International Journal of Engineering Education Vol. 32, No. 1(B), pp. 532–541, 2016
Printed in Great Britain
0949-149X/91 $3.00+0.00

Enhancing the Engagement of Intelligent Tutorial Systems through Personalization of Gamification*

CARINA S. GONZÁLEZ, PEDRO TOLEDO and VANESA MUÑOZ
Department of Computer Engineering and Systems, Universidad de La Laguna, Pabellón de Gobierno, C/ Molinos de Agua s/n., 38200 La Laguna, Spain. E-mail: {cjgonza;petode;vmunoz}@ull.edu.es

Gamification is the use of game mechanics and strategies in non-game contexts. Currently, gamification is an emerging trend in many application fields, including education. Many gamification initiatives use points, badges and leaderboards as a way to motivate and incent participants to alter their behavior. Some gamified systems use analytics to measure and monitor users' actions and social components to increase the user motivation. Most of them, fails to keep the user involved over the long term. To solve this problem, the entire gamification process should be considered from a highly personalized view. In this sense, intelligent tutoring systems (ITS) have the propriety of adaptation to the user characteristics. Moreover, ITS have been shown to improve student achievement and enhance learning, but one of the main problems found is the inappropriate use of these systems by the students, perhaps due to boredom, lack of interest or motivation and monotony. So, in this paper we present gITS, a conceptual architecture proposal for an ITS that includes gamification elements as key components of the system. Furthermore, we analyze typical gamification approaches, highlighting some issues that should be considered when designing gamification systems.

Keywords: gamification; ITS; GBL; personalization

1. Introduction

According to Woolf (2008) [1] current changes in Education are related with artificial intelligence, cognitive science and the Web. Thus, artificial intelligence leads to personalized training by modeling domain, student, tutoring and communication knowledge; cognitive science leads to a deeper understanding of how people think, solve problems and learn; and the Web provides an unlimited source of information, available anytime and anyplace. In this sense, it is presented the Intelligent Tutoring System (ITS) concept as a system capable to guide students along a particular domain of knowledge through the solving of tasks tailored to the needs of the student.

In the past ITS have been defined by their behaviors and functions: generative (generation of appropriate problems, hints and help), student modeling (assessment of the current state of the student's knowledge), expert modeling (assessment and modelling expert performance), teaching modeling (management of the teaching) and self-improving (monitoring, evaluation and improvement its own teaching as a result of experience). In this sense, the key components of traditional ITS are organized in different modules as a student model, domain model, tutor model and interface or communication module, which interact with the user [2].

The "student model" module contains the body of knowledge that characterizes the user. This user is represented from different perspectives such as the characteristic psycho-sociological aspects that influence the learning process, the knowledge that it has on the domain and the minimum skills and abilities that it is needed to perform the learning activities. This model must also be able to pick up the evolutionary behavior of the student while working in different sessions and model the mental state of the student, i.e. "what you know and what you do not know". Some simple data about students, like age and gender, can impact in their levels of attention and motivation [3]. The research about student model focuses on the learner and the representation of his/her knowledge [4]. So, this module represents the cognitive state of the student. From this mental state, this module is responsible to adapt the system on the basis of user's responses.

Regarding the "domain model" module, it contains the representation of expert knowledge in areas related to evaluation processes, teaching and learning methodologies. In this module the reasoning-knowledge base and problem solving mechanisms- are stored. This module is responsible for directing the implementation of the module "tutor model" taking into account the input data from the module "student model".

The "tutor model" module serves as a tutor or teacher and contains information to decide which tasks are presented to the student, according with the objectives of learning the "domain module". It is responsible for generating the plans of each instructional session. Moreover, this module is responsible for the activation of the "interface" module.

* Accepted 11 August 2015.

Learning tasks are presented by the ITS to the student through the "interface" module. The "interface" module contains the representation mechanisms of educational contents (images, sound, animations, language, etc.). This issue gained interest in the field of Cognitive science, and the research showed that it is essential to consider some principles of multimedia design to achieve and enhance learning [2].

Depending on the system architecture, these modules can be organized in different ways. They may be divided and subdivided into smaller pieces, functioning as organizations, semi or fully autonomously, communicating with each other and acting rationally according to their perceptions of the outside and the state of their knowledge. This is a standard architecture based on intelligent agents. Moreover, there may be many other variations to the architecture to fulfill specific requirement, like in our proposal. In order to build intelligent tutoring systems as games-based learning environments, we need to incorporate a "gamification" module. This paper proposes gITS, a conceptual architecture for game-based learning ITS implementations, which is then used in the design of a system for teaching and learning elementary mathematics concepts, presented as a case-study.

