Enhancing the Adaptative Gamification Process Through User Behavior and Context

Diego Torres[1,2], Juan Enrique Garrido[3], Maria Dalponte Ayastuy[2,1], Alejandro Fernandez[1], and Cesar A. Collazos[4]
(1)LIFIA, CICPBA Facultad de Informatica, Argentina
(2) Departamento de CyT, UNQ, Argentina
(3) Department of Computing Systems, University of Castilla-La Mancha, Spain
(4) Departamento de Sistemas, Universidad del Cauca, Colombia
diego.torres@lifia.info.unlp.edu.ar

Abstract

This article presents an innovative approach to developing a strategy for situational awareness in an adaptive gamification framework within the context of Collaborative location-based collecting systems (CLCS). The proposed approach involves incorporating five key factors that represent user behavior and context in the adaptive gamification process for CLCS. These factors include player preferences, player status, gamified activities, groupware activities, and project goal status. Each factor is crucial in describing various aspects of the framework and groupware interaction that players should be aware of during their game experience. By acquiring knowledge about these five axes, users can analyze and react appropriately to various situations. This modeling approach enables the early development of awareness and facilitates decision-making. Ultimately, this article serves as a useful guide for improving existing frameworks and enhancing the overall user experience through situational awareness.

Keywords: Situated Awareness, Adaptive Gamification, Collaborative Collecting Systems.

1 Introduction

Citizen Science (CS) is a methodological approach that encourages people non-related to an academic institution to actively participate in the design and run of a scientific project[1]. Different activities could be performed in CS projects, for example, co-design activities, analysis of data, collection of data in the field, data analysis, or collaborative solving problems[2, 3, 4]. Collaborative location-based collecting systems (CLCS)[5] are collaborative systems for a community of users that collect data that minimally includes geo coordinates and timestamp information. In the con-text of CS, there are several such as iNaturalist[6], or Spotteron[7]. Users involved in CLCS move to a specific location and collect information in situ by completing a survey task, taking pictures, recording a video, or doing another type of activity using a mobile application. Usually, CLCS has specific objectives related to coverage in terms of space and time. For example, collecting specific data in a specific area during the weekend. Adaptive gamification is a trending strategy to engage, direct participation, and retain users according to users' behavior and preferences[8]. Gamification is the way to add game elements to an action that was not designed as a game[9]. Indeed, adaptive gamification considers that gamification elements cannot be generalized to all domains and all users. CLCS could incorporate adaptive gamification to have better participation from the public and improve project goals with an adequation of gamification activities that better fit user behavior and project goals. An approach to adapting gamification is to provide personalized game elements to the users. Indeed, as the user is interacting and solving the activities proposed by the CLCS, the adaptive gamification engine generates game elements, which could be, for example, more or less difficult than the current one according to the player profile.

Dalponte et al.[8], propose a basic framework that includes the following steps (see Fig. 1): the system recommends a list of game elements ordered by the user's expected preferences, then the user selects one according to her actual preferences, and according to the selection, the system adjusts the preferences of the users (i.e. user selects the second implicitly means she prefers that instead of the first), then the user

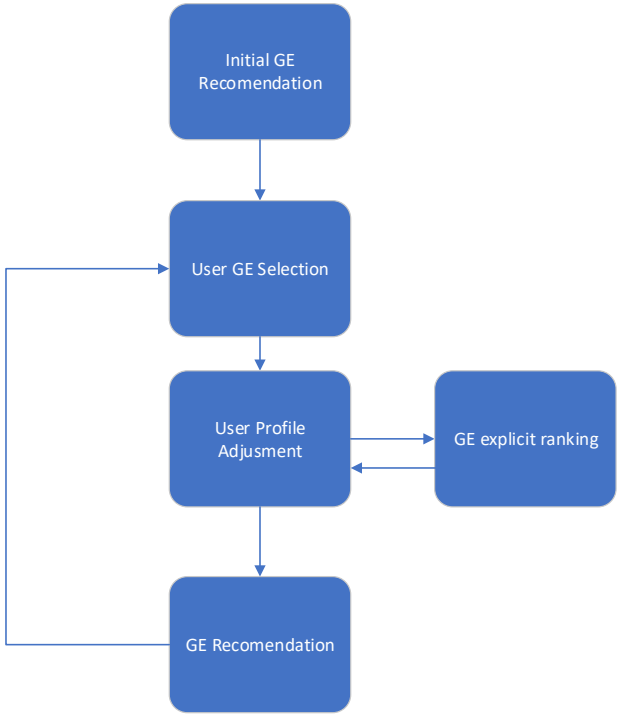

Figure 1: Dalponte et al. recommendation approach

provides explicit feedback about the game element (for example by rating it), all of this generates adjustment of user profile to be updated to the next game element recommendation. However, the initial approach of Dalponte et al. does not include an awareness of system behavior or other players' activities.

