprehensive details and clear guidelines on how they can use it to design a gamified software system and how to make it adaptive on runtime neither how it can adapt the gamification elements based on the user types.

Thus, there is still a lack of systematic methods that can be used by software engineers to design dynamic adaptive software that can customize the elements that appear to the users based on the different user types and how to measure the rules of adaptivity.

Ontology makes the computer understand the language or logic as much as the human does by having definitions of basic concepts in the domain and relationships

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among them. The reasons to have Ontology are to share the same understanding of concepts, to be available for new users to learn those concepts, and to define the data and structure to be used in the future as domain knowledge. The ontology is simply a model of reality [13].

The existing ontologies in gamification were implemented to a limited basic level as they missed lots of relations between the concepts and missed the rules that govern the software engineers how they use those concepts and how they apply the mappings between user types with the game elements [14].

This paper is organized as follows: Section two represents the "Literature Review" and discusses the gamification applications, elements, user types, gamification frameworks, adaptive gamification, and existing gamification ontologies. Then, section three explains one of the user-based adaptive gamified frameworks that the researchers adopted with an explanation of the main extended blocks. Section four explains the interviews with actual engineers in the industry to enhance the proposed framework and test its validity when applied in practice. Section five represents the results of the interviews and represents the enhanced framework according to the interviewees' comments. Section six represents a demonstrated Proof of Concept (POC) application resulting from the study and evaluation. Section seven explains in detail the ontology implementation and evaluation using instances, Reasoner, and the SPARQL queries which were developed to demonstrate the usefulness of the implementation and demonstrating how it can extract knowledge that can aid software engineers in making more informed design decisions. Finally, section eight concludes the research validation, and discusses its contributions and possible future directions.

II. LITERATURE REVIEW

This section provides a background on the concepts of "Gamification", "Gamification elements and User types", "Gamification Frameworks" and "Adaptive Gamification". Also, the related works of the previous "Gamification Frameworks" and previous "Gamification Ontologies" research related to the proposed framework are presented and give an idea of the efforts of previous researchers and what the gapes in their work are.

A. GAMIFICATION DEFINITIONS AND APPLICATIONS

Gamification is the process of turning non-game environments into games to increase people's participation in a variety of fields [1]. Feedback, themes, leaderboards, challenges, badges, and points are all utilized in gamification to change undesirable behaviors, enhance motivation, and reward good behavior and productivity [1] [15].

Gamification is used in many different domains and applications as shown in lots of research in education in [16] where it studies the development of Pedagogical Agents enriched with Gamification for an e-Learning system, while in [17], the authors discussed the smart feedback while using Gamification in math application in a primary school and in [18] the authors validate the gamification mechanics and player types in an e-learning environment. Gamification mechanics and player types are discussed below in this section. Others include, but are not limited to, researchers who use gamification in health-related applications [19], and in crowdsourcing [20].

B. GAMIFICATION ELEMENTS

Gamification elements have been divided into many categories. For example, some researchers divide the elements into two categories (***Mechanics and Dynamics***) [21].

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The Mechanics parts are the functional components that offer the actions and controls mechanism (for example, points, leaderboards, levels, challenges, badges, onboarding, etc.). The Dynamics elements, on the other hand, indicate the reactions that occur when the user interacts with the mechanics' elements (e.g. rewards, competition, status, and achievements).

Marczewski further categorized the elements in [22] that divide the gamification elements into six types ***(Feedback, Schedule, Emotion, Element, Dynamic, and Mechanic)***. ***Schedules*** are the factors that indicate when something may occur; ***Emotion*** is a component that represents a user's feelings, such as interest and the fear of losing something. The user receives ***Feedback*** in the form of indications or messages from the system. Narrative/story and themes are examples of ***Elements*** that can assist the user in using the system [23].

Other researches classify the elements through the MDA model ***(Mechanics, Dynamics, and Aesthetics)***, where ***Aesthetics*** is the emotional result of the interaction of the users' dynamic experience, or DMC (Dynamics, Mechanics, and Components) [24].

In addition to this, Self Determination Theory of Motivation (SDT) intrinsic motivation activities are those that fulfill people by their interests, pleasure, and lack of conditions and are based on their psychological requirements. Those activities are based on the psychological and social demands listed below ***(Autonomy, Competency, and Relatedness)*** [25]. ***Autonomy*** refers to a user's ability to do tasks depending on his interests and the ability to choose and make judgments without having to follow directions (For example, profiles, avatars, and a customizable UI). ***Competency*** is defined as a user's desire to feel efficient and competent as a result of learning information and skills or receiving good feedback (Feedback, challenges, progressive information, points, levels, as well as leaderboard, for example) ***Relatedness***: when a user is socially linked and related to others (e.g. groups, social networks, and blogs).

C. CLASSIFICATION OF USER TYPES

Several research studies have recommended that gamified systems should be personalized based on the personalities of the users. Many studies have provided frameworks for investigating user and player-type models. According to [26] the Big Five Personality Traits "OCEAN", the user's personalities are divided into ***Openness:*** known for being curious and open to new ideas; ***Conscientiousness:*** known as ordered and systematic; ***Extraversion*** is characterized by outgoing behavior and a desire to interact with others; Tolerance and trustworthiness are traits of ***Agreeableness***; and Anxiety and irritability are symptoms of ***Neuroticism***.

Players are characterized as Dominant, Objectivist, Humanists, Inquisitive, and Creative by Ferro et al. [27]. ***Dominant*** users enjoy being seen in public. They may be assertive, aggressive, confident, egotistical, and self-driven; an ***Objectivist*** 's attention is on oneself before others, but they are not selfish; they may be assertive, aggressive, confident, egotistical, and self-driven. ***Humanists*** prefer to work in groups; ***Inquisitive*** users enjoy trying new things and discovering; and ***Creative*** users enjoy creating and developing things while learning through experimentation.

In [22], Marczewski proposed the "Four Keys of Fun," which are: ***People fun (friendship)*** when they engage in activities such as competition and cooperation. ***Easy Fun (Novelty):*** enjoys exploration, role play, and invention; ***Hard Fun (Challenge):*** Favors spectacular victory over accomplishing a difficult goal; ***Serious Fun (Meaning):*** Enjoys

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altering the player's environment.

According to [15] [28] [22], Gamification player types are ***Philanthropists, Socializers, Free Spirits, Achievers, Players, and; Disruptors***. ***Philanthropists are humanitarians and altruists who enjoy assisting others without expecting anything in return.*** Users who are ***Socializers*** interact with others, form social bonds, and prefer to be social. ***Free Spirits*** like creating and exploring, and they value their independence. ***Achievers*** prefer to conquer hurdles, difficulties, and challenges, and they relish the opportunity to learn new things and grow. ***Players*** user types will do whatever is required of them to obtain benefits from a system. ***Disruptors*** like obstructing, interfering, and sabotaging activities. They intend to cause havoc in any system, either directly or through other users, by introducing positive or negative changes.

Bartle Player Types include the MUD (Multi-User Dungeon) games which are classified into four types: ***Achievers, Explorers, Socializers, and Killers*** [29]. ***Achievers*** have a point-gathering goal as well as a level-rising goal.; ***Explorers*** are driven by a desire to learn more about the game's inner workings. They test out new acts in the wild, search for distinctive features, and try to find out how things function.; People, communication with other people, and what they have to say are all things that ***Socializers*** are interested in. Empathizing, sympathizing, joking, and listening are all things that they value. Relationships play an important role in their development, and emotions are rewarding for them; ***Killers*** get pleasure in not only inflicting misery on others but also in imposing their will on them. Each type can be divided into two types and is called "Eights Types Model" as described in [30].

Finally, the "Five Domain of Play" was discussed in [30] which ***are*** (***Novelty, Challenge, Stimulation, Harmony, and Threat). Novelty:*** distinguishes open, imaginative experiences from repeating, conventional ones. ***Challenge:*** deals with how much effort and/or self-control the player is expected to use. ***Simulation:*** deals with the stimulation level and social engagement of play. ***Harmony:*** reflects the rules of player-to-player interactions. ***Threat:*** reflects the game's capacity to trigger negative emotions in the player.

D. GAMIFICATION FRAMEWORKS

This section presents a review of related gamification frameworks. Several attempts were made to design gamification frameworks that can be used while implementing gamification in different context systems using systematic ways. The researchers needed to review the previous works in this part and define what the gaps that are resolved are in their proposed framework.

For example, in [31], the authors presented a framework to guide the process of project management in the work environment. They also support the framework by designing an ontology for their work. However, this research did not mention how the proposed framework can be used to design a gamified software system.

In [2], Morselheuser et al. provided a method for engineering and developing gamified software using a list of design principles. However, this research did not provide any details on how to design systems that can be adaptive on runtime and how they can adapt the gamification elements based on the user types.

Martin et al. have provided a design framework to be used while designing adaptive Gamification applications [9]. But, it only works with a small number of gamification elements ***(Feedback, Points, Level Difficulty, Customized Challenges, Competition)***. Also,

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there are no clear guidelines that can be used by the Software engineers to design a dynamic adaptive software that can customize the elements that appear to the users based on the different user types. For Example, there is no clarification on how to adapt the system for the different Player Types and Personality Types and there is no clarification on how to personalize the contents, adapt the navigation paths, or adapt the user interface.

E. ADAPTIVE GAMIFICATION

Researchers have attempted to develop a personalized user-centered adaptive mechanism to dynamically re-engage users to achieve the goal of adaptive gamification. This is because they discovered that the efficiency of gamification varies depending on the situation and individual. This means that various users are motivated in different ways, and the same users are motivated in different ways in different settings. In addition, continual monitoring has been used to take into account the system's deteriorating engagement and loss of interest to adapt it [2]. This poses numerous issues and questions regarding user kinds, gamification mechanics, and dynamics, as well as what factors influence the design of such an adaptive system [32].

Adaptive gamification is achieved by tracking how gamification features are used and how they affect each user type, then tailoring gamification mechanics and dynamics accordingly. This adaptive technique is used to improve the efficiency of constructing and designing information systems, as well as to incorporate adaptive gamification to encourage user acceptance and assist businesses through long-term user engagements [3].

Codish and Ravid proposed a framework to take into consideration the playfulness of personalities while taking into consideration the contexts and gamification analytics. Then Ferro et al. [27] explore the relationship between the personality types and the player types [33].

Specht et al. proposed a classification scheme for adaptive methods: "What is adapted?" "Why?" "How?" "To which feature?" This schema served as the foundation for the final classification of adaptive gamification, which was divided into four categories [11]. Purpose of adaptivity: [5] presented an adaptive reward mechanism, Adaptivity criteria: [6] proposes customizable challenges, Adaptive game mechanics and dynamics: dynamically modify the awards points proposed by [7], Adaptive intervention: tailored articles suggestions proposed by [8].

In [3], adaptive gamification research has been categorized into three thematic areas:

1. ***ADAPTIVE ENVIRONMENTS:*** which use gamification to support the adaptive functionalities. The adaptive part represents the user needs and interests while the gamification part works as a support for user engagements through instant feedback and multiple navigation paths or adapts the user interface based on the satisfaction level of each user.

2. ***SUPPORTING CONTRIBUTIONS:*** which work toward adaptive gamification-like frameworks and approaches and research focusing on the relationship between user types and gamification mechanics and dynamics.

Like in [34] adaptive gamification applied this concept by extending the MDA (***Mechanics, Dynamics, and Aesthetics***) category framework with user demographic data like age and gender, however, this only helps to categorize the elements with their effect on different

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classes of individuals but not by personalities. On the other hand, Bartle in [23] provides the ***(Achiever, Socializer, Explorer, and Killer)*** types while Marczewski and Tondello in [15] provide the ***(Socialisers, Achiever, Philanthropist, Disruptor, Free Spirits, and Player)***. Ferro et al. [27] examined the relationships between personalities and player types. But still, these researches lack how to effectively select the right gamification elements that motivate each user type adaptively.

3. ***ADAPTIVE GAMIFICATION APPROACHES:*** which try to find meaning between users and their activities like customized challenges, adaptive paths functionality, and personalized feedback. This area also was divided into Partial and Ful approaches.

The partial approach uses extrinsic rewards to prevent the lack of intrinsic motivation like providing personalized suggestions and rewarding users with free choices and new categories [35].

Also, personal recommendations can be applied using a pedagogical agent [16]. Shi and Cristea [36] use SDT (Autonomy, Competency, and Relatedness) for social adaptive e-learning by using feedback and flexible choices in Autonomy, goals, and tasks with levels of difficulties in Competence and status visualization and contributions and interactions in Relatedness.

a. For the Ful approach, González et al. [37] try to adapt the user interface and the gamification elements of an Intelligent Tutoring System (ITS) based on user needs. Also, Andrade in [38] proposes to the ITS system a way to avoid negative impacts and overuse. Other research tries to investigate specific gamification elements and how they can affect the different user types [3].