2. Gamification for educational systems

Game based learning approaches are mainly two: the learning games and gamification. Learning games are digital games used or created for learning purposes, and gamification is "the use of game design elements in non-gaming contexts" [5]. Currently, gamification is an emerging trend in many application fields, including education [6, 7]. There are several differences between a learning game and a gamified application. In a learning game, the application is designed like a game from the beginning, while in a gamified application, gaming elements are added to an existing application. Other difference is that a learning game is a videogame which offers activities for the user to acquire knowledge and skills, while in gamified application a learning application is enriched by game mechanics to motivate the learner.

In this work we focus on gamification, because we will try to create a generic approach of gamification for different educational systems (e.g. existing educational systems, such as EMATIC [8], TANGO:H [9], etc.). So, we analyze the main game elements to be applied into an educational system or environment. Moreover, according to Cook (2013) [5], any process which satisfies the following assumptions can be transformed into a game or be gamified: (a) an activity can be learned; (b) user actions can be measured, (c) feedbacks are timely delivered to the user. Therefore, we consider feasible gamifying training activities in an intelligent tutoring system.

2.1 Game elements and techniques

In a game development, game designers consider important to define elements called "game elements", which make any scenario a playable environment. There are many ways to classify the elements that form a game or a gamified activity. Thus, Jesse Schell [10] classifies game elements in four categories (mechanic, story, aesthetics, and technology), Zagal et al. [11] classifies these elements in four categories (interfaces, rules, entity manipulations and goals), Gabe Zichermann and Christopher Cunningham [12] classify these elements in three categories (mechanics, dynamics and aesthetics), and Jorge Simões, Rebeca Díaz Redondo and Ana Fernández Vilas [13] classify these elements in two categories (mechanics and dynamics). In this sense, Kevin Werbach (2012) [14], proposes three game elements as dynamics, mechanics and components. These three elements are organized in a pyramid structure, depending on whether the element is tactical or conceptual. The dynamics are the concept, the implicit structure of the game. Mechanical processes are those that cause the development of the game and can be of different types such as: a) on the mechanical behavior (focusing on human behavior and the human psyche), b) mechanical feedback (relative to the cycle feedback on the gameplay) and c) mechanical progression (significant accumulation of skills). The components are the specific dynamics and mechanical implementations: avatars, badges, points, collections, rankings, levels, equipment, virtual goods, etc. There are few popular components, such as points, shields and leaderboards, commonly named PBLs (Points, Badges & Leader-boards achievement). Note that the elements are not the game, the game is how these elements come together to make the player have fun.

2.2 Type of learners/players and motivations

Montserrat, Lavoue and George [15] analyze the problem in research of user model in gamified systems. People have different ways of get fun. So, the research has identified different player types and motivations to play. Bartle [16] identified four player types: killer, achiever, socializer, and explorer. Regarding the motivations, Lazzaro [17] detected four motivational factors for playing games: hard fun, easy fun, altered state and people factor, and Yee [18] identified three main motivation components: achievement, social and immersion. So, the student model must represent the way people play, and the types of players. The personalization of game elements in the system [15] should take into account the forms of adaptation proposed by Kobsa et al. [19]: to user data, to usage data and to environment data. Besides, a typology of engaged behaviors to determine if a player is engaged or not has been proposed by Bouvier et al. [20]. Finally, some research help to understand the influence of environment data. For example, Cheng [21] tried to find the good moments to play at work.

Moreover, in order to gamify an activity you need to find the right way to motivate the right person at the right time. Therefore, it is important to know the different types of motivation, which can be: (a) intrinsic: inherent in the person, taken for its own sake or interest (for example, status, power, access to certain skills) or to contribute to a common good and (b) extrinsic: outside the person, made for reward or feedback. Furthermore, the social component is also important (to compete, to collaborate and to compare achievements). So, in the social game, the objectives can be competitive or collaborative. Therefore, in team games, it should be considered a separation between the collective mechanical equipment (projects, group scores, etc.), from the mechanical equipment that only apply to the individual (motivation, positive reinforcement, etc.). In this article we will explain how we have applied these techniques and elements in the context of the design of an ITS.

2.3 Personalization

Adaptation and personalization are concepts closely related and similar, which have a common goal: to provide a closer user experience by offering content close to the user, tailored to your interests and seeking to increase loyalty and satisfaction. To perform this adaptation/personalization, the basic elements are: to define the user profile, to define the content and functionality that you want to adapt, and to define the interface elements that allow this adaptation / personalization.

Personalization allows the adaptation of the interface automatically according to the user profile and experience with the system. For this, there are different techniques to infer the user's needs and preferences, such as rule-based filtering, simple filtering, collaborative filtering and content filtering [22].