Being aware of what is happening around the user is an essential factor for completing objectives. In this sense, there is a need to consider awareness as a key factor to be included in a framework oriented to gamification. Awareness has been defined as "knowing what is going on" by Mica Endsley in 1995[10]. The concept refers to the perception users have of the system state. It is a real need to a greater or lesser extent based on their role. The concept appears in groupware systems, but it represents an attribute to be considered in any context and user. In this sense, the context has offered several types of awareness based on the context: workspace awareness[11], interpersonal awareness[12], Residental Care Home (RCH) Awareness[13], or gaze-based awareness[14], among others.

Mica Endsley offers an interesting work focused on how awareness can evolve from the user's point of view. Concretely, the work defines Situation Awareness (SA) posed it as "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning, and the projection of their status in the near future" [10]. The definition is based on an individual's mental model of the ongoing situation working on three levels in which the knowledge evolves.

Taking decisions and obtaining adequate awareness are part of games. Therefore, the levels of SA should be considered for gamification frameworks as it can help to reflect the evolution of the information given to users to decide future actions. There is a need to define parameters allowing designers to offer correct awareness for users of games. To that end, this paper tries to offer the integration of awareness as part of a particular adaptive gamification framework to generate a complete tool. The resulting framework pretends to be the correct way of modeling games with an adequate user experience.

This article proposes a deepening of the novel approach to designing a situated awareness strategy for an adaptive gamification framework in the context of CLCS which was presented in the "IX Jornadas Iberoamericanas de Interacción Humano-Computadora" [15]. Particularly the introduction of five representation features of user behavior and context in adaptive gamification for CLCS, namely, according to player preferences, player status, the gamified activities, groupware activities, and project goal status. Each describes as-pects of the framework and groupware interaction that each player should be aware of during their game experience. The user acquires knowledge about these 5 axes, and the user receives, analyzes, and generates reactions. With this modeling, it is possible to make decisions in early awareness development. Finally, this article can be used as a best practice guide to improve an existing framework through awareness to improve the user experience.

This article is organized in the following. Related approaches in the literature are described in Section 2. Section 3 introduces Rayuela[16], a reference framework to apply adaptive gamification. The framework sets the bases of the interactive activities and profiles the system stores about the players and which variables are considered to adapt. Then, Section 4 describes the main five perspectives that we consider relevant in the impact of the adaptation and also in the awareness of the users. The awareness design strategy is introduced in Section 5. Finally, the conclusions and further work are enumerated in Section 6.

2 Related Work

We have not found specifically related works that combine the awareness design for gamification frameworks at the moment of writing this article. Related to social games, social presence awareness in a videogame and consoles[17, 18] are mainly focused in the context of game consoles.

Most of the development of awareness is in groupware systems, including definitions of virtual space awareness[11, 19]. In the work of Collazos et al.[20], the authors also introduce five-axis in an awareness architecture which includes awareness goals to support, awareness information identification, modeling, distribution, and awareness of user interface. Although the goals are not directly connected, the approaches could be complemented by the one introduced in this article.

3 A proposed framework for adaptive gamification

To define the implications of an awareness strategy to an adaptive gamification framework, this article takes as reference Rayuela, an adaptive gamification framework for CLCS. This platform adds an adaptive gamification layer to existing citizen sci-ence projects. Figure 2 shows an overview of the challenge-based adaptive gamification layer. There, the citizen science project in the gray box provides the task that users (a.k.a. citizen scientists or volunteers) should complete, generally by collecting loca-tion-based information using their mobile phones. Volunteers complete the task using the project tool without any type of gamification. Rayuela provides a new layer of gamification outside the project's main application. In Rayuela, the citizen science project manager registers their project and configures their goals in Rayuela (Project setup box). Then, volunteers make a registration for Rayuela and select to play the game of the citizen science project. Every time the volunteer completes a task in the citizen science project, the volunteer registers the action in Rayuela. Then, Rayuela uses that information to combine through the Gamification Engine, a user profile, and a game challenge recommendation, a specific game challenge adapted for that volun-teer.