F. GAMIFICATION ONTOLOGIES

Ontologies are designed to capture information about a particular topic and provide a machine-interpretable representation that can be reused and shared by a variety of applications and groups [39].

Researches try to investigate specific gamification elements and how they can affect the different user types [3]. Some of the researches try to implement ontologies for gamification, like in [1], named ***OntoGamif*** (Ontology of Gamification), which implements lots of classes and subclasses for concepts like target users, ethical issues, organizational structures, and psychological factors but without mapping it with game elements.

Some other researchers try to implement ontologies for specific areas like in [31] as they built a framework named ***GOAL*** (Gamification focused On Application Lifecycle Management) to be used in the Software Engineering area and they implement an ontology, especially in the areas of requirement gathering management, project management process and the testing phase.

Another area like the intelligent knowledge exchange was enriched with gamification methodology where the authors in [40] have built the ***ONARM+*** ontology which is used as a knowledge discovery technique that helps the user to get his optimal decision path to achieve his objectives funnily and they applied it into tourism area to help the user get the types of places and interests he/she likes when traveling using his/her social networking for common interests.

In [41], researchers implement an ontology for the learning area of Software Modeling to increase learner engagement. They implement it in two specific areas which are the learning UML and the learning of SQL.

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Also, for the area of Intelligent Tutoring Systems (ITSs), an ontology has been implemented in [42] and named GaTo (Gamification Tutoring Ontology) to perform adaptive tutoring to learners using artificial intelligence techniques taking into consideration their knowledge into a specific domain.

G. REQUIREMENTS ENGINEERING MODELS

System modeling is an abstraction of software systems, and it helps to identify and list the features and requirements of the system. This modeling facilitates communication with stakeholders. In system analysis documentation, the system modeling can be done through the traceability matrix which provides the mapping between requirements, design, and test cases. The traceability matrix needs to be up-to-date all the time by updating it after each change request because it allows one to know the impact of any changes on the system and where exactly this change can affect the researchers' proposed system [43].

In other words, the requirements engineering models are an adequate representation of the real-life that maps all the required features to the system. If this model does not exist, this will have potential consequences while trying to make an extent of a feature [43]. That is why the feature model is very important for software engineers because it models all the system features and the relations between them. This helps software engineers capture the requirement of a model shape and link all its details and any related things to it. In this research, one of the links that need to be modeled is the link of the features with the gamification elements. For example, if a change request wants to make a change in one of the elements, then, the software engineers need to know all the features that are linked to this element and will be affected by this change. That is why the feature model is critical for maintenance, impact analysis, managing change requests, and requirements traceability.

IV. INITIAL PROPOSED METHOD FOR USER-BASED ADAPTIVE SOFTWARE DEVELOPMENT FOR GAMIFIED SYSTEMS

As presented above, all the research and the four groups of adaptive gamification have not provided a way to dynamically adapt the gamification elements' appearance at runtime according to user types. This gap was the main motivation for the proposed framework [44] .

This research focuses on the relation between the elements and user characteristics and proposes a framework that focuses on finding the solution to implement an adaptive gamification environment in software development based on user types and their mapped elements. The framework works to change the gamification elements themselves based on user types and not only to adapt the game mechanics and dynamics implementation by, for example, changing the feedback mechanism (warning messages) or using the points to create a suitable degree of Level Difficulty for each user types or even customize the challenges and competitions [9]. The framework works to manage the choices of elements for each user based on his/her type and the elements that fit him/her to get the most user' engagement, satisfaction, and performance while using the developed software. The below subsections give an overview of this study.

The proposed model in [44] adopts the "Design principles for engineering gamified software" proposed in [2] by adding some components and providing guidelines and steps for Software Engineers to follow while designing a gamified software to make the gamification items adaptive based on each user type by showing to each of the users only his preferred gamification items. Also, the research in [44] proposed a new extension on the implemented ontology by [1] named "OntoGamif" following the seven steps process provided in [14]. The added components to the framework are explained in the subsections below:

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A. THE ONTOLOGY COMPONENT

The "User-Centered Gamification Ontology" in [44] components defines the concepts of the "Gamification Elements", "Elements Categories", "User Types" and the mapping between the "User Types" and "Gamification Elements". This was implemented by declaring the ontology classes and relations to define a formal definition of the rules to be utilized by the Software Engineers while having systematic automated reasoning for those concepts.

1. CLASS HIERARCHY

In [44] the Ontology Class Hierarchy has been divided into three main classes (Elements, Elements_Categories, and User_Types). First, the ***Elements Class*** includes a list of 36 gamification elements [23]. Second, the ***Elements_Categories Class*** includes sub-classes representing the different researches elements categorizations like "Mechanic_Dynamic_Model" [21], "MDA_Model [24], "Mechanics_Elements_Model" [22], and "Self_Determination_Theory_of_Motivation_SDT" [25]. Third, the ***User_Types Class*** includes sub-classes representing the different researches user types categories like "BigFive_PersonalityTraits_OCEAN" [26], "Ferro_Players_Classification" [27], "Five_Domain_of_Play" [45], and "Four_Keys_of_Fun" [22].

- "Marczewski_User_Types" which includes two subclasses ("Hexad" and "Initial_Motivators") [28] [22] [15] .
- "Bartle_Player_Types" class which includes also two subclasses ("Four_Types_Model" and "Eights_Types_Model") [29].

2. OBJECTS PROPERTIES

In [44], the authors classify the mapping relationships into some relation types as the examples shown in Figures 1 and 2 which show ***Direct*** and ***Indirect*** relations between the User Types and Gamification Elements while the ***Indirect*** is divided into ***Partial*** and ***Total.***

The mapping linkages between the user type and the gamification elements can be ***direct.*** This means that, like in the case of the "User Types Hexad" with the gamification elements, each User Type includes a list of Elements that are directly linked and defined to it [15] [46]. Alternatively, one can go the ***indirect*** route by mapping one user type classification to another, which is then linked directly to gamification features. The ***indirect*** mapping can be ***partial,*** meaning that each user can be linked to two additional user types in a different category, each of which is directly mapped to the elements. For example, the mapping between the "Big Five Personality Traits" and the "User Types Hexad" [28] or ***total,*** implying that each user type can only be associated with one type in another category, like in the case of the "User Types Hexad" and their "Initial Motivators" [28] [22] [46].

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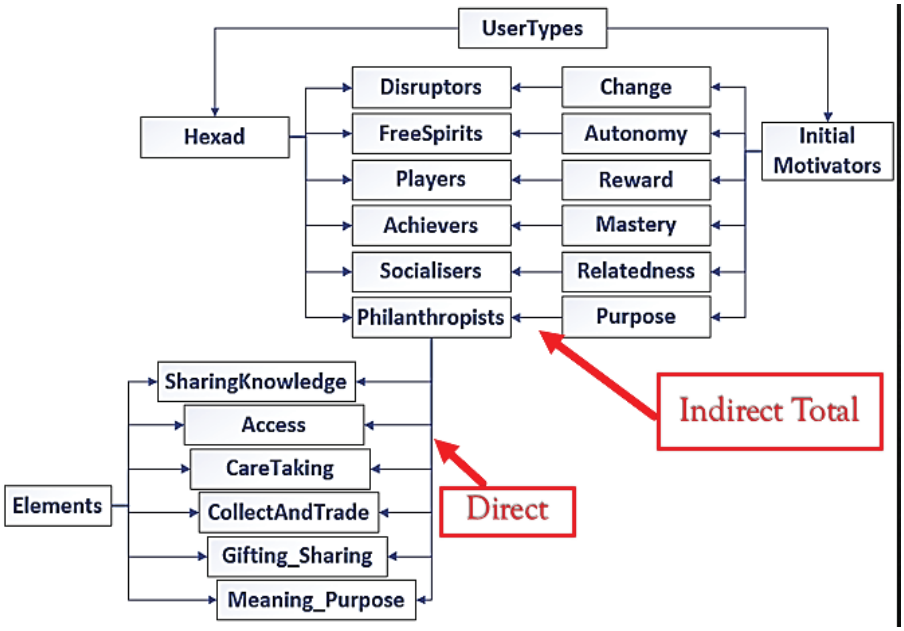

Fig. 1. Graph representation of mapping between the initial motivators and Hexad user types

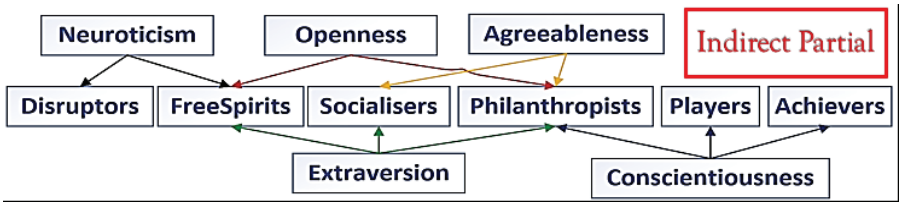

Fig. 2. Graph representation of mapping between "Big Five" and the "Hexad" User types

The above relations have been represented in the ontology as object properties like "MAP_Element_ElementCategory", as shown in Figure 3, which represent the relation between the Element and its categories.

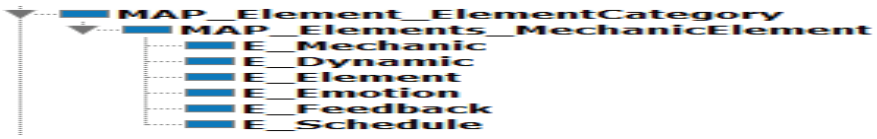

Fig. 3. "Element" to "Element Category" objects properties [44]

Then the "MAP_Element_UserCategory" shown in Figure 4 is divided into "DirectMapping" and "IndirectMapping" which in turn is divided into "TotalMapping and PartialMapping" like the examples shown in Figures 1 and 2. Also, each of the Objects' Properties Domains, and Ranges were configured as in the example in Figure 5. Table I shows a sample of the created object properties with their domains and ranges.

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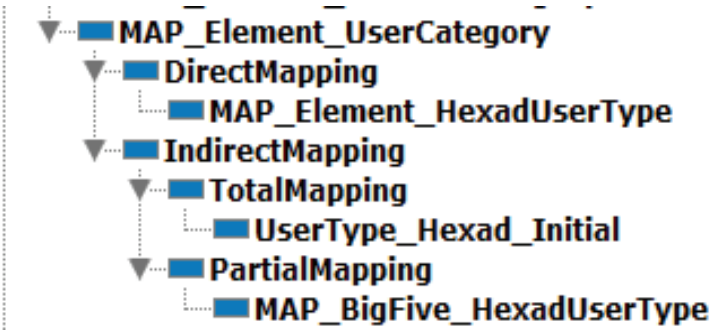

Fig. 4 "DirectMapping" and "Indirect Mapping" sub-properties [44]

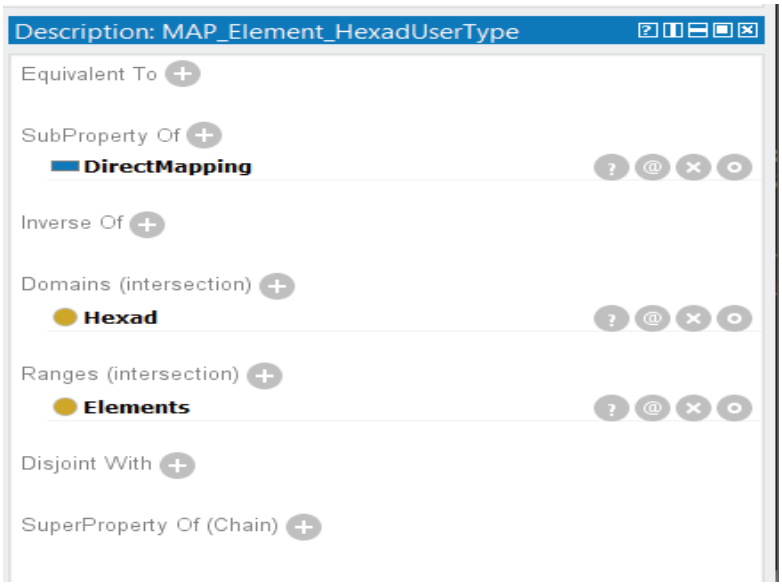

Fig. 5. Domain and range of the "MAP_Element_Hexad UserType" object property

TABLE I: EXAMPLE OF THE CREATED OBJECT PROPERTIES WITH ITS DOMAINS AND RANGES

Mapping type	Object Property Parent Group	Object Property Example	Domain	Range
Elements with Elements categories	MAP_Element_ ElementCategory	MAP_Elements_ MechanicElement	Mechanics_ Elements_ Model	Elements
Elements with Users categories Direct Mapping	MAP_Element_ UserCategory / DirectMapping	MAP_Element_ HexadUserType	Hexad	Elements
Elements with Users categories Total Indirect Mapping	MAP_Element_UserCategory / IndirectMapping / TotalMapping	UserType_ Hexad_ Initial	Hexad	Initial Motivator
Elements with Users categories Partial Indirect Mapping	MAP_Element_ UserCategory / IndirectMapping / PartialMapping	MAP_BigFive_ HexadUserType	BigFive_ PersonalityTrait_ OCEAN	Hexad

3. CLASS RULES

After describing the class and object property hierarchies, this section demonstrates

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how to use them to define the rules that govern class usage.