For personalization/adaptation of a gamified system, we must think about what are the features that make the system fun and if the system can work with or without these gamified features. We must also think about how these features relate to gamified different user profiles. Moreover, we must also consider whether the system can work independently to gamification without affecting the core functionality, which in our case is learning. For example, a leaderboard can be activated for the most competitive users, while not for others like introspective or special needs users. This is the case of students with Down syndrome, which are non-competitive.

We can also think of the functionality can be part of the learning system (i.e. chats, forums, etc.) or may be specific functionality gamification system. The second option leads to the design generic functionality that can be used in different learning systems. Both specific and general features can be controlled by an engine of gamification. For the adaptation / personalization experience, the gamification engine must decide when and how specific and general features will be activated, taking into account: (a) the student model (consisting of the user profile or static information and user history or dynamic information, and (b) contextual information.

The static part of the student model or profile contains data such as age, gender, administrative information, learning style, type of player and preferences. Identifying the type and player preferences will increase the student motivation. The dynamics of the model student or history contains information of student interaction with the learning system and the state of their learning. However, a gamified system must also incorporate the trace of student interaction with the system for activation or deactivation of the functionality of gamification to increase the degree of engagement. Moreover, contextual information is essential in a gamification engine. The students can perform the activities from school, work or in their free time, in the classroom with their peers and with the teacher, or remotely. Student can also do the activities from a tablet, a mobile device, a laptop or desktop computer. All these contextual characteristics affect the gamified experience and the gamification engine must be able to adapt the features to different contexts. For example, if the activity is carried out in the classroom with teacher assistance, the chat cannot be very useful.

Many gamification initiatives use points, badges and leaderboards as a way to motivate and incent participants to alter their behavior [23]. These gamified systems use analytics to measure and monitor users' actions and social components to increase the user motivation. Most of them fail to keep the user involved over the long term. To solve this problem, the entire gamification process should be considered from a highly personalized view [23].

Gamification techniques should try to understand users, their personality, feelings, behaviors and actions. Big data, behavioral insights and elements of psychology can be used in gamification to provide a better end-user experience. Thus, in a

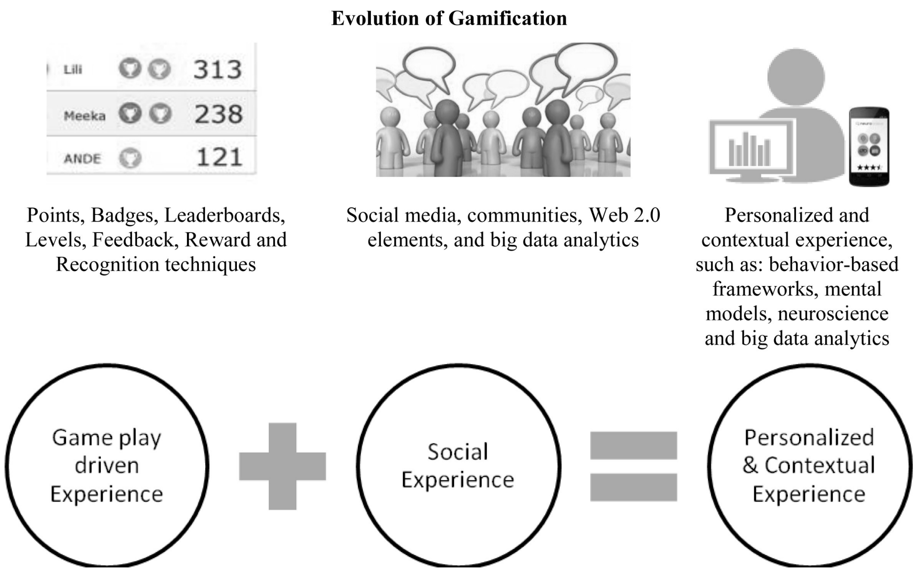

Fig. 1. Evolution of gamification. From PBL to Personalized Gamification (Adapted from Gadiyar, 2014 [23]).

gamification experience, every feedback, message or response should relate with user characteristics and situation properly.

Typical gamification approaches, includes PBL, Levels, Feedback, Reward and Recognition techniques. The social gamification includes social media, communities, Web 2.0 elements, and big data analytics. Next generation of gamification systems, includes the elements for a personalized and contextual experience, such as: behavior-based frameworks, mental models, neuroscience and big data analytics (Fig. 1). In this paper, we highlight some issues that should be considered when designing gamification systems for educational purpose, taking into account the characteristics of newest generation of gamification.