The previous overview of Rayuela, implies different aspects of the system and the context in which the volunteer (user) needs awareness. Many aspects are involved in the awareness of the users. The following are the main characteristics of the Rayuela framework

3.1 Rayuela architecture

Project Setup and Gamification engine are the main modules of Rayuela architecture. The project setup module manages the configuration the citizen science project man-ager provides. The Gamification Engine module provides adapted game challenges according to volunteer behavior. Particularly it has three main components: user pro-file to manage the implicit and explicit information about the user, game challenge generation to build game challenges that are in line with project goals, and finally, the game challenge recommendation module to select the game challenges generated by the former module that best fit to the specific user

3.2 Rayuela Framework

Rayuela is also designed as a black box framework that implements the adaptive gam-ification approach and could be extended with specific strategies. Fig. 3 introduces a UML class diagram depicting the main object classes. It has three packages: User profile, Generation and Recommendation. user information (User class), playing his-tory (AssignedGameChallenge class), and completed tasks (CompletedTask class) are the main classes of the first package; the second package includes the GCGenerator interface to allow the implementations of any generation strategy, particularly Rayuela includes a default generator class. The last package also includes a hierarchy for the game challenges recommendation. Similarly to the Generation package, it includes a GCRecommender interface and a default implementation.

The conceptual workflow detailed in Fig. 2 is implemented by ProjectsGamifica-tionEngine class (Figure 3). It combines the different strategies of UserProfile, Genera-tion and Recommendation packages. In a few words, the workflow starts with the recommendation of the initial game challenges with the information that is recorded in UserProfile (considering the cold start problem). After the initial recommendation, the