Figure 6 shows a sample of the rules which is the "Feedback" Subclass of the "Mechanics_Elements_Model" and the list of the only elements assigned to it as described in [22]. It shows the list of elements which is considered Feedback elements. Those elements are (Badges_Achievements, Certificates, Leader boards_ Ladders, Levels_Progression, Lottery_Game Of Chance, Physical Rewards_Prizes, Points_Experience Points XP, Social Status, Unlockable_Rare Content, Virtual Economy). Table II shows a list of implemented rules of the subclasses with their filters.

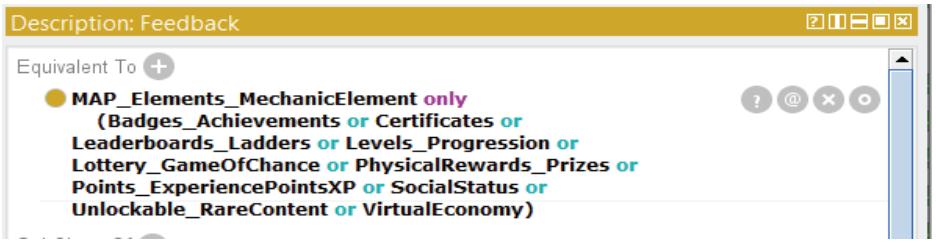

Fig. 6. Rules of the "Feedback" subclass of the "Mechanics_Elements_Model"

TABLE II: LIST OF IMPLEMENTED RULES OF THE SUBCLASSES

Subclass	Restricted property	Restriction type	Restriction filter
Achievers	MAP_Element_ Hexad User Type	Only	(BossBattles, Certificates, Challenges, Learning_NewSkills, Levels_Progression or Quests)
Disruptors	MAP_Element_ Hexad User Type	Only	(Anarchy, Anonymity, Development Tools, Innovation Platform or LightTouch or Voting_Voice)
Free spirits	MAP_Element_ Hexad User Type	Only	(Branching Choices, Creativity Tools, Customization, Easter Eggs, Exploration or Unlockable_Rare Content)
Philanthropists	MAP_Element_ Hexad User Type	Only	(Access or CareTaking or Collect And Trade or Gifting_Sharing or Meaning_Purpose or SharingKnowledge)
Players	MAP_Element_ Hexad User Type	only	(Badges_Achievements, Leaderboards_Ladders or Lottery_ Game Of Chance, PhysicalRewards_Prizes, Points_Experience 85% Points XP or Virtual Economy)
Socialisers	MAP_Element_ Hexad User Type	only	(Competition or Guilds_Teams, Social Discovery, Social Network, Social Pressure or Social Status)
Achievers	-	Equivalent To	Mastery
Disruptors	-	Equivalent To	Change
Free Spirits	-	Equivalent To	Autonomy
Philanthropists	-	Equivalent To	Purpose
Players	-	Equivalent To	Reward
Socialisers	-	Equivalent To	Relatedness
Mechanic	MAP_Elements_ Mechanic Element	only	(Access, Boss Battles, Branching Choices, Challenges, Collect And Trade, Competition or Creativity Tools, Customization or Development Tools, Easter Eggs, Exploration, Gifting_Sharing, Innovation Platform, Learning_NewSkills, Physical Rewards_ Prizes, Quests, Sharing Knowledge, Unlockable_Rare Content, Virtual Economy or Voting_Voice)

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Subclass	Restricted property	Restriction type	Restriction filter
Dynamic	MAP_Elements_ Mechanic Element	only	(Anarchy, Anonymity, Boss Battles, Care Taking, Collect And Trade, Creativity Tools, Customization, Development Tools, Exploration, Gifting_Sharing, Innovation Platform, Leader boards_Ladders, Learning_New Skills, Light Touch, Sharing Knowledge, Social Network, Unlockable_Rare Content, Virtual Economy or Voting_Voice)
Element	MAP_Elements_ Mechanic Element	only	(Boss Battles, Challenges, Competition, Creativity Tools, Customization, Guilds_Teams, Innovation Platform, Learning_ New Skills, Levels_Progression, Quest, Social Discovery or Social Network)
Emotion	MAP_Elements_ Mechanic Element	only	(Care Taking, Competition, Meaning_Purpose, Social Pressure or Social Status)
Feedback	MAP_Elements_ Mechanic Element	only	(Badges_Achievements, Certificates, Leader boards_Ladders, Levels_Progression, Lottery_Game Of Chance, Physical Rewards_Prizes, Points_Experience Points XP, Social Status, Unlockable_Rare Content or Virtual Economy)
Schedule	MAP_Elements_ Mechanic Element	only	Lottery_Game Of Chance

4. THE WEIGHTING MODULE COMPONENT

A method was proposed in [44] as a guideline for Software Engineers to apply the concept of the adaptive customized Gamification Elements for each user depending on his/her user type, preferred elements, and system usage. The algorithm is mainly dependent on weighting scores and values that are given to each of the available gamification elements in the system which are changed based on the user feedback and usage. The system then customizes the shown elements to each user based on the elements' scores and on the mapping of those elements which is formalized in the ontology. This will be further elaborated before and after evaluation in section 4.

5. THE EXTENDED PHASES

This component describes the extended phases that need to be added to the design principles for engineering gamified software [2]. The first part is that the "Monitoring" component is changed to "Monitoring and Runtime Evaluation" to permit the system to monitor the users' preferences though continuously capturing their feedback on the gamification features in the system and monitoring their features usage. To achieve that, the discussed weighting system shown in Figure 9 is utilized to show the steps upon which the adaptation decisions are made. Accordingly, these decisions are realized in the following added phase named "Adaptation". A feedback arrow is also added between the "Adaptation" phase and the "Monitoring and Evaluation" phase to show the continuous loop (an ongoing task) of capturing feedback and personalized adaption at runtime.

VI. EVALUATING THE PROPOSED FRAMEWORK

This Section explains the evaluation process of the proposed framework. The below sections provide details on the recruitment and the participants and details about the company the researchers used for recruiting. Then, the next section gives some details on the introductory session and what was included in it. The Immersion scenario used is then explained in detail as well as the software that was employed and the reason to use this software in addition to the supporting documents and the Interviews structure. After that, the interviews results are discussed and categorized to finally apply the recommended modification to the applied framework.

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A. RESEARCH METHODOLOGY

In this research, the ***qualitative approach*** was chosen to help fulfill the research objective, to validate the proposed framework and to get the experts' opinions to enhance it. Due to the exploratory nature of this research, after identifying the gaps in the previous frameworks which are missing the adaptivity of the different gamification elements based on the different user types classifications is explained. This research provided a suggestion to solve this problem. This suggestion needed to be validated by actual software engineers by exploring the idea providing their feedback and collecting their concerns and ideas to enhance the proposed framework based on their experience.

Direct feedback from software engineers is needed for exploring ideas and evaluating the design of this research. Interviews are a traditional way to apply this kind of research. There are many kinds and ways for interviews [14].

1- Structured interviews: need a prerequisite of a good understanding of the topic from all sides and a well developing questionnaire. This kind of interview can be handled even face-to-face or through telephone.

2- Semi-structured interviews: this is a kind of formal interview. It is handled by having some qualitative open-ended questions and points that need to be covered during the interviews. Those points can be re-ordered, or a little bit changed based on the situation of the interviews but without getting away from the initial target points that need to be covered. This way helps in expressing their views in a freedom way.

During the interview, the interviewers mainly wrote notes because of the open-ended questions. However, it was difficult in some cases to write notes and to discuss points with interviewees at the same time. To solve this problem tape-recordings can be used to be able to focus on conducting the interviews.

3- Unstructured interviews: are only limited with a plan in mind regarding the goal and focus of the interviews and let the discussion be open-up and let both parties of the interview talk in their ways.

4- Informal interviews: In this type of interview, the interviewer has a casual informal conversation with the participant without any structure guide and he/she can take small notes.

In this research, semi-structured interviews were chosen due to their flexibility, discovery nature, and ability to go deep freely with the interviewees' concerns and detailed responses, which results in ambiguities and incomplete answers being cleared and filled up. Recordings of the sessions were applied in addition to taking notes.

However, there are also disadvantages to interviews, which are: 1) time-consuming: planning, setting up, recruiting, interviewing, transcribing, analyzing, feedback, and reporting; 2) they can be costly: participants can cancel or change the meeting place at the last minute; 3) different interviewers and different interpretations [47].

The ***data analysis technique*** that was used in this research was the coding technique. In the beginning, the "Open Coding" technique was used to list the comments of the participants from the resulting documents notes, and recordings. The data collected is represented into codes by mapping each comment from each participant and representing it with one code-named "Open Code". Then all the codes with similar meanings and concepts across all the participants were grouped and merged into groups. These groups represent the "Axial Codes" which is simply a grouping by

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meanings and concepts of the "Open Codes". Then finally, the researchers grouped the "Axial Codes" into bigger categories named "Selective Codes" representing the main ideas of the comments of the participants [48].

B. PARTICIPANTS RECRUITED

Interviews were applied to employees in a Saudi Arabian software company working on many artificial intelligence projects with many customers in the Middle East. This working field was one of the biggest reasons to choose this company. Software engineers of such a company focus on the details of the idea, the user experience (UX) of the users who will use an adaptive gamified system, and the steps they will follow when they try to design this kind of system. The company develops applications using recent technologies in Artificial Intelligence, Machine Learning, and Business Intelligence. The demographic analysis of the interviewee is shown in Table III.

The projects the company works on are: ***Robotics software***: Android applications to manage Humanoid Robots; ***Robots management systems:*** Systems to manage many types of Robots using one interface; ***Chatbots and Voice bots***: To make digital interaction faster and more human; ***Intelligent Travel Assistants:*** To help users get the best travel offers without human interference; ***Intelligent Insurance Assistants:*** To help users to compare the best insurance offers; ***Robotic Process Automation (RPA):*** To handle repetitive tasks that do not need human thinking effort. Table III gives an overview of the demographic of the participants (Gender, job position and years of experience)

TABLE III: THE DEMOGRAPHIC ANALYSIS OF THE INTERVIEWEE

Interviewee number	Gender	Job position	Highest level of education	Years of experience
1	Female	Database developer	Bachelor degree	10
2	Female	Senior software engineering	PhD	15
3	Male	UX designer	Bachelor degree	14
4	Female	Junior business analyst	Bachelor degree	2
5	Male	Junior business analyst and bot implementer	Bachelor degree	1
6	Male	UI designer	Bachelor degree	3
7	Female	AI developer	Bachelor degree	2
8	Male	UX-UI team leader	Bachelor degree	15
9	Male	System architect consultant	PhD	22
10	Male	AI team leader	Master's degree	11
11	Male	Senior system architect	Bachelor degree	18

C. INTRODUCTORY SESSION

The evaluation methodology started with an Introductory session to explain the topic through a presentation. Around three introductory sessions were handled with one hour each. The presentation introduces gamification and how gamification can help people get more engaged and enhance their motivation to do tasks. Then, Gamification Elements were shown and described in general with some examples of the elements and how they can be used. Gamification Elements categories are described after that with some examples and the difference between them. User

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Types are then discussed and shown samples of their categories. After that, a basic introduction to Ontology, what it is, and what the steps to make an Ontology are.

Then after that, the purpose and need for this research were given. Besides, the research problem was clarified, and a quick overview of the literature work. Finally, a description of the proposed framework and a description of each block was given.

After the introductory session, an evaluation session was conducted with each participant through a semi-structured interview which included a set of predefined questions to get their opinion/suggestions to modify/enhance the proposed framework and the weighting module design. Those semi-structured interviews started with an immersion scenario that is discussed in the next section.

D. IMMERSION SCENARIO

To better engage the participants in the interview and get their focus to evaluate and enhance the proposed framework, a fictional scenario was used to help the participants apply the steps they are following while immersing themselves in situations similar to what they do in real life [49].