Understanding the user roles, behaviors and motivations require looking beyond basic gamification design components such as game mechanics and dynamics. Gamification initiatives that focus on behavior change are typically based on intrinsic motivation, and involving recurrent and long-term activities. These initiatives seek to link with users with diverse personalities and beliefs. So, it is possible to achieve it combining the power of big data, behavioral insights, plus elements of psychology and neurosciences to understand a user's activities, behavior and feelings.

In this sense, we can identify different core elements in a personalized gamification system (Fig. 2):

- *Learner-player types*. As we mentioned before, there are different player types and learning styles. For example, we can consider in the player model the Bartle's player types [16] or the Myers-Briggs Type Indicator [24].
- *Static and dynamic user attributes*. Understanding individuals' age, sex, geography, education, etc., is critical.
- *Activity tracking*. All user activities in the system must be tracked. For example, number of times the system has been accessed, the sections where the most time is spent, etc. are closely monitored. This tracking is stored into the student model too (history component). The data collected about the user (during the interaction with the system) must be analyzed to create a personalized and customized gamification system. Thus, the interface elements can be adapted dynamically according to the user behavior.
- *Observable user behavior*. It is vital to compre-

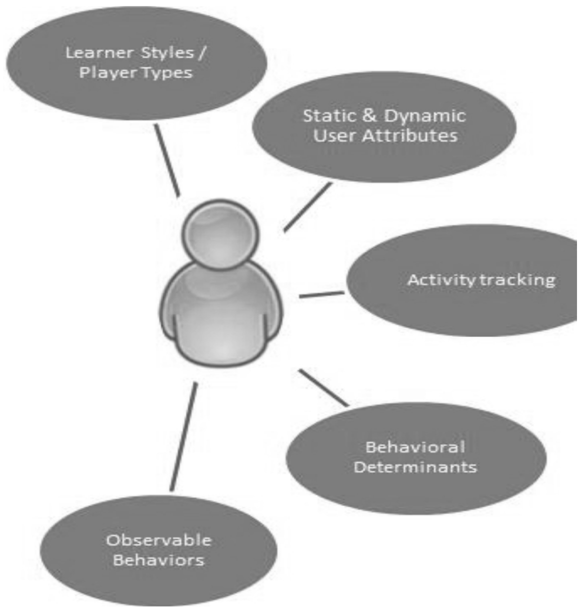

Fig. 2. Core elements in the personalization of gamification systems.

hend users' reactions to your application, product or service. So, we need monitor and measure the user behavior to understand how they perceive the system.

- *Behavioral determinants*. Transtheoretical Model [25] can be utilized to assess a person's readiness to change. Other psychological aspects, such as motivations, emotions, etc., can similarly be measured.

Considering the elements mentioned above, the personalization process in gamification systems is carried out as follows: all interactions with the system are collected, analyzed and then, the student model is updated. Moreover, regular analysis of the user engagement is carried out. Thus, the gamification engine selects appropriate gamification functionality taking into account the student model and specifically the results of the user engagement. Then the selected functionality is introduced and integrated in the user activity/interface.

In the next section we describe our proposal of gamification for an intelligent tutorial system considering the personalization elements presented above. This proposal should be considered just an example of application of the conceptual model in order to build a gamified ITS. Note that this model can be applied to other intelligent educational systems, including the related to engineering teaching.

3. Our proposal: gITS

EMATIC is an ITS, designed as a multi-device Web tool, especially oriented to digital tablets and mobile phones, for teaching basic mathematical operations to children with SEN. Technologically, the system was developed in Python language on the server side and it can be chosen between MySQL, PostgreSQL and Oracle as database engine. The interfaces are based on HTML5, CSS3 and JavaScript which gives you ownership of platform standards. This Web platform gives access to different users of the application (students, teachers or administrators), allowing to each role to access only the granted processes and assigned actions.

The software is adapted to mobile devices aimed at two distinct profiles: adults such as the specialists who need to create quick and easy educational and cognitive rehabilitation activities and children with SEN children who need friendly and fun software to perform the activities recommended by specialists. Moreover, the system has been designed with a Model-View-Controller) software architecture (MVC). The knowledge to be taught is defined in the domain module. The individual characteristics of the student and the individual knowledge about the domain are stored in the student model.

EMATIC also includes a module for creating educational activities, which allows the professionals of education to design custom activities for a pupil or group of students (authoring module). Those designs may be either completely fixed, or allow randomized variations of the activity in an adapted sequence to the student. This module allows pedagogical experts the design and building of activities strategies (tutor module). Those strategies may include very different behaviors such as: free navigation through activities, fixed sequences, conditional sequences, and gamifications components. Furthermore, teachers can manage users, groups and activities through the management module. The students can complete their activities using the execution module. Finally, results may be explored using the visualization module. Individual records visualizations are especially suited for the use of students, parents or tutors, and teachers. The visualization and analysis of aggregated group results may be accessed by teachers and education managers. Fig. 3 shows our conceptual architecture, named gITS, which includes gamification elements in ITS modules and the core elements of personalization of gamification..