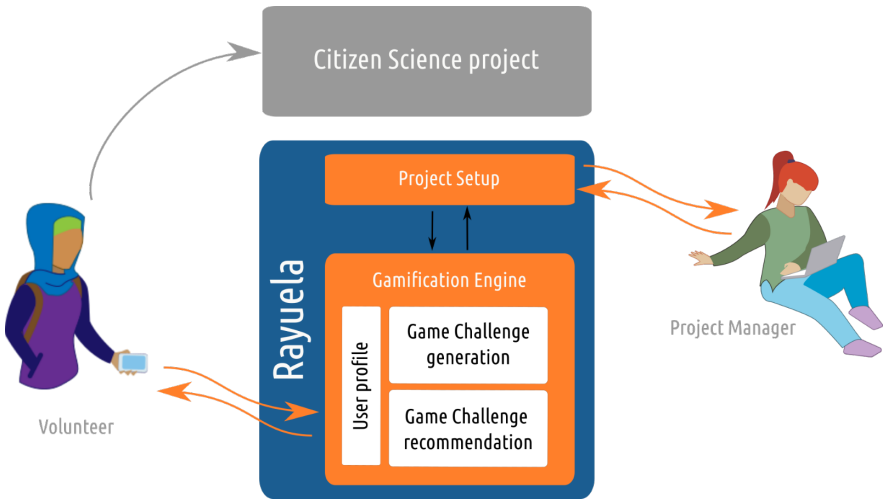

Figure 2: Rayuela overview

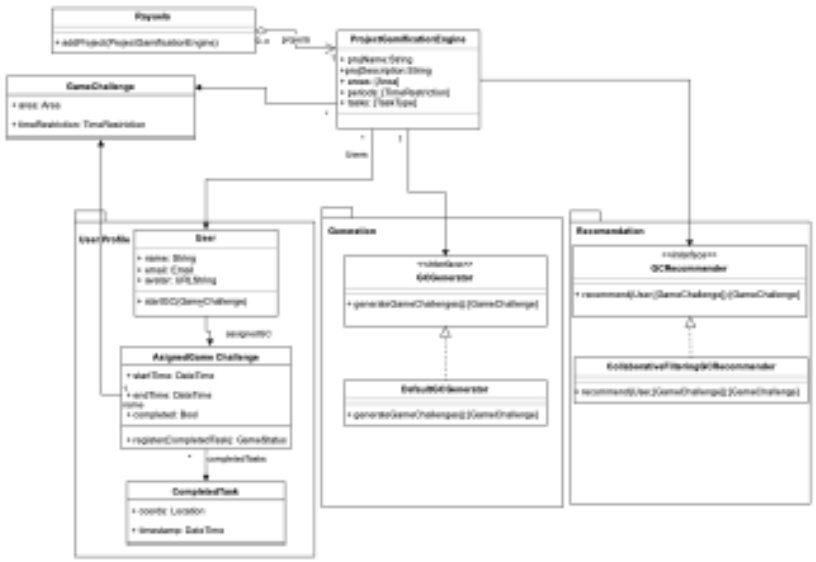

Figure 3: Rayuela class diagram

framework records the user selection. This selection could be recorded as implicit feedback from the user; for example, if the selection is not the first recommendation, it could mean the recommender needs to do an accurate order of the recommended elements. After the game challenge selection, the user provides another type of feed-back to improve the recommender. All these user feedbacks are also interpreted as specific user preferences or behavior activities and then stored in the User profile. Having that, the following recommendations will be based on a most robust user profile.

As we can notice, user interaction generates updates in its profile. The system creates content based on the user's profile. Therefore, the user must be aware of their profile status and understand how their behavior affects the system's response. Having all the relevant information is essential to ensure a smooth user experience. In this sense, it could be useful to consider the definition of Situation Awareness as indicated in the introduction of this paper. The evolution of the profile status is awareness received by the user. Therefore, a key point is to consider how the user perceives, analyzes, and uses it to react in the near future as part of the game. To that end, the application of the SA's levels is essential for the definition of attributes to let the framework in the generation of the evolution of the information received by users.

The following section will introduce different interactive hotspots to be aware of the interaction of the users related to an individual and a group point of view.

4 Characteristics of users from the adaptive gamification perspective

As we have explained in the previous section, the system performs adaptive gamifica-tion by taking into account the internal representation of each player. This representa-tion, also known as a profile, is given in terms of the person's preferences, the activi-ty the person is playing, the person performing the gamified activity, other people performing the gamified activity, and the general state of the project. These dimensions, in turn, are represented internally in the system. And it is based on these inter-nal representations and modeling that adaptive gamification makes decisions and recommendations.

In the following, we will describe what aspects are important to model for the Rayuela adaptive gamification system that serves as a framework for describing differ-ent aspects of the internal representation of an adaptive gamification system.

4.1 Player Preferences

The preferences of a player are generally pairs of attributes and values that describe static aspects of the tastes and preferences of each player. Among them, we can find from aspects linked to personal descriptions such as gender, age, or language preference, to issues specifically linked to their character as a player, for example, tastes in game types or narrative themes. All of these characteristics will not change during the game's life, or in any case, they will suffer very few changes made explicitly by the player. That is why they are considered static.

4.2 Player status

Citizen science projects propose to carry out tasks for which gamification is proposed. Common tasks are to collect situated information using a mobile application. For example, taking a picture of an object or filling out a form. These activities are linked to a geographical location. In Rayuela, task types are configured for each project at the setup stage. After performing one of these activities, each player registers in Rayuela that he/she has performed it and logs in. For each player, Rayuela records the type of activity they performed, when and where they performed it, and for which CC project. The information linked to time and space allows the system to project behavioral models of each player linked to displacement. Linked to the recording of the player's activities, we can list the following:

- Traveling characteristics
- Activities based on the task:
  - How many collections were made?
  - What is the collection rate per day, week, etc?
  - Which are the thematic preferences? (according to the most chosen projects)
- Quality of the performed activity

4.3 Gamified activity

They are determined by the characteristics that can be determined of the player linked to the elements of the game or the gamification layer. For example, determining the profile of the player[21].

- Player characteristics (Killer, Collector, etc)
- Selected Challenges
  - Challenge status, including Completed, Abandoned, Started, Remaining time, or Completeness.

4.4 Groupware related activities

Understanding the participation status of other players can aid in the efficient collaborative building of knowledge. The characteristics can be classified as either specific to the presence of other players or related to their status in the game.

Being around other people means having the opportunity to socialize and interact with them. This proximity can happen either in physical space, where they are close to each other, or in virtual space, such as being in the same virtual activity room. In both cases, temporality is important since if the space is shared at the same time, synchronous communication can be established, while if it is shared at different times, asynchronous communication can take place.