The software employed in the immersion scenario was "Samsung Health" which is a personal health application that can be used on users' mobile devices and can be personalized based on each user's needs. The user for example can choose all the exercises that he/she is interested in and he/she can also customize his/her home screen. [50]

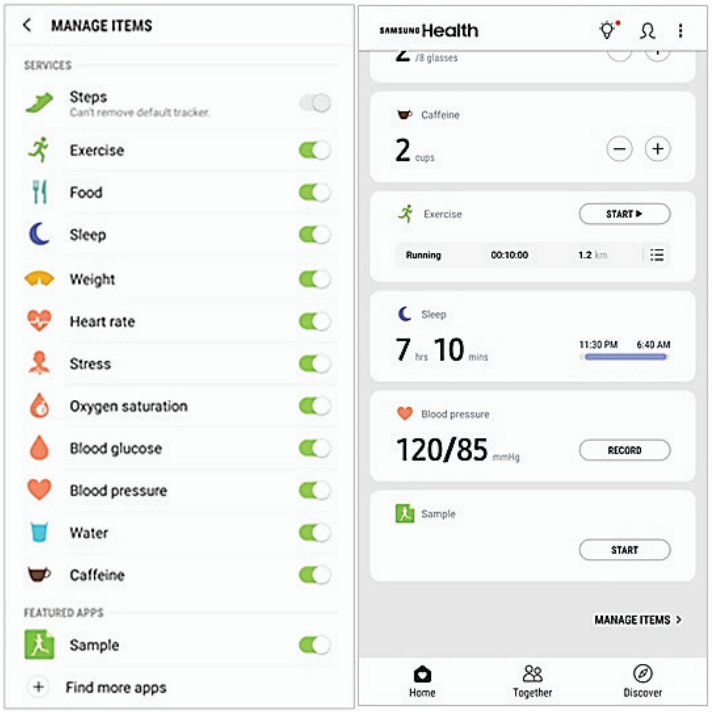

Fig. 7. Screenshot from the immersion scenario of Samsung Health [51]

A small introduction was given to "Samsung Health" software in addition to some of its capabilities and features as shown in Figure 7.

The immersion scenario software features were discussed and taken into consideration during the discussion. For example, how the list of displayed features can be customized manually for each user on his home screen (Landing Page). Some

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of the discussed features are "Wellness" features where the user can track his workout activities, set up goals, and track the progress of calories, quality of sleep, and water intake. Also, the "Learning from others" feature and how to get other people's experiences by viewing videos and reading about their stories and their suggested workouts. The "Challenging yourself" feature can be used by getting some fitness motivation while challenging friends and other people and comparing your progress with their progress.

After that, the participants were asked to try to enhance this software and add gamification elements to it while trying to make the homepage features and gamification elements appear adaptively for each user based on his/her personality and based on his/her usage. They were also asked to follow the proposed steps to do so.

E. SUPPORTING MATERIALS UTILIZED IN THE INTERVIEWS

Before each session, a printout of some supporting documents was provided in addition to some points that have been declared and discussed with the participants to immerse them into the mode of designing and enhancing the "Samsung Health" application and adding some game elements and making them adaptive based on the end-user types. The points and supporting documents include:

1- The proposed framework diagram was given to the participants to be visualized and to take their comments on it.

2- Screenshots overview of the developed Ontology.

3- Immersion scenario description:

- What is the tool that has been chosen?
- Why choosing this tool?
- What is the feature that is currently implemented in "Samsung Health"?
- What is the feasibility of adding gamification elements to the chosen tool?
- What are the types of users who will use this immersion scenario?

4- Gamification elements Periodic Table [22]

5- Gamification Elements Descriptions [22].

6- One chosen list of user type categories with their descriptions [15] [28] [22].

7- Elements mapping with selected user types category [22].

8- Mapping Table (Elements – User types category mapping – Elements category mapping)

9- Design principles for engineering gamified software [2].

10- Elements Relations

11- Weighting Algorithm Activity Diagram

12- Simulation table for simulating the weights of elements for each user to be used in the Immersion Scenario

13- Simulation table for the appearing Initial list of elements used in the Immersion Scenario tracing

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The participants immersed in that fictional scenario previously prepared as if they were designing a system using the proposed framework (The supporting documents can be found at this link https://bit.ly/3m9gjfq). This helps during the interview session to walk through the proposed framework with the participants and to provide more valuable results and more proper testing of the framework.

F. INTERVIEW'S STRUCTURE

An interview was conducted with each of the recruited participants. The interviews took about 14 hours of the total time of discussions with an average of 1 hour and 15 min for each interview. All the interviews were voice-recorded after getting approval from each participant. Those records were then transcribed later to be used in addition to the notes in the interviews' analysis. The interview was divided into two parts:

- The first part is walk-through testing on the whole framework when using it to design a Health application with adaptive gamified elements based on the users' types. This part was mainly to get the interviewee's suggestions and opinions on the weighting module.

- The second part of the interview was a discussion about the overall proposed framework. After that, the Software Engineers (the interviews participants) walked-through the proposed idea components, this second part was to put all these components of the framework (Process, Ontology, Weighting Module, …) into practice while designing a gamified application based on the given fictional scenario and given requirements. This part helps to identify the proposed framework's strengths and weaknesses. Also, it helped to collect their feedback to enhance the framework while applying their suggested changes and solving the issues.

1. EVALUATION RESULTS

The comments of the interviews were analyzed and categorized into three types:

Comments on the "***Design principles for engineering gamified software"*** phases→ ***(Process Evaluation)***

Comments on the linkage between the "***Design principles for engineering gamified software"*** phases and the proposed framework modules → ***(Components Links Evaluation)***

Comments on the proposed framework structure, modules, and their relations → ***(Modules Evaluation)***

A. PROCESS EVALUATION

In the beginning, the participants understood the immersion scenario and agreed that it would be feasible and profitable to add gamification elements to it and that it could enhance user engagement for such applications. Then, they started applying the proposed framework with the immersion scenario and comments on each part while simulating the real process.

The first group of comments of the interviewees commented on the design principles for engineering gamified software phases and how they need to be modified to cope with the proposed framework.

Some Interviewees commented on the ***Project Preparation and Ideation Phases*** when analyzing the immersion scenario and trying to integrate gamification elements into

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it. They wanted to move the ideation phase after the preparation phase before the user and context analysis phases. Other participants see that the ideation cannot be done before analyzing the user and context and knowing exactly the target users and the target context. Project preparation is done through some searches, data collection, and scoping while studying the gamification applicability and how to implement it. On the other hand, ideation is done through brainstorming and focus group sessions directly after the preparation phase. Also, some users think about how the researchers can get the statistics to define the project objectives in case they do not have a history, or it is very poor in the case of the adaptive gamification data which may be similar to the recommendation engines which depend on the history and mining of the data of other previous users.

All interview comments are uploaded on the drive and can be found at this link https://bit.ly/3m9gjfq).

Changes to the framework (Process: Project Preparation and Ideation Phases)
• Leave the Project Preparation and Ideation Phases as is because the ideation cannot be done without knowing the target users and context.

Other Interviewees focused on the Analysis Phase, even ***Context or User analysis*** or both. Some users see that both of them can work in parallel and not sequentially which means that they are not dependent on each other, and some other opinions want to switch the context analysis before the users' analysis because the elements defined during the context analysis can be changed for the same user from domain to another. Others see that the Context/Field/Domain of the project needs to be defined then the researchers define which users in this domain will focus on as users for the system and that is why the analysis is conducted. Also, the researchers can swap the user analysis with the project preparation as user analysis happens through research and interviews then the researchers start the project preparation based on the users and market research results. Another comment was that phases should be repeated per context and integration and that they should have a phase to define gamification elements that will be used for each context level. Also, the researchers need a phase that structures the Hierarchy of the Context levels (in case of sequential or parallel levels or after a specific period). For example, Fitness/ Exercise is parallel to Food/Diet in the case of health applications.

Changes to the framework (Process: *Context or User analysis*)
• Leave both phases of analysis to be parallel as there is no dependency between the two of them.

Some attendees focused on the ***System Design*** Phase. For Example, their idea was to add an Onboarding Component to be able to give the users an idea of the system controls and how the weighting module will adapt to their needs.

Changes to the framework (Process: *Context or User analysis*)
• Leave both phases of analysis to be parallel as there is no dependency between the two of them.

Some of them see that the ***Evaluation and Monitoring*** practice needs to be modified by for example applying it after each phase. Others want to add an ***Evaluation*** phase called "***Usability Testing***" after the ***Ideation or Design*** phases. Others see that after the "Evaluation" Phase the researchers need to add a ***Feedback Loop***.

Another idea was to add ***KPIs*** to the evaluation phase to be able to set the targets

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of the evaluation process.

Changes to the framework (Process: Evaluation and Monitoring)
• The researchers need to have two types of evaluations; one for the evaluation of the software development phases and results and the other one will be for the evaluation on runtime for the system adaptations based on the users' feedback and usage.

B. COMPONENTS LINKS EVALUATION

The second group of comments from the interviewee focuses on the relations between the design principles for engineering gamified software phases and the proposed modules/components. In addition, they commented on the relations between the proposed modules themselves.

Some of them say that instead of working with the ***Proposed Framework in parallel during the phases*** of (User analysis, context analysis, ideation, design, and implementation) the researchers must remove the implementation. Others see that the researchers should work with the framework only during the (Context analysis and ideation) phases.

Some of the interviewees see that they need to ***Link each phase of the Design Principles to its related component in the proposed framework***. So, for example, the User Analysis phase is to be extended by the User Characteristics/Types.

Changes to the framework (Components Links Evaluation)
• Link each phase of the design principles to its related component in the proposed framework to be as an extension to it (e.g. user analysis will be linked to the "user type" component, context analysis to be linked to the "Feature Model" Component).

C. MODULES EVALUATION

The third group of comments from the interviewee focuses on the proposed framework components themselves (Gamification Mappings, System Design, Elements Relations, Weighting Module, and Elements Adaptation).

1. ONTOLOGY MODULE

Some comments were related to the ***Ontology section***. Moreover, the ***other comments*** category were added as well in the database. Some comments mention that the researchers need to ***add subtypes or tasks or features under each element*** because the users may like an element for a specific feature/task and do not like it in another feature/task. Also, tasks may differ from one context to another. They want also to add this mapping between the elements and the tasks to the Ontology using Feature Models. Again, some users are against this because they do not want to complicate the model calculations.

Changes to the framework (Process: Modules Evaluation - Ontology section)
• Divide the Ontology sub-modules to include a part for the user type, a part for the relations and categories of the elements and their features, and a part for the mappings. • Add Tasks/Feature Model based on the context into the ontology module.

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2. WEIGHTING MODULE

Some comments were related to the weighting module and how it works and most of them try to enhance the framework and add some other criteria to get the best results.

Some of the comments were trying to ***enhance the weighting system by not only depending on the clicks of the users but also on adding a feedback section*** to get the user's input through the Like/Dislike functionality AND/OR adding a star rating on each element level. However, other users were against this because they wanted to measure the behavior of the user and not to ask him/her. Some other comments wanted to ***add a component to limit the stress on the user*** as some users may put loads on themselves to reach the targets or to gain points.

Some interviewees think that this ***framework may face the bubble issue*** which appears a lot in the recommendations systems of the search engines. The bubble issue mainly happens when a user searches for the stuff of the same category for a long time. Then, most of the recommendation engines, in this case, recommend stuff from the same category. Other opinions provided a solution for this issue by enabling other elements from the nearest category even if they were not in the top high weights. Other opinions want to use the 80/20 algorithm used in some recommendation engines to solve the same issue by providing 80% of the same user recommendation bubble and 20% of any random other categories. Another idea was to hide some of the top high weights at some points and replace them with other elements with low weights and enable the user to try other elements and be away from the bubble issue.

Other interviewees want to ***make the weighting module more personalized*** by asking the user if he/she likes each element or not. Some other ideas include adding more intelligence to the weighting module and wanted to add some AI and machine learning algorithms like Random Forest to better enhance the results for the users, but the problem that the researchers can face will be the data history/Dataset to train the model to be more intelligent. Another opinion was to integrate social media to build clusters based on the similarities between the related people. Another idea was to add a threshold to get more confidence level before taking the decision and to be sure that the user is interested in this element.

Some of the interviewees commented on the ***weighting module activity diagram as it needs more details for software engineers*** to understand the actions in each branching condition.

Changes to the framework (Process: Modules Evaluation - Weighting_section)
• Change the feedback to include other types like (Like/Dislike, Star Rating, and Direct Questions). • Add a User Load Stress Control component in the weighting module. • Add a component to handle the threshold for confidence level. • Add a component to handle the ability to pin an element if he/she likes it and does not want to change it. • Add more explanation on how to manage the mapping of the elements and the user types with all its types of mappings (direct, indirect, Total, and Partial) to the activity diagram.

At the end of each interview, three main questions were asked to each of the participants to know their overall opinion on the idea of the proposed framework.