3.1 ITS modules

3.1.1 Domain model's module

The domain model's module has the knowledge of the subject and the rules and relations among the concepts. From this module the tutor module can obtain the knowledge to be imparted. EMATIC's domain consist of concepts of logic, numbers and operations with single and double digit numbers, problems and algorithms of addition and subtraction. Related to these concepts, there are 10 different types of activities categories (classification, relationships, mapping, quantifiers, counting, recognition, cardinality, ordering, ordinality and problems) [26] and more than 150 tasks templates (Fig. 4).

3.1.2 Student model's module

The student model stores all the information about the pupil (knowledge, preferences, learning styles, etc.). It is composed by the student profile (persistent information such as cognitive age or disability) and the student's records (collected data through the interaction with the system). EMATIC's software facilitates the processing of interaction data for cognitive reasoning tracing of the child during the execution of a task or set of tasks. So, based on the domain model, the student model is responsible of the generation of the student knowledge state.

The student knowledge represented in this

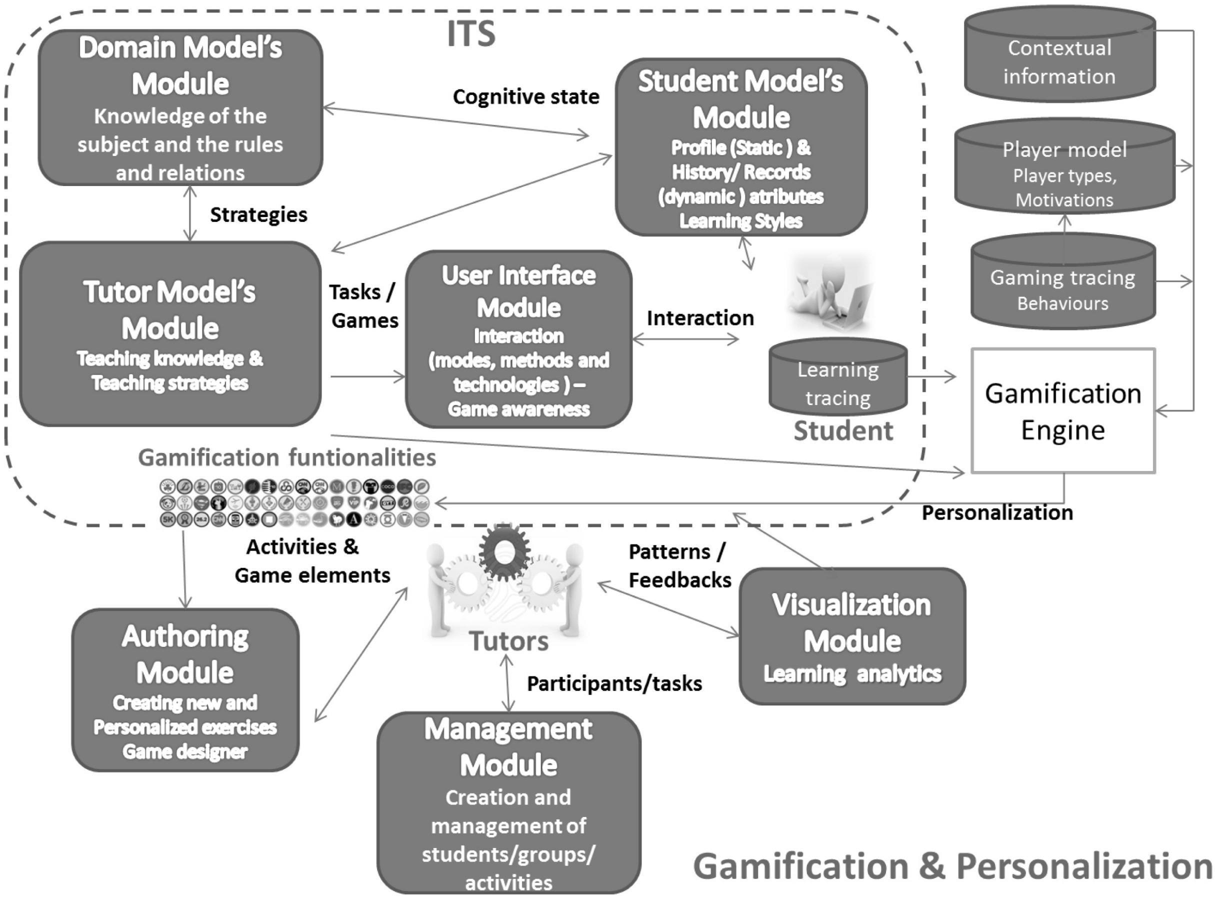

Fig. 3. Conceptual model proposal about personalization of gamification in ITS named gITS