- Physical proximity and Virtual proximity
- Presence
- Activity performed by other players
- Current activity

The status of other players in the game is already defined in the previous section. However, in a groupware context, it is used to show the status of a third person different from the current player. With this, it is possible to make comparisons, for example:

- Activity rate in other projects.
- Scoring table.

4.5 Project Status

Projects have different characteristics that are susceptible to change during their life cycle. Although these characteristics can be very diverse, in this paper, we will limit them to those linked to the project's objectives. For example, the number of tasks performed to achieve an objective, the areas surveyed, or the number of active players.

The change of status of a project is mainly produced by two roles: the manager and the player. The manager is the one who adds or modifies objectives, defines the areas of interest and the types of activities to be performed. The participants are the ones who perform the tasks to be carried out throughout the game. This makes the state of the project dynamic as well.

The general characteristics of a project are:

- Level of completeness
- Number of active people
- The number of completed tasks
- Affected areas / geo-localized activity
- Temporal activity

5 Situation Awareness from the gamification perspective

Situation Awareness is a natural element of games, composing the part of the system that generates knowledge of those elements in the environment related to the users and their activities. Mica Endsley[9] offered a key definition that represents the con-text situation in an evolutive process matching with the mental model of the ongoing situation. That situation evolves along three levels (see Fig. 4. The situation aware-ness process as defined in [10]. Figure) :

- Level 1: perception of the elements in the environment. The user receives infor-mation from the environment.
  - Example - users perceive data: to workers are at their office. Suddenly, they perceive smoked aroma, an acoustic alarm and others workers who are apparently running for the exits.
- Level 2: comprehension of their meaning. The user analyses and understands the information received according to their context.
  - Example - users understand received data: the two workers (example of Level 1) analyze the received information as a whole and understand that there are problems in the building supposing a fire has started.
- Level 3: projection of future system states. According to the knowledge acquired, the user can decide what to the in the future. The user can make a decision.
  - Example - users predict based on received data: the workers (example Level 1 and 2) detect in a dynamic context that there is a need to go out of the building. The fire can affect the location where they are.