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The first question was "***Do you think this framework shall enhance and increase the motivation of systems users?***" They had to choose one choice of three (Too Much, The right amount, Not really) and almost all of them chose "Too Much" but they insisted on having an Onboarding strategy when designing the system to help the end-users understand how the systems will be adaptive based on their feedback and that the system will interact with those feedbacks and with their usage.

The second question was "***Is it easy to integrate this framework with your software process?***", some of them replied with "yes" it is easy to integrate it and some others said that it needs first to have new design patterns to work with this new kind of adaptive software and that it will have some resistance from some of the software engineers to adapt the process they are following now.

The third question was "***How clear are the framework diagrams of the proposed framework and the sequence diagram?***", most of them said that it was extremely clear for them to understand and to read it.

3. FINALIZED FRAMEWORK MODIFICATIONS

After studying and analyzing all the comments and collecting all the biggest and most feasible comments as shown in the "Changes to the Model" blocks of the above section. A redesign of the whole framework was handled taking into consideration the participants' comments. Figure 8 shows the updated gamified adaptive framework after applying the changes.

Also, the weighting module activity diagram has been enhanced as shown in Figure 9 by adding more details and conditions to fulfill all the cases of the provided Ontology rules that are explained later in this research. Finally, Algorithm 1 shows the weighting system pseudocode to facilitate the work of the software engineers to follow the steps while designing adaptive gamified systems based on user types.

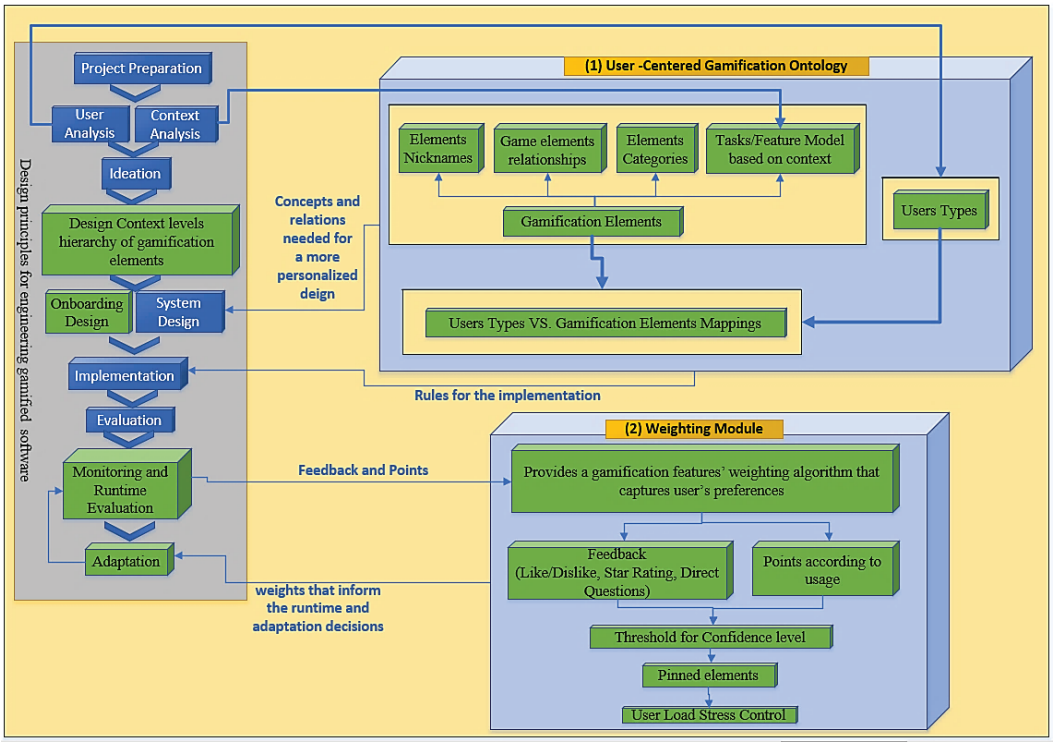

Fig. 8. Updated gamified adaptive framework

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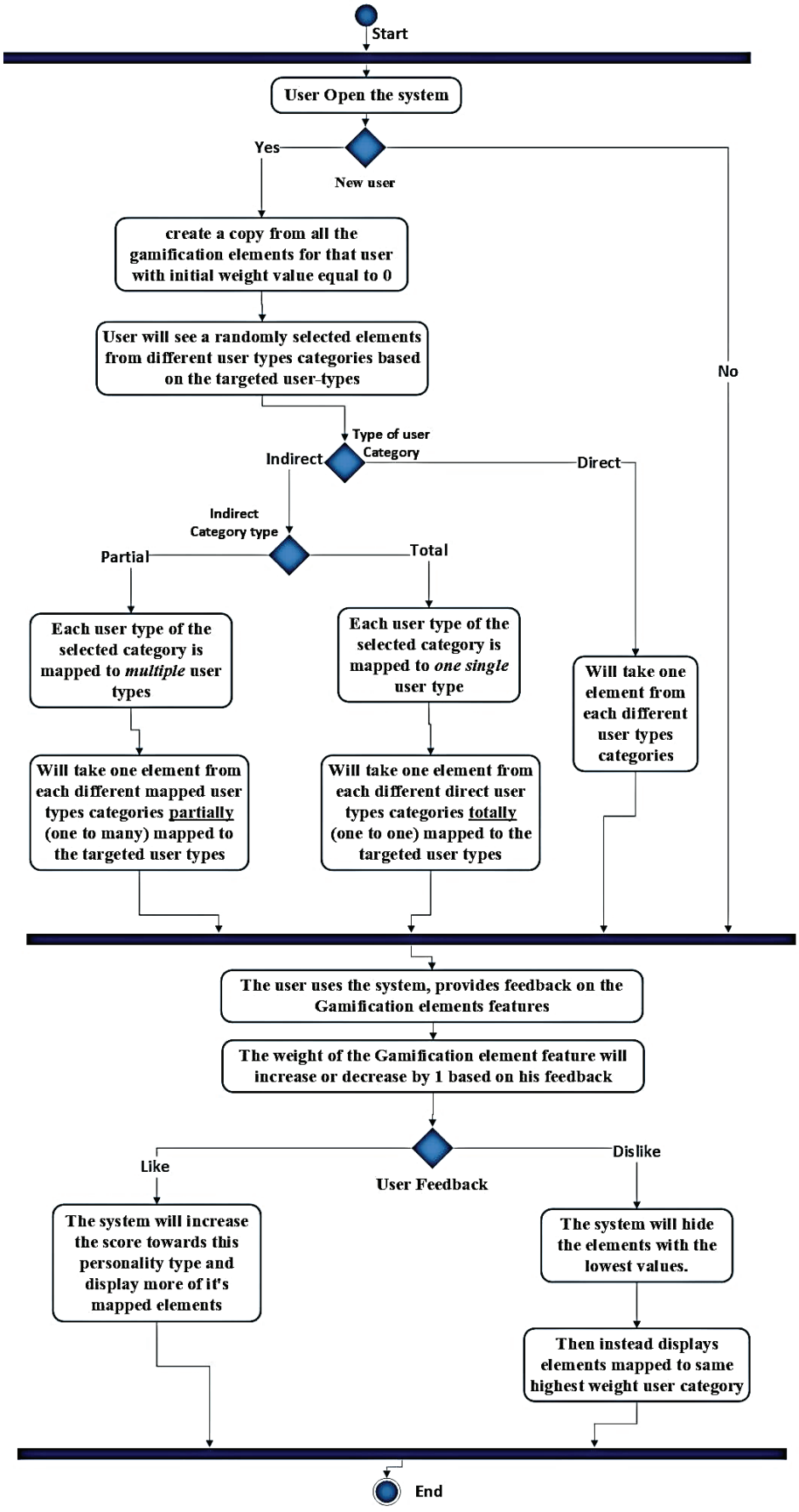

Fig. 9. Activity diagram of the weighting system after modification

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Algorithm 1: Weighting System Pseudocode

LOGIN to the system
FOR EACH User
IF New User
CREATE a copy from all the gamification elements for that user with initial weight value equal to 0;
DETERMINE RANDOMLY some selected elements from different user types categories based on the targeted user-types;

IN CASE OF choosing user types that are mapped directly to the elements "*DIRECT*":
Will take one element from each different user types categories;
END "*DIRECT*" **CASE**

IN CASE OF choosing user types that are mapped indirectly to the elements "*INDIRECT*":
IN CASE OF One-to-One mapping "*TOTAL*":
Each user type of the selected category is mapped to one *single direct* user type; Will take one element from each different direct user types categories *totally* mapped to the targeted user types;
END "*TOTAL*" **CASE**

IN CASE OF One-to-Many mapping "*PARTIAL*":
Each user type of the selected category is mapped to *multiple direct* user types; Will take one element from each different user types indirectly mapped elements minus the other directly related user types;
END "*PARTIAL*" **CASE**
END "*INDIRECT*" **CASE**
END RANDOM DETERMINATION

SET the randomly selected elements to be initially visible for the user;
END New User

COLLECT feedback from the user on the Gamification Elements Features
IF user Feedback is Like
INCREASE by 1 The weight of the Gamification element feature
ELSE IF user Feedback is Dislike
DECREASE by 1 The weight of the Gamification element feature
END User Feedback
IN CASE OF choosing user types that are mapped directly to the elements "*DIRECT*":
INCREASE / DECREASE the score towards this personality type based on the feedback
DISPLAY more of its directly mapped elements in case of highest user types values
HIDE the elements with the lowest user types values
DISPLAY instead of it the elements mapped to same highest weight user categories
END "*DIRECT*" **CASE**

IN CASE OF choosing user types that are mapped indirectly to the elements "*INDIRECT*":
IN CASE OF One-to-One mapping "*TOTAL*":
INCREASE / DECREASE the score towards the targeted user types categories totally mapped to the direct user types based on the feedback
DISPLAY more of its indirectly mapped elements in case of highest user types values
HIDE the elements with the lowest user types values
DISPLAY instead of it the elements mapped to same highest weight user categories
END "*TOTAL*" **CASE**

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IN CASE OF One-to-Many mapping "*PARTIAL*":
INCREASE / DECREASE the score towards the targeted user types categories partially mapped to some of the direct user types based on the feedback
DISPLAY more of its indirect partially mapped elements in case of highest user types values
HIDE the elements with the lowest user types values
DISPLAY instead of it the elements mapped to same highest weight user categories
END "*PARTIAL*" **CASE**
END "*INDIRECT*" **CASE**

END User Repeat
Result: Write here the result

```
Initialization;
while While condition do
    Instructions;
    if condition then
        instructions1;
        Instructions2;
    else
        Instructions3;
    end
End
```

4. THREATS TO VALIDITY

1- During the interviews, while explaining the fictional immersion scenario, some examples of the features and how the researchers can apply gamification to them were given to the participants. This could have influenced the thinking of the participants, especially in providing new ideas. To minimize this effect, the interviewer pushes the interviewees to give more and different examples and to think out of the box. Also, the interviewer always challenges the interviewees with the issues that can happen to the system while they provide ideas to let them think in all directions to get the most profit from the interview and to enhance the framework.

2- Another threat in the interviews was the lack of experience of the interviewees in creating new frameworks. This was taken into consideration by encouraging them to think from a high-level view and to look for general ideas that can work with a different type of software and not to think about how this will be applied technically. Besides, the use of the supporting documents and the initial proposed framework helped to give them an idea of how to create new frameworks that can be used by other software developers in different domains.

3- All the recruited interviewees were from the same company which might produce a population bias because they may have been working on the same projects and have current near-thinking ways despite their experience levels.

A common threat to validity might be the lack of knowledge of the participants on the ontology concepts and why it is used as a barrier to understanding the rules and what the benefit of creating them is. This was solved by giving them an idea of the need for ontology while providing the basic concepts with some examples.

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V. PROOF-OF-CONCEPT APPLICATION

While running the interviews and discussing the immersion scenario of the Samsung Health application, the interviewees provided some ideas on how to add more elements that adapt to the different types of users. Below are some samples of some elements that can be added to the Samsung Health Application to cover all types of users and to be an evolution for the application. This will help the system to adapt the elements that are shown based on the user preferences and user type by following the steps of the proposed framework in this research.

To make the evolution of the system without changing the whole user interface and user experience, the interviewees suggest some added icons that represent new gamification features mapping to different user types. So, the application in this case will cover the needs of the different user types, permit the integration of the new proposed framework, and be able to adapt the gamification elements based on the usage and preference of the users on runtime.