Fig. 4. Example of an EMATIC interface.

module is related with the topics (concepts, facts, procedures, rules, skills, etc.), misconceptions (well-understood errors, bug library, incorrect buggy knowledge in addition to missing knowledge), learning skills (learning style [27], preferences, habits, type of thinking -inductive, deductive-, degree of concentration), affective skills (engagement, challenge, boredom, seriousness), student experience (user history, student attitude, task experience), stereotypes (general knowledge of the student, initial student model).

In short, in this module is represented static attributes such as age, learning style, preferences, etc. (profile) and dynamic attributes, like the state of knowledge about the topics (history, user records).

3.1.3 Authoring module

It's possible to set up of the activities to limit the randomness in creating personalized exercises and the group of the exercises for the students. The setting up of an activity consists on the particular definition of a type of activity in the system (classification, ordering, relations, etc.). For example, teachers can enable the audio instruction in order to replace the "Text To Speech Agent" (TTS). They can also set up the maximum time for testing and the maximum number of attempts to pass the activity and. Moreover, teachers can choose and replace the picture's collections to be used in the activity, selecting the most suitable for each type of activity. Also, the authoring module includes a designer of a prizes' gallery. So, the tutor can create new prizes and associate a custom value (points) to achieve it. The prizes can be assigned to individual or group activities.

3.1.4 Tutor model's module

The tutor module has the knowledge about teaching strategies, in order to adapt the strategy taking into account the information of student module (knowledge state and profile). Thus, the student model delivers the style which best suits the user; then the tutor module selects the most suitable pedagogical style, according to the particular characteristics of each student. The components of tutoring module can be: (a) objects (explanation, examples, hints, counter examples, quizzes, questions, displays, analogies, etc.); (b) actions (test, summarize, describe, define, interrupt, demonstrate, implication, application, teach procedure) and (c) tasks (teach step by step, ask student, move on, stay here, go back to topic).

Moreover, different types of teaching knowledge can be represented in this module such as: problem-solving/handling errors, bug-based tutoring, tutorial dialogue, case-based reasoning, collaborative learning, model-tracing/cognitive tutors, constructivist theory, situated learning, the zone of proximal development, etc.

3.1.5 Management module

In the management module, teachers can create and manage their students and their groups assigning particular characteristics to students. Teachers may have several groups in charge, for example, they can have different students in diverse institutions. Moreover, teachers can assign the student's group to a new activity setting.

3.1.6 User interface module

This module saves the modes, methods and technology to support trainee interaction. EMATIC stores all interaction data, stepper made by the user in solving a task in order to determine and infer the reasoning performed by the child during the task execution. Each exercise evaluates some cognitive ability. These exercises are randomly generated based on the collections and images loaded into the database. When a student selects an exercise, this is generated and displayed to the student. When the student responses, it is stored in the database with specific data (images that show collections relate, etc.) That defines the features shown to the student. Student interactions are traced and stored. The results of the session are compiled and translated by the tutor module. The obtained result is knowledge (or not) of the subjects. This also updates the stack of goals to fulfill for the session that is taking place.

This module includes several aspects of awareness of the components of mathematical learning activity (special distribution, sound and visual feedbacks, pedagogical agents, errors, hints, etc.) and gamification elements (rewards, points, time, level, etc.). Moreover, we have considered "game aesthetics" elements [28]. Game aesthetics includes the desirable emotional responses evoked by the player, when he/she interacts with the gamified system. So, this element is the most direct relationship to a player's experience, which elicit the emotional response from the user when interacts with the game system: These aspects can be personalized through the gamification engine.

3.1.7 Visualization module

EMATIC tool includes a data visualization module, which provides specialist a tool to discover patterns in certain learning difficulties, thanks to data mining. Moreover, teachers can analyze different groups of students with a same problem (for example, Asperger) (Fig. 5). Students also can see their results through the visualization module, but with specific adaptation to their profiles.