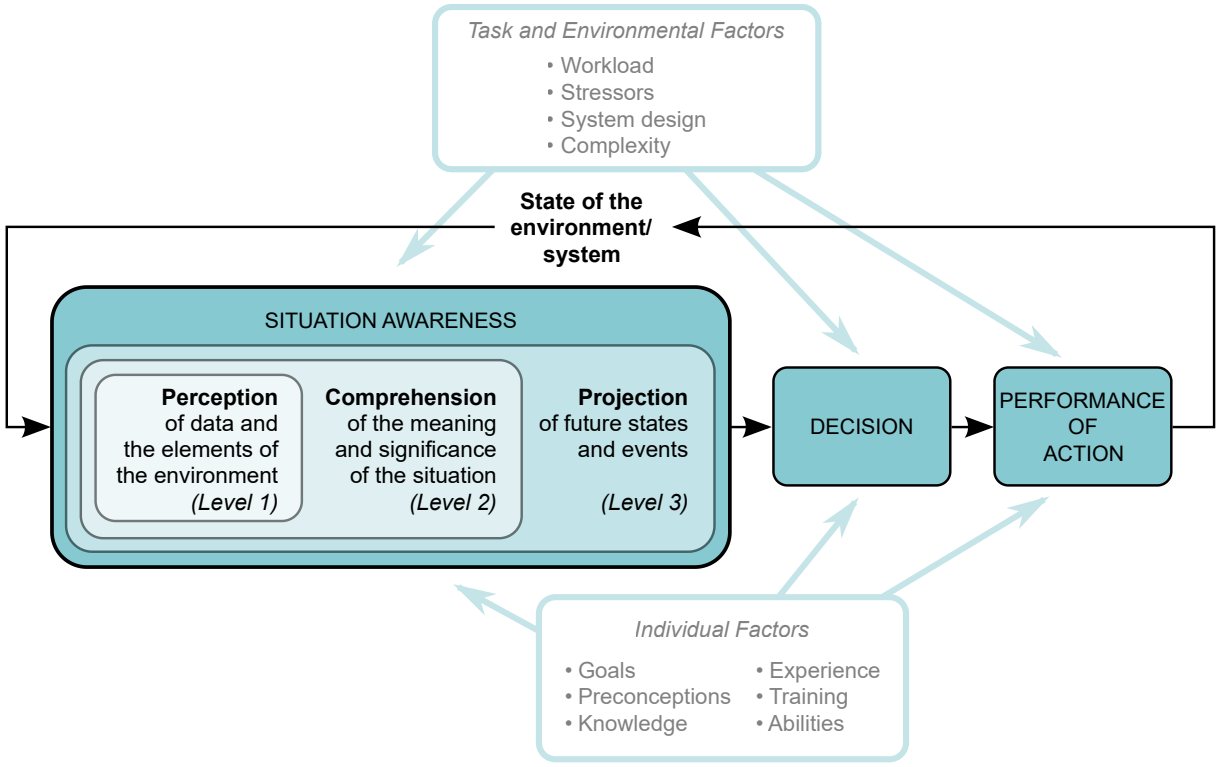

Figure 4: The situation awareness process as defined in [10]. Figure adapted by Dr. Peter Lank-ton in May 2007 (Wikipedia)

The three levels represent how awareness evolves from the user's point of view. The result is the evolution of the knowledge about the context. At the final state, the users are in conditions to predict and decide the next action more accurately. This issue is essential for dynamic decision-making, a key step in the context of this paper: adaptive gamification.

In videogames, understanding the information a user receives, while playing a game, represents a remarkable step in their experience. Each user needs time for receiving and detecting, analyzing and reacting to received information from an interaction. In other words, the user needs an evolutive process related to the received information. In this sense, the levels inside SA as Mica Endsley has proposed matches perfectly with the mental model of a user while gaming.

Making decisions and obtaining adequate awareness are part of videogames. There-fore, the levels of SA should be considered for gamification frameworks as it can help to reflect the evolution of the information given to users to decide future actions. There is a need to define parameters allowing designers to offer correct awareness for users of games. To that end, this paper tries to offer the integration of awareness as part of a particular adaptive gamification framework to generate a complete tool. The resulting framework pretends to be a correct way of modeling games with an adequate user experience.

The previous section has described specific characteristics of users offered as part of the game to be aware of the context. Therefore, each characteristic offers information that can be considered independent of general awareness. In this sense, there is a need to analyze those characteristics to know and understand which is their contribution to the awareness offered to the user.

The user receives each of the characteristics in two possible ways:

- Quantitative view in terms of objective values such as a percentage.
- Qualitative view in terms of a more subjective way as it is an explanation of the meaning of the quantitative related value. This explanation can be seen as the interpretation of the quantitative data according to the user's preferences given to the system and considered as a key part of Rayuela.

Both views work in parallel as each quantitative view has an associate view for any of the gaming characteristics. On the one hand, the quantitative view is an adequate option to measure as it should contain quantities. On the other hand, the qualitative view is oriented to offer a more understandable way as it should contain explanations of the quantities (quantitative view). These views are complemented with

General Family	**Specific Topic**	**Quantitative view (Level 1 SA)**	**Awareness understanding (Level 2 SA)**	**Projection (Level 3 SA)**
Player Status	Challenge progress	Accomplish percentage of the total	How near or far the challenge is to be completed	The intensity of the effort to be applied in the next steps
Groupware	Physical proximity	Meters from a collaborator	How near or far a collaborator is in the real context	The options for being helped ot to help others
	Current activity	Activity in progress	Current objective of the player	Action to perform as the next step
Project Status	Temporal activity	Number of intensity level related to the current activity	How intense is the current activity	The level of concentration in the next task

Table 1: Situated awareness levels of adaptive gamification perspective

a final decision related to each characteristic, named the projection view, representing the result of applying the knowledge obtained during the current context of the game.

The views help in the objective of the present paper as it implies an evolution of the situation awareness received by the user during a game. Concretely, those views represent the two first levels of Situation Awareness as M. Endsley described. The quantitative view matches with the first level in which the user receives information about the situation. Once that information is analyzed it helps users to understand the meaning of what has been perceived. The third level appears in a natural way because of the knowledge obtained from the qualitative view allowing the user to take deci-sions looking for a result in a near future as a projection.