The Home screen of the Samsung Health Application is composed of the items that the user prefers to manage the most as shown in Figure 10 (Number of steps per day, Active time, Caffeine, Water, Sleep time, Weight management, Blood pressure, ...). Each user can manage the items that appear on his/her home screen from the "Manage Items" screen as shown in Figure 11. As a POC, the interviewees have chosen one of Samsung's features to show how the researchers can add Gamification Elements to it that can cover all the different user types' needs. The chosen feature is called "Together" as shown in Figure 12 which is used to track one's steps activity with regards to other people. One can also challenge one of his/her friends or participate in the global challenges as shown in Figure 13.

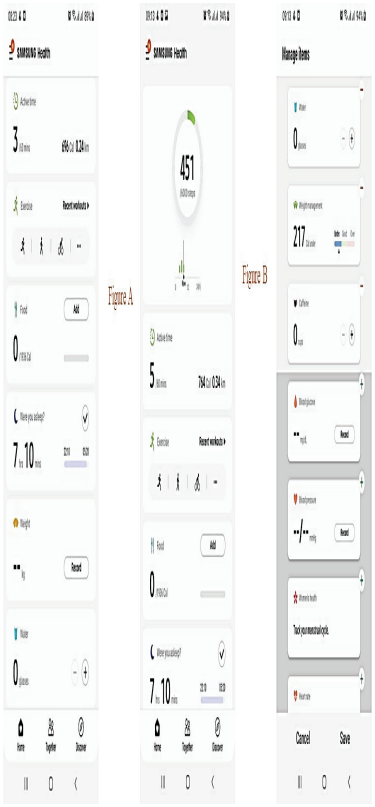

Fig. 10. Samsung Health Home screen

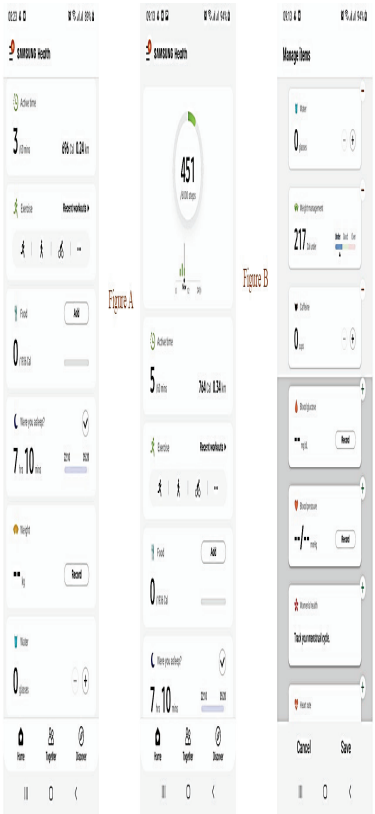

Fig. 11. Manage Items

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Fig. 12. Together Icon

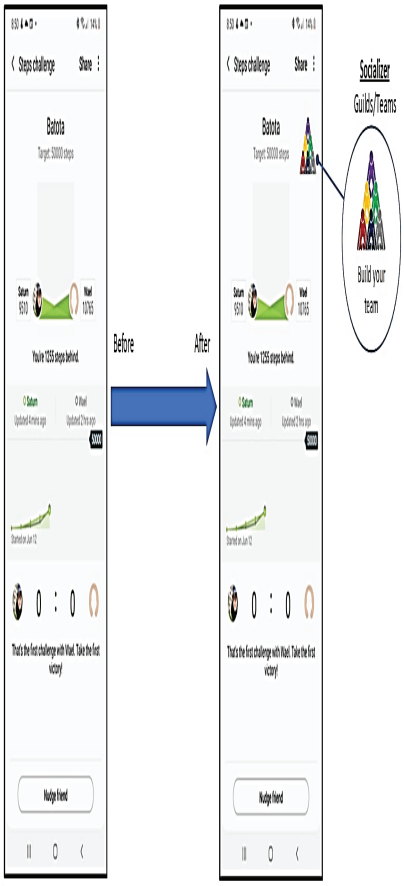

Fig. 13. Steps Challenge

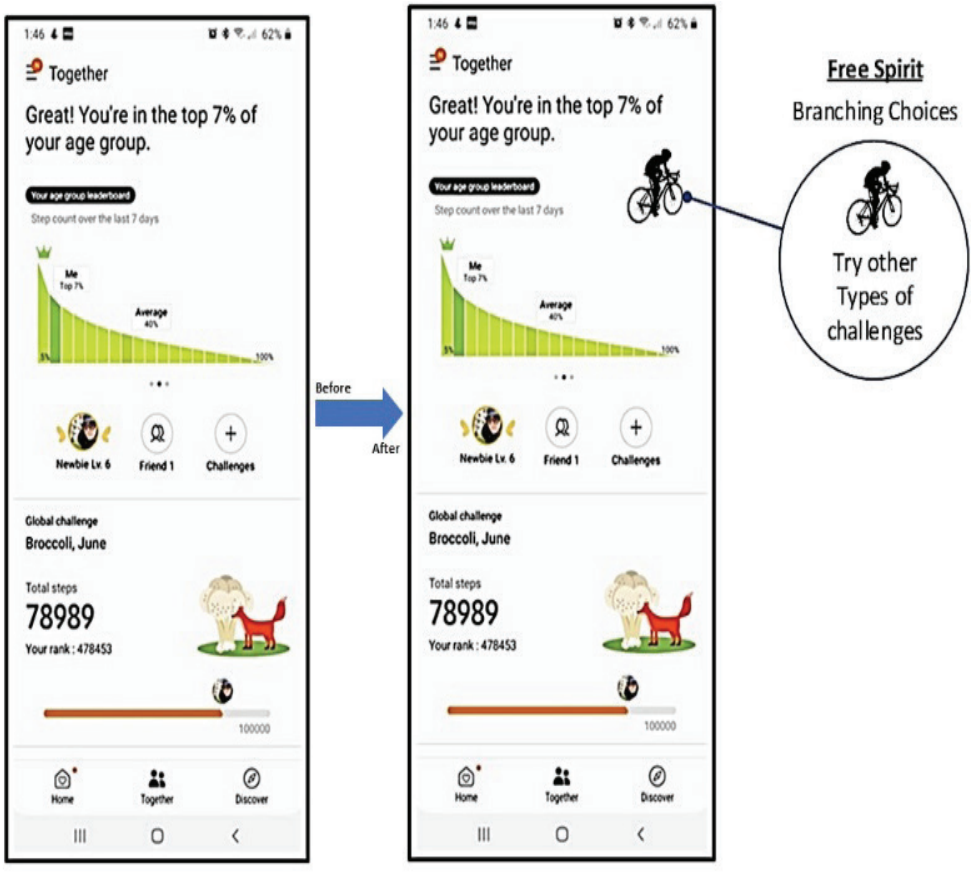

Fig. 14. Branching Choices

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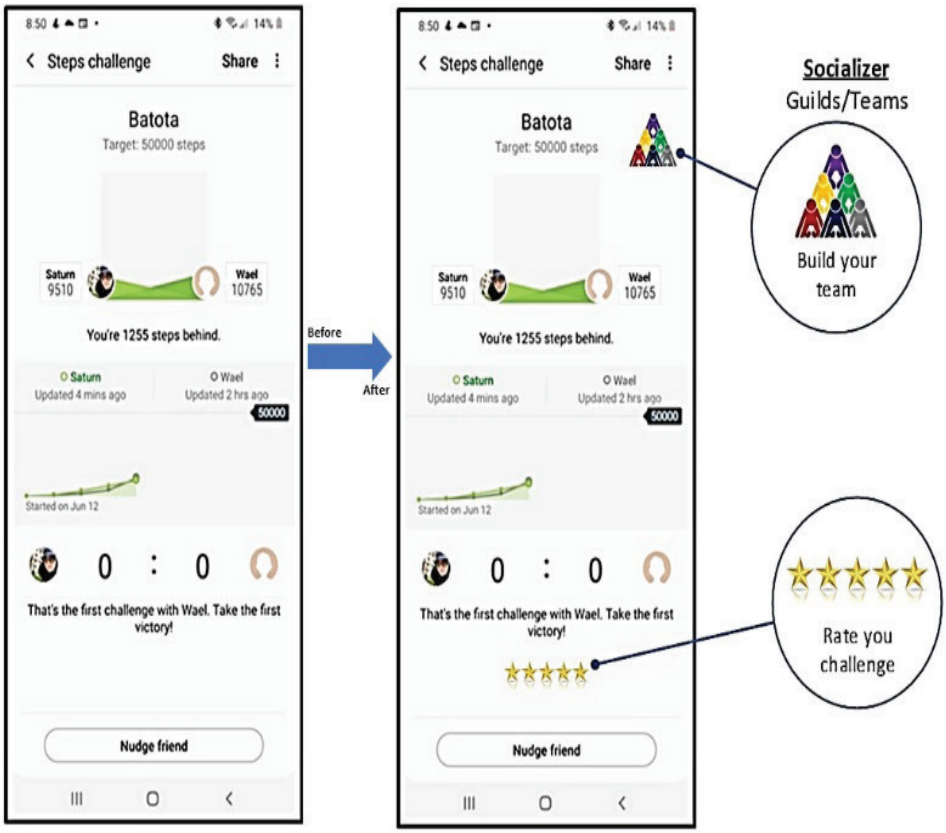

Fig. 15. Guilds/Teams and Rating

Another suggested example is to add a new icon called "Build your teams" as shown in Figure 15 to help the socializer user type to have a place where he/she can use the "Guilds/Teams" gamification element to engage and attract him/her to the system and fulfill his/her needs. A star rating can be added to take the feedback of the user on each feature too.

To this point, everything is fine but the problem is that this feature does not cover all the gamification elements that help in the engagement of the different user types. Some of the interviewees suggested some changes to the "Together" screen while conducting the evaluation study with the Software engineers. For example, the application can provide different types of challenges other than the "Number of Steps" challenges by adding a new icon called "Try other Challenges" like in Figure 14 to help in the engagement of the Free Spirit user type using the "Branching Choices" element and give them different branches to make their choices.

Another example is to add Cloud on the top of the challenge map as shown in Figure 16 and let the Free Spirit user enjoy the exploration of the full map step by step by having the "Exploration" gamification element. Also, a (Like/Dislike) icon can be added to take the feedback from the users in different ways on the different features.

Figure 17 shows the "Personal Bests and Achievements" of the user. Besides, other interviewees suggested having an icon called "Share your achievement" which can be used for the Socializer users to make them able to have the gamification elements that suit them like the "Social Status" element. Also, the "Share and Give reward" icon can be added for the Philanthropist users to enable to them the "Gifting/Sharing" gamification element.

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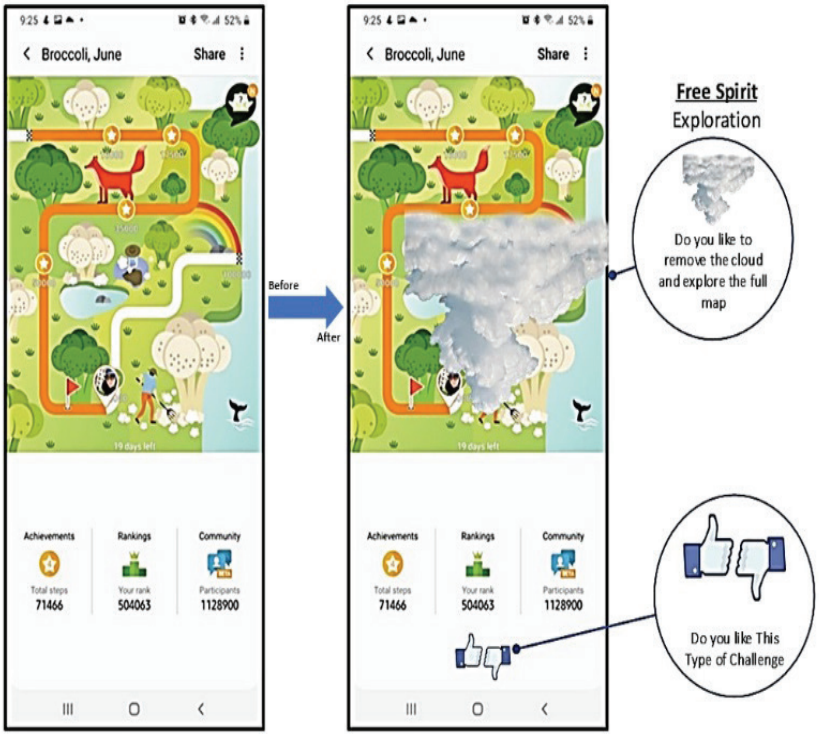