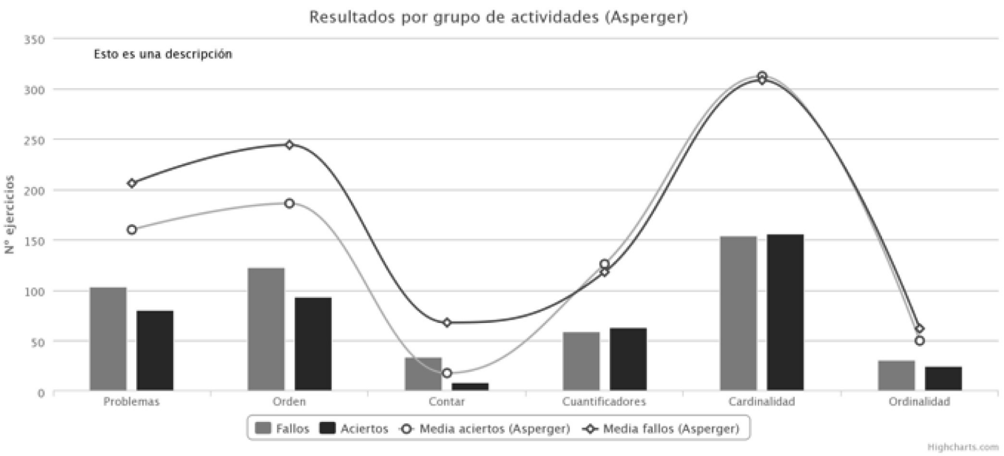

Fig. 5. Results by activities order by groups (features).

3.2 Personalization modules

3.2.1 Player module

The player module is represented the *learner-player types*, the Bartle's player types [16] or the Myers-Briggs Type Indicator [24]. Their main function is to identify the player's preferences and to determine the engagement of the user. The engagement is calculated through the interactions traced by the gaming tracing module. Then, the level of engagement is calculated and communicated to the gaming engine.

3.2.2 Contextual information module

The *contextual information* module collects data about the localization of user (school, home, outside), when he/she is performed the activity (free time, school time, etc.), the type of devices (laptop, smartphone, tablet, desktop computer) and other information contextual related with activity (virtual activity, in classroom, collaborative activity, etc.). The gamification engine is responsible to adapt the gamification functionalities of user interface to different contexts.

3.2.3 Gaming tracing

This module involves the *activity tracking,* the *observable user behavior* and the *behavioral determinants* of the user. The data collected about the user (during the interaction with the system) is analyzed to create a personalized and customized gamification system. Thus, the interface functionalities are adapted according to the user behaviors.

3.2.4 Gamification engine

Gamification engine module is responsible of real-time personalization features, enabling the system to tailor the interface and gamification functionalities and producing a more enjoyable experience for users. So, the gamification engine combines game mechanics with game dynamics to drives the engagement, increasing the experience. The gamification mechanics and dynamics elements of the system are closely related to the tutor module [29]. Thus, game dynamics guides how players interact during the run-time. These are: unlocking badges, social engagement and reward scheduling. So, game dynamics are the procedures and rules of a game related at the level of data representation and game algorithms. Furthermore, mechanics describes how players can and cannot try to achieve the game goals (challenges), and what happens when they try to achieve them. So, the mechanics are: point systems, levels, access, and power and leader-boards.

4. Conclusions

In this paper we have presented a gamification model, named gITS, applied to gamify an ITS. gITS includes gamification elements and core elements of personalization of gamification into the intelligent systems' modules.

Firstly, it has been presented an analysis of ITS systems, explaining the most relevant modules that normally conform them. More specifically, the student, domain and tutor models and interface or communication module have been detailed. Despite ITS's have been shown to improve student achievement and enhance learning, they still have major problems that hinder their use and need further investigation. Among them, one of the main problems found is the inappropriate use of these systems by the students, perhaps due to boredom, lack of interest or motivation and monotony, that cause an incorrectly behavior when interacting with these kind systems.

Secondly, the gamification process applied to educational systems has been explained. The main learning approaches, the learning games and gamification were discussed followed by a review of the concepts of "game elements" and "type of learners".

Thirdly, the personalization approach has been developed in the context of gamification of ITS. The aims and strategies have been detailed, identifying the different core elements included: Learning-player types, static and dynamic user attributes, activity tracking, observable user behavior and the behavioral determinants.