Table 1 shows the connection between five characteristics of users from the adap-tive gamification perspective (it only a sample for the case) and the levels of SA. As it can be checked, the levels show a clear evolution of the information given to the user from level 1 to level 3

6 Conclusions and Future Work

Adaptive gamification is an essential strategy allowing users to interact and experi-ence games in a more customizable way. The result is a context-aware gamification focused on the needs, preferences, and behaviors of the users. The gamification ac-quires an individual experience from the user's point of view. Situation awareness represents the knowledge a user obtains about what is happen-ing in the system. It is an essential element for users of games as they need infor-mation about the environment (collaborators, resources, tasks, etc.) to be in adequate conditions to decide the steps to do for accomplishing objectives. The inclusion of awareness when designing games seems to be a key factor for improving user experi-ence. Therefore, the present paper tries to show a way of inclusion of awareness as part of an existing adaptive gamification framework named Rayuela. Concretely, the framework, which is applied for collaborative contexts and interactions, is focused on offering recommendation according to the user's preferences given to the game.

The integration is made by the evolutive definition of Situation Awareness offered by M. Endsely[10] based on three levels in which the awareness received by users evolves in the mental model of them: firstly, the information is perceived by the user (level 1); secondly, the user analyses and understands the information (level 2); and finally, the user takes a decision as a projection in the future according to the analysis made (level 3). To that end, the source of knowledge is the set of characteristics of users from the adaptive gamification perspective that Rayuela offers. In this sense, the integration is done by including the evolution of each characteristic as three evolutive views in the mental model of each user as part of the framework when defining those characteristics such as parameters. As a result, each characteristic is described by a quantitative view representing the first data the user receives and by a qualitative view representing the analysis of that data according to the profile and preferences of by the user (the meaning the user gives to the data). The evolution of the information finish-es with a projection that represents the next step to be given by the user according to the knowledge received and analyzed. In conclusion, the information given to the user evolves in a customizable way based on the users' preferences, which allows the own users to take decisions more accurately.

As this article explained before, the contribution could be a useful guide for im-proving existing frameworks and enhancing the overall user experience through situa-tional awareness. In this direction, further work will include developing an extension of the functionality of Rayuela that includes an API to allow concrete development of awareness projection, for example, by adding specific user interface elements that could be integrated into Rayuela UI. Additionally, several evaluation and use cases design to demonstrate its usefulness are part of the future work.

References

[1] M. M. Haklay, D. DÃ¶rler, F. Heigl, M. Manzoni, S. Hecker, and K. Vohland, "What Is Citizen Science? The Challenges of Definition," in *The Science of Citizen Science*, K. Vohland, A. Land-Zandstra, L. Ceccaroni, R. Lemmens, J. Perello, M. Ponti, R. Samson, and K. Wagenknecht, Eds. Cham: Springer International Publishing, 2021, pp. 13–33. [Online]. Available: https://doi.org/10.1007/978-3-030-58278-4_2

[2] J. Cochero, "AppEAR: Una aplicación móvil de ciencia ciudadana para mapear la calidad de los hÃ¡bitats acuÃ¡ticos continentales," *Ecología austral*, vol. 28, no. 2, pp. 467–479, 2018, publisher: SciELO Argentina.

[3] I. Kapenekakis and K. Chorianopoulos, "Citizen science for pedestrian cartography: collection and moderation of walkable routes in cities through mobile gamification," *Human-centric Computing and Information Sciences*, vol. 7, no. 1, pp. 1–23, 2017, publisher: Springer.

[4] G. McCrory, C. Veeckman, and L. Claeys, "Citizen Science Is in the Air - Engagement Mechanisms from Technology−Mediated Citizen Science Projects Addressing Air Pollution," in *Internet Science*, I. Kompatsiaris, J. Cave, A. Satsiou, G. Carle, A. Passani, E. Kontopoulos, S. Diplaris, and D. McMillan, Eds. Cham: Springer International Publishing, 2017, pp. 28–38.

[5] M. D. Ayastuy, D. Torres, and A. FernÃ¡ndez, "Adaptive gamification in Collaborative systems, a systematic mapping study," *Computer Science Review*, vol. 39, p. 100333, 2021. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1574013720304330

[6] S. Unger, M. Rollins, A. Tietz, and H. Dumais, "iNaturalist as an engaging tool for identifying organisms in outdoor activities," *Journal of Biological Education*, vol. 55, no. 5, pp. 537–547, 2021, publisher: Taylor & Francis.