Fig. 16. Feedback and exploration

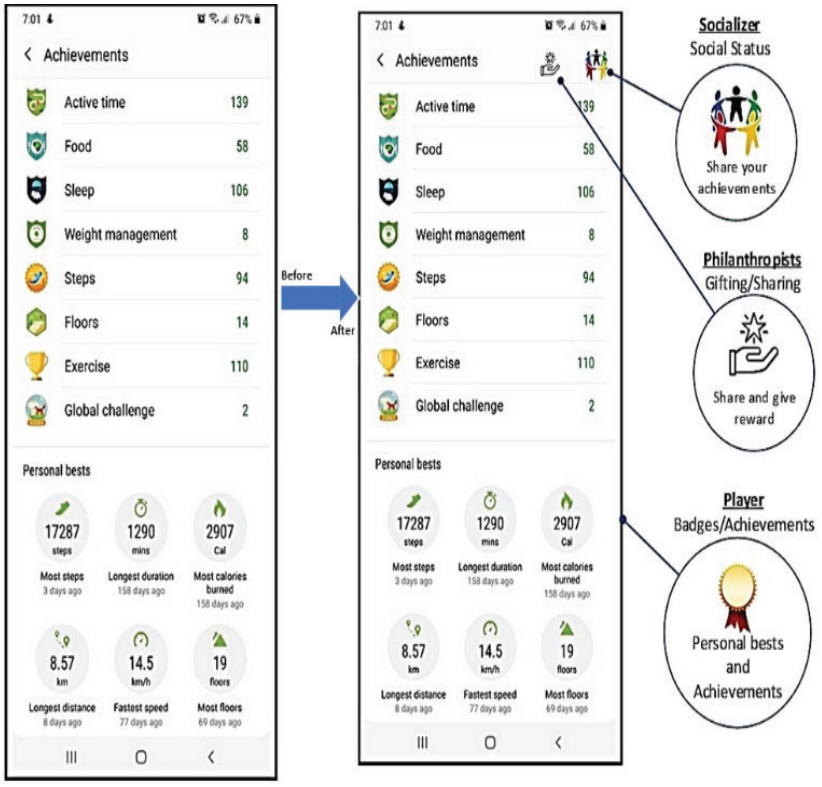

Fig. 17. Social Status, Gifting/Sharing, and Badges/Achievements

The interviewees want to enhance the functionality of the "Promotions" icon in the side menu of the Samsung Health application shown in Figure 18 to give the user different types of promotions and gifts like the Physical Rewards and Prizes which help the users of type "Player" to be more satisfied. A menu item called "Help us with your ideas" can be added if the Disruptors users have ideas for enhancement

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that use the "Innovation Platform" gamification element to engage them more in the application.

Figure 19 shows how the application can satisfy the users of type Disruptor by enabling them to masquerade their data for other users using the "Anonymity" gamification element. Also, the application can satisfy the needs of the users of Free Spirit by enabling them to customize their avatars using the "Customization" gamification elements.

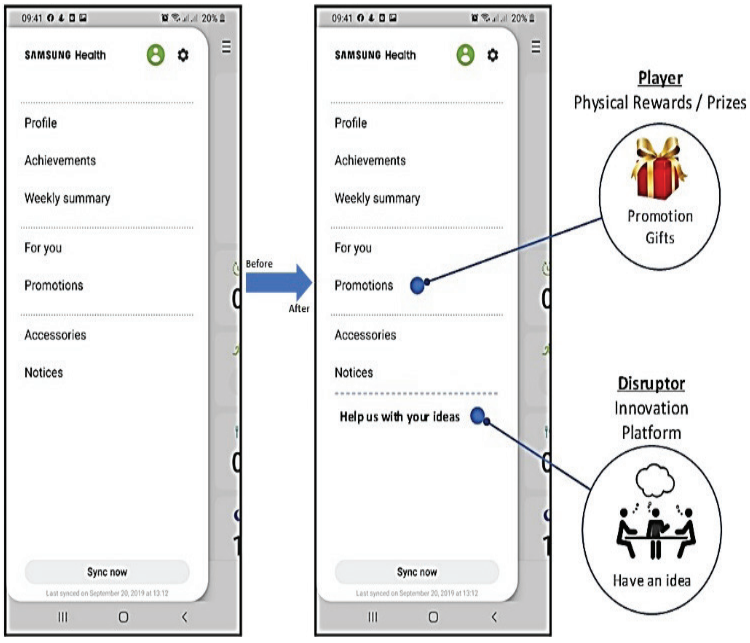

Fig. 18. Physical rewards and innovation platform

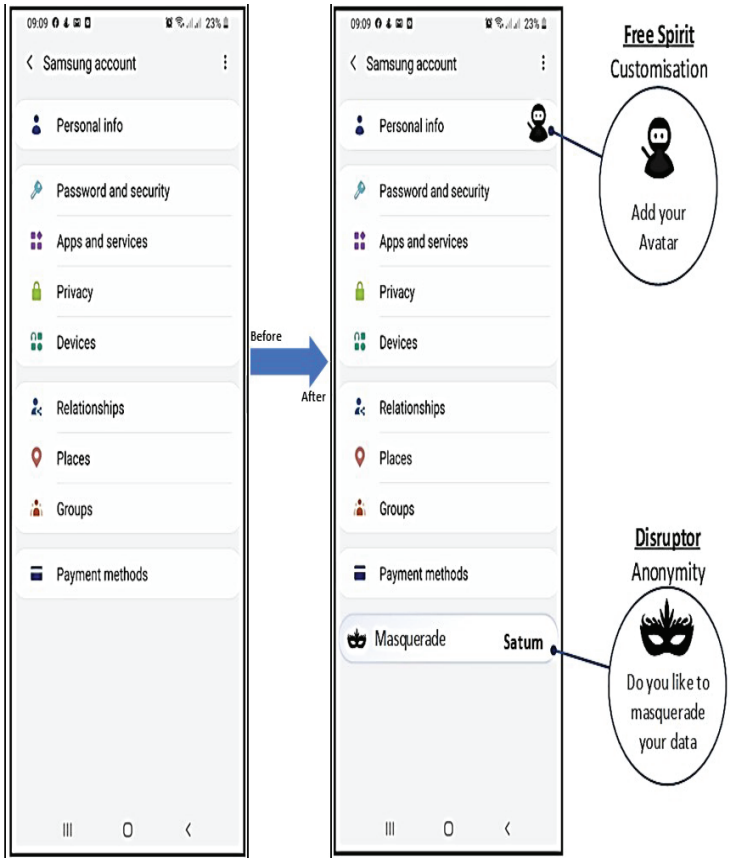

Fig. 19. Customization and anonymity

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Figure 20 shows how the onboarding that was suggested by some of the Software engineers during the interviews can be applied for the user to know the system works and help him/her get the full benefits from the system. Also, this will help the user to understand that the system will be customized based on his interaction and based on his preferences.

The above-suggested changes will permit the different users to access the elements that suit their user types, engage them more with the system, and fulfill and satisfy their needs. On the other hand, the system will record their usage and their preferences to show and hide the elements while following the steps of the proposed framework.

VI. EXTENDED ONTOLOGY IMPLEMENTATION

This section discusses the evaluation of the design and structure of the ontology of the model. The research of [44] shows the main classes of ontology and the object properties hierarchy which contains the relationships between the classes in ontology. In the below subsections, the ontology validation is presented using reasoned, Instances, and SPARQL queries to test the ontology and evaluate its utilization.

Figure 20: Onboarding

VII. REASONER AND ONTOLOGY VALIDATION

One of the important stages of the ontology that helps to guarantee that the implemented structure is following the common best practices is the Reasoners. Reasoner automatically detects any inconsistency in the ontology while checking the instances and the equivalence. Also, the reasoner checks on the properties and their hierarchy and ranges. In this research, a Reasoner was added to validate the ontology structure and rules of the proposed framework. This step of validation is used to validate the inner structure of a model [52].

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In this research, the researchers used HermiT reasoner [53] to validate the inner structure of the ontology which has an easy user interface that works with Web Ontology Language (OWL) that can be integrated with Protégé and supports object properties, classes, and rules with OWL 2 standards. This is a parallel task that helps in enhancing and structuring the ontology.

VIII. INSTANCES

Instances were created and used with classes and object properties. This helps to validate the created ontology structure by linking the classes, testing the rules, and the object properties, and defining if the listed rules and classes are enough and sufficient for the target model.

Figure 21 shows a sample with a list of instances created for the User type Hexad, Motivators, and Big Five personality traits. The instances have been created with the same naming convention on the subclasses.

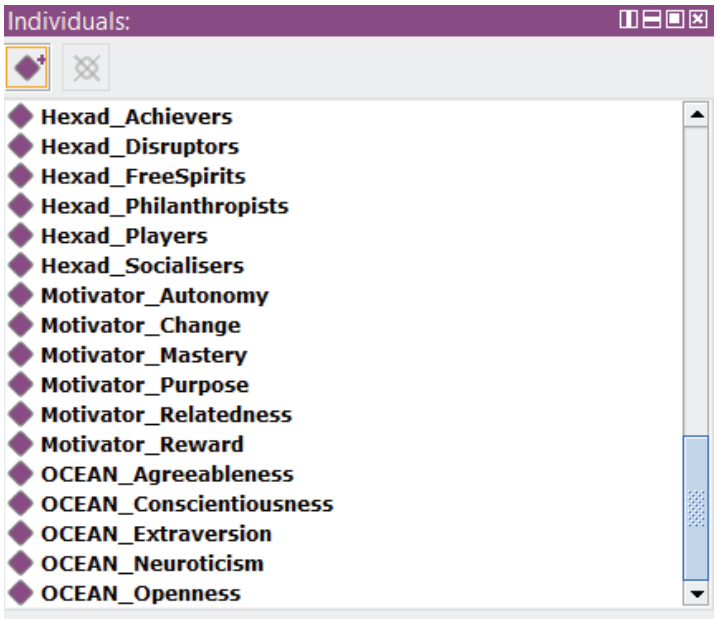

Fig. 21. List of instances created for the User Type Hexad, Motivators, and Big Five personality traits

Figure 22 shows a sample of the Instances of Hexad user Types. Each of them is linked to its mapped subclass type to be used in the validation of the ontology. Figure 23 shows a sample of the Hexad Instances property assertions to apply the Object properties created.

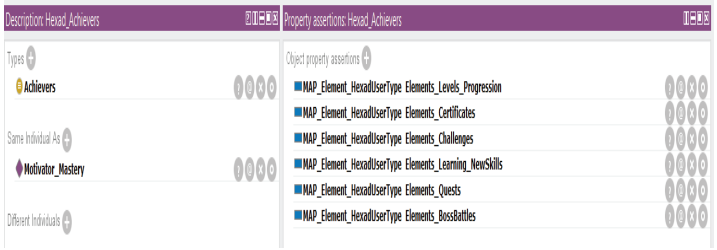

Fig. 22. Sample on the Instances of Hexad User Types

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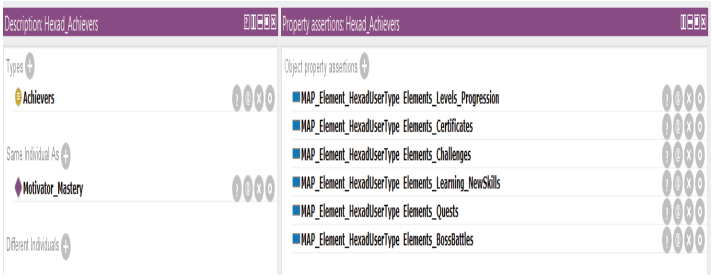

Fig. 23. Sample on the Hexad Instances property assertions

Figure 24 shows some of the list of instances created for the Elements. Each of them is linked to its elements subclass to be mapped to the needed user types and to configure whether the rules of the mappings (Direct, Indirect, Partial, Total) are implemented in the right way.

Each of the Elements Instances configuration is linked to its mapped subclass type. In addition, each of the Instances of Motivators is linked to its mapped subclass type. The OCEAN Instances configuration is linked to its mapped subclass type to be used in the validation of the ontology as well all found at this link https://bit.ly/3m9gjfq

Figure 25 shows a sample of the OCEAN Instances property assertions to apply the Object properties created.