Finally, the above mentioned gamification model gITS is presented with the example of EMATIC—A framework for teaching elementary mathematics to children with SEN. This proposal include game elements to enhance the motivation and learning in intelligent tutorial systems. Traditional modules of intelligent tutoring systems, allow us to model the cognitive and affective characteristics of students, customizing and adapting the system to the particular needs of the student. Moreover, it is also possible to model the cognitive stated and discover learning patterns based on the intelligent processing of data collected from interactions with the system. The technological design of the model was detailed, followed by its modular design, incorporating both ITS and gamification features: Domain, student, tutor models, authoring, management, user interface and visualization are ITS modules which are connected to personalization modules like the player, contextual information, gaming tracing, and gamification engine modules. So, our proposal uses artificial intelligence techniques to represent the knowledge (student, domain and tutor), adds other specific tutoring modules (execution, authoring, management and visualization) and specific gamification elements into some ITS' modules, such as: game aesthetic and game awareness (execution module), game feedbacks (visualization module) and game designer (authoring module) and other specific for the personalization of gamification. Furthermore, we analyze typical gamification methods and presented a proposal of personalization elements for designing gamification systems (learning a style, player types, static and dynamic attributes, activity tracking, observable behaviors, and behavioral determinants). Also, the presented proposal includes a set of personalization modules based on the analyzed elements (player module, gaming tracing, contextual information, gamification engine).

Currently, we are working on the development and validation of the conceptual module into EMATIC as case of study. Also, we are designing and developing an independent gamification engine platform, with the objective to connect to other educational systems, such as TANGO:H, Moodle, or edX.

References

1. B. Woolf, Building Intelligent Interactive Tutors: Student-centered strategies for revolutionizing e-learning. Editorial Morgan Kaufmann. USA, 2008.
2. González, Carina Soledad, Sistemas Inteligentes en la Educación: Una revisión de las líneas de investigación actuales, *Revista Electrónica de Investigación y Evaluación Educativa*, **10**(1), 2004.
3. T. Hainey, E. Boyle and T. Connolly, M. Stansfield, Gender Differences in Motivations for Playing Computer Games: A Combined Analysis of Three Studies. In: *5th European Conference on Games Based Learning (ECGBL)*, pp. 111–119. Athens, Greece, 2004.
4. C. Conati, A. Gertner and K. Vanlehn, Using Bayesian networks to manage uncertainty in student modeling. *User modeling and user-adapted interaction*, **12**, 2002, pp. 371–417.
5. W. Cook, Training Today: 5 Gamification Pitfalls. Training Magazine. Retrieved from: http://www.trainingmag.com/content/training-today-5-gamification-pitfall, 2013.
6. B. Burke, Gamification 2020: What Is the Future of Gamification?. Retrieved from: http://www.gartner.com/technology/research/gamification/, 2012.
7. J. Anderson and L. Rainie, The Future of Gamification. Pew Research Center. Retrieved from: http://pewinternet.org/Reports/2012/Future-of-Gamification.aspx, 2012.
8. C. González, V. Muñoz , P. Toledo, A. Mora and L. Moreno, EMATIC: an inclusive educational application for tablets. *Interacción'14 Proceedings of the XV International Conference on Human Computer Interaction*, 2014.
9. C. González, P. Toledo, M. Padrón, E. Santos and M. Cairós, Including Gamification Techniques in the Design of TANGO: H Platform, *Jurnal Teknologi*, **63**(3), 2013.
10. J. Schell, The Art of Game Design: A book of lenses, Taylor & Francis US, 2008.
11. J. Zagal, M. Mateas, C. Fernandez-Vara, B. Hochhalter and N. Lichti, Towards an Ontological Language for Game Analysis, In *Proceedings of the Digital Interactive Games Research Association Conference (DiGRA 2005)*, Vancouver B.C., 2005.
12. G. Zichermann and C. Cunningham, Gamification by Design: Implementing game mechanics in web and mobile apps. O'Reilly Media, Inc., 2011.
13. J. Simões, R. Díaz Redondo and A. Fernández Vilas, A social gamification framework for a K-6 learning platform, *Computers in Human Behavior*, 2012.
14. K. Werbach, *For the Win: How Game Thinking Can Revolutionize Your Business*, Wharton: Wharton Digital Press, 2012.
15. B. Monterrat, E. Lavoué and S. George, Toward Personalised Gamification for Learning Environments. *4th Workshop on Motivational and Affective Aspects in Technology Enhanced Learning (MATEL 2013)*, 2013.
16. R. Bartle, Hearts, Clubs, Diamonds, Spades: Players Who Suit MUDs, *Journal of MUD Research*, **1**(1), 1996.
17. N. Lazzaro, Why we play games: 4 keys to more emotion. Retrieved from http://www.xeodesign.com/xeodesign_whyweplaygames.pdf, 2004.
18. N. Yee, Motivations for play in online games, *CyberPsychology & Behavior*, **9**, 2006, pp. 772–775.
19. A. Kobsa, J. Koenemann and W. Pohl, Personalized hypermedia presentation techniques for improving online customer relationships. *Technical report No. 66 GMD*, German National Research Center for Information Technology, St. Augustin, Germany, 1999.
20. P. Bouvier, E. Lavoué