[7] P. Hummer and C. Niedermeyer, "Don't walk alone: Synergy effects for citizen science created through adaptive platform design in SPOTTERON," in *Austrian Citizen Science Conference 2018*, 2018, p. 66.

[8] M. Dalponte Ayastuy, D. Torres, and A. FernÃ¡ndez, "A Model Of Adaptive Gamification In Collaborative Location-Based Collecting Systems," in *Artificial Intelligence in HCI: 3rd International Conference, AI-HCI 2022, Held as Part of the 24th HCI International Conference, HCII 2022, Virtual Event, June 26 to July 1, 2022, Proceedings*. Berlin, Heidelberg: Springer-Verlag, 2022, pp. 201–216. [Online]. Available: https://doi.org/10.1007/978-3-031-05643-7_13

[9] S. Deterding, D. Dixon, R. Khaled, and L. Nacke, "From game design elements to gamefulness: defining" gamification"," in *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments*, 2011, pp. 9–15.

[10] M. R. Endsley, "Toward a theory of situation awareness in dynamic systems," *Human factors*, vol. 37, no. 1, pp. 32–64, 1995, publisher: SAGE Publications Sage CA: Los Angeles, CA.

[11] C. Gutwin and S. Greenberg, "A descriptive framework of workspace awareness for real-time groupware," *Computer Supported Cooperative Work (CSCW)*, vol. 11, pp. 411–446, 2002, publisher: Springer.

[12] C. Neustaedter, K. Elliot, and S. Greenberg, "Interpersonal awareness in the domestic realm," in *Proceedings of the 18th Australia conference on Computer-Human Interaction: Design: Activities, Artefacts and Environments*, 2006, pp. 15–22.

[13] J. E. Garrido, V. M. Penichet, and M.-D. Lozano, "Residential care home awareness," in *Ambient Assisted Living and Home Care: 4th International Workshop, IWAAL 2012, Vitoria-Gasteiz, Spain, December 3-5, 2012. Proceedings 4*. Springer, 2012, pp. 167–170.

[14] J. E. Garrido, V. M. Penichet, M. D. Lozano, P. O. Kristensson, and A. Quigley, "Gaze-based awareness in complex healthcare environments," in *REHAB 2014*, 2014.

[15] D. Torres, J. E. Garrido, M. Dalponte, A. Fernández, and C. A. Collazos, "Awareness for an adaptative gamification in collaborative collecting systems," in *IX Jornadas Iberoamericanas de Interacciń Humano-Computadora, IX JIHCI, Buenos Aires, Argentina, September 13-15, 2023. Proceedings ISBN 978-987-8931-86-9*. Springer, 2023, pp. 80–85.

[16] M. Dalponte Ayastuy, Torres, Diego, and A. Fernandez, "Rayuela." [Online]. Available: https://github.com/cientopolis/rayuela

[17] M. T. Cepero, L. G. MontanÃ©-JimÃ©nez, G. Toledo-Toledo, B. HernÃ¡ndez-Ocana, and C. A. Ochoa, "Social Presence Awareness Visualization in a Collaborative Videogame," *International Journal of Human-Computer Interaction*, pp. 1 – 17, Oct. 2022, publisher: Taylor & Francis. [Online]. Available: https://doi.org/10.1080/10447318.2022.2132357

[18] M. Hudson and P. Cairns, "Interrogating social presence in games with experiential vignettes," *Entertainment Computing*, vol. 5, no. 2, pp. 101–114, May 2014. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1875952114000020

[19] C. Gutwin and S. Greenberg, "Workspace awareness for groupware," in *Conference Companion on Human Factors in Computing Systems*, 1996, pp. 208–209.

[20] C. A. Collazos, F. L. GutiÃ©rrez, J. Gallardo, M. Ortega, H. M. Fardoun, and A. I. Molina, "Descriptive theory of awareness for groupware development," *Journal of Ambient Intelligence and Humanized Computing*, vol. 10, no. 12, pp. 4789–4818, Dec. 2019. [Online]. Available: https://doi.org/10.1007/s12652-018-1165-9

[21] R. Bartle, "Hearts, clubs, diamonds, spades: Players who suit MUDs," *Journal of MUD research*, vol. 1, no. 1, p. 19, 1996.