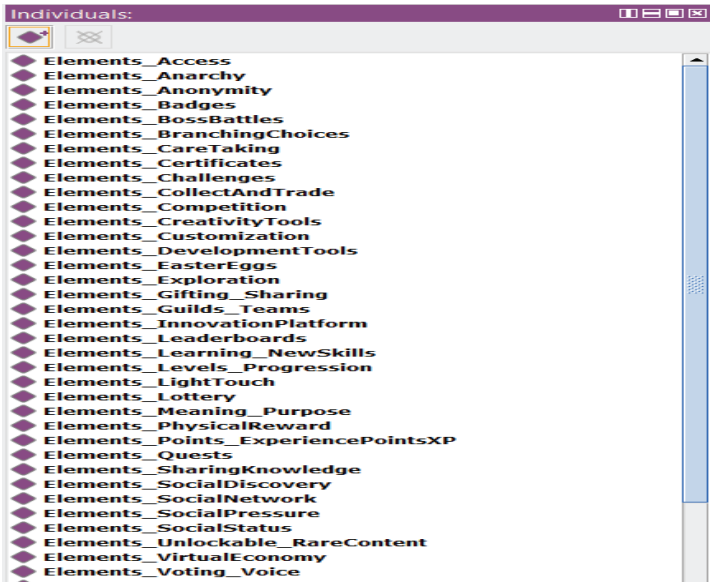

Fig. 24. A sample of the list of instances created for the Elements

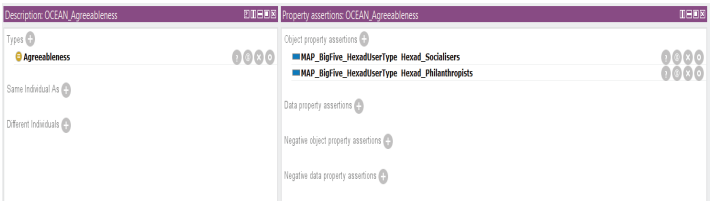

Fig. 25. Sample on the OCEAN Instances property assertions

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SPARQL QUERIES

After ontology implementation, enhancement, and fixing the bugs that resulted from the reasoner comes the need for queries that extract all the needed information from the ontology and test the result too. Those queries prove that the software engineer will be able to extract the needed information from the implemented ontology and he/she can use it as a knowledge base of structure and rules of the model and be able to enhance the process of designing an adaptive gamified software based on each user type.

The Query shown in Figure 26 is designed to get all the available mapping between the Hexad player types and its Motivators and their related elements for each of them representing the direct mapping that is explained in the Weighting module previously discussed. The result of this query can be used by the software engineers to select the random elements and to adapt the system elements based on these mappings. Mapping between the OCEAN user types and Hexad player types is available as well. Finally, the ontology is designed to get all the available mapping between the OCEAN user types and their related elements for each of them represents the indirect mapping that is explained in the Weighting module of the "Proposed framework" using SPARQL queries. The result of this query can be used by the software engineers to select the random elements and to adapt the system elements based on these mappings.

Snap SPARQL Query:

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX owl: <http://www.w3.org/2002/07/owl#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX E: <http://www.semanticweb.org/admin/ontologies/2017/10/untitled-ontology-37#>
PREFIX U: <http://www.semanticweb.org/admin/ontologies/2017/10/untitled-ontology-5#>


SELECT DISTINCT ?Hexad ?Elements
        WHERE {
                        {?Hexad E:MAP_Element_HexadUserType ?Elements}
                }
ORDER BY ?Hexad ?Elements
```

Execute

?Hexad	?Elements
E:Motivator_Relatedness	E:Elements_SocialDiscovery
E:Motivator_Relatedness	E:Elements_SocialNetwork
E:Motivator_Relatedness	E:Elements_SocialPressure
E:Motivator_Relatedness	E:Elements_SocialStatus
E:Motivator_Reward	E:Elements_Badges
E:Motivator_Reward	E:Elements_Leaderboards
E:Motivator_Reward	E:Elements_Lottery
E:Motivator_Reward	E:Elements_PhysicalReward
E:Motivator_Reward	E:Elements_Points_ExperiencePointsXP
E:Motivator_Reward	E:Elements_VirtualEconomy

72 results

Fig 26. Screenshot for SPARQL Query to get elements of each Hexad player type and its motivators

IX. FEATURE MODEL IMPLEMENTATION

According to the comments resulting from the interviews in the section of "Evaluation Results", it was mentioned that it is very important for software engineers to know each feature in the system is linked to which game elements. So, to add this part, a tool is needed to help in modeling and listing the features. This can be done through the ontology by adding the list of features in a dedicated class for Features Model which can carry any of the features. Then, creating object properties to allow the different types of linkage between the features and the elements. Finally, creating instances was implemented to simulate the link between the feature model and the elements already created and to validate the rules of the Feature Model.

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In this section, a small example representation of the Healthcare Feature Specification (Feature Model) is represented as an example of the feature-to-elements mapping.

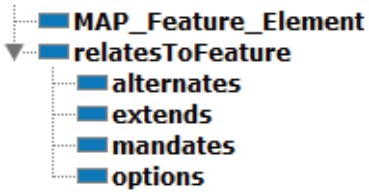

Fig. 27. Feature Model Object Property List for sharing feature

First, a class for the Features Model was created and named "FM_Features" to carry any of the features. After that, Feature Model Object Properties were created. The "relates To Feature" object property was created with the four types of applicable relations (alternates, extends, mandates, and options). Also, the "MAP_Feature_Element" is created to relate the features with the elements. Figure 27 shows the created object properties.

Then, to test and validate the created Feature Model class and the Object properties, sample instances for the features were created. Assuming that the researchers have a sharing feature that has two alternatives (ShareWithFriend and ShareWithOther). The ShareWithFriend feature has three options (Facebook, Instagram, and Twitter). Figure 28 shows the list of created instances.

Fig. 28. Feature Model Instances List for sharing feature

Figure 29 shows a representative graph of the list of features and the relations between each other and the elements based on the object properties.

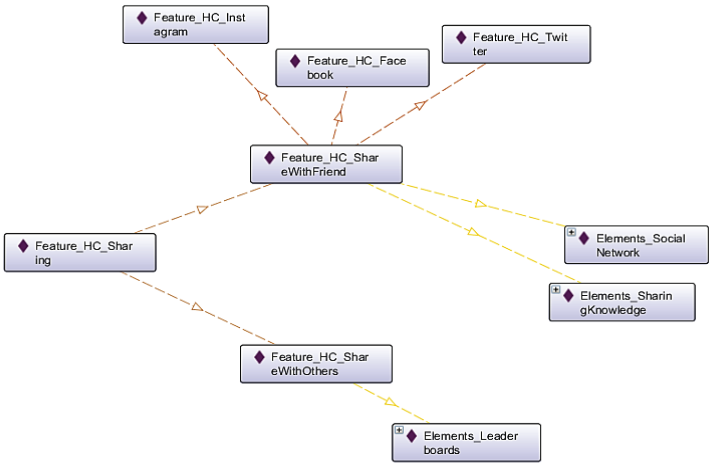

Fig. 29. Representation graph on the Features Instances property assertions relations

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Figure 30 shows the Feature_HC_Sharing Instance configuration of a type Feature class and with two object properties assertions with "alternates" relation (Feature_HC_ShareWithFriend and Feature_HC_ShareWithOthers) to identify the two types of sharing.

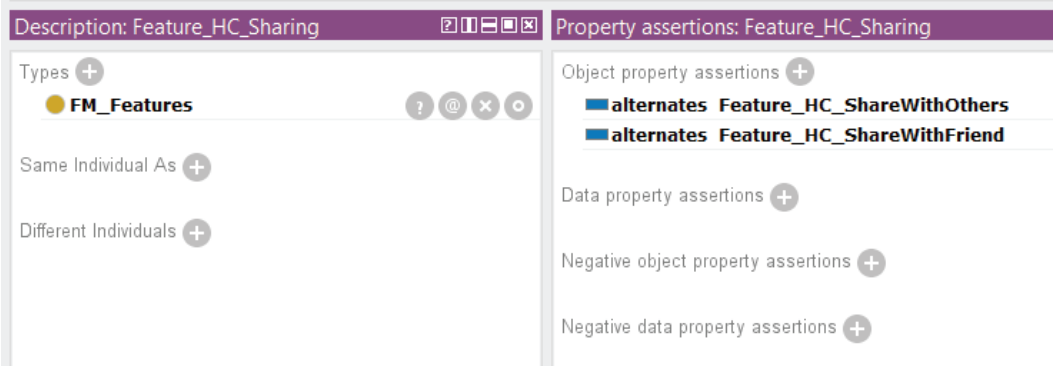

Fig. 30. Feature_HC_Sharing Instance configuration and property assertions

Figure 31 shows the "Feature_HC_ShareWithFriend" Instance configuration of a type Feature class and with three object properties assertions with "options" relation (Feature_HC_Facebook, Feature_HC_Twitter, Feature_HC_Instagram). Figure 32 represents the options relations, respectively.

Also, in Figure 31, the relation between the "Feature_HC_ShareWithFriend" instance and the gamification elements of (Elements_SharingKnowledge and Elements_SocialNetwork) is shown.

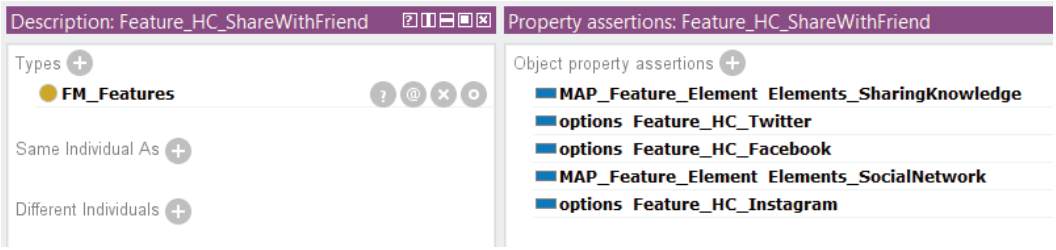

Fig. 31. Feature_HC_ShareWithFriend Instance configuration and property assertions

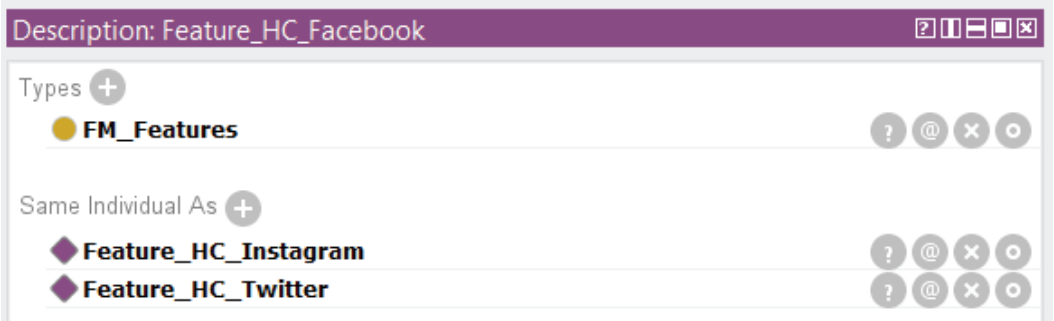

Fig. 32. Sample on the Feature_HC_Facebook Instance configuration

Figure 33 shows the "Feature_HC_ShareWithOthers" instance configuration of a type Feature class and its relation to the gamification elements of "Elements_Leaderboards".

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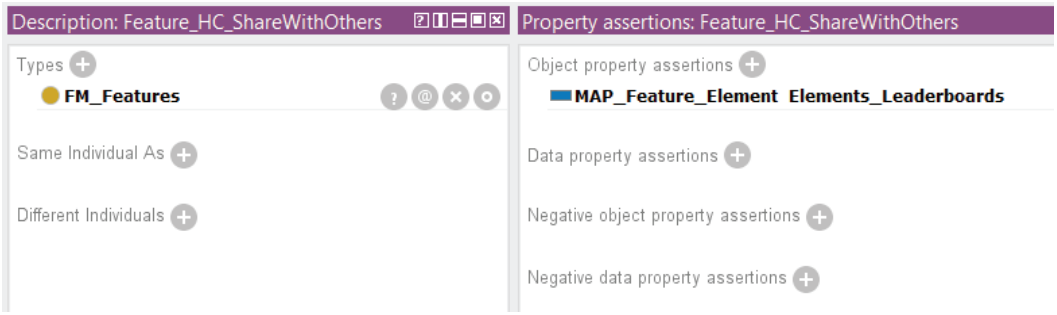

Fig. 33. Feature_HC_ShareWithOthers instance configuration and property assertions

X. CONCLUSION

Adaptive personalized gamified systems are one of the top research scopes for software engineers. This paper focuses on evaluating a previously introduced adaptive personalized gamified framework in the actual context, i.e., evaluating software when users are using it in practice. By access to a broader and different set of users and contexts of use that were unpredictable by analysts, this approach allows users to act as the actual validators of the system and give feedback and it informs the software development process, e.g., by introducing a more formalized structure for concepts and their relationships to provide useful and meaningful information to accurately accomplish the design and adaptation tasks. The enhanced framework and weighting module is also presented after applying the experts' comments.

Also, the paper includes validation testing of the previously introduced Ontology for the adaptive personalized gamified framework using reasoned, Instances, and SPARQL queries.

For future work, extending the framework to include a recommender module which will be an asset to the design framework by integrating social media, using historical data for initial weights, identifying the probability that the user can see the nearest elements, clustering the elements, use teaser popups and suggestions for the users.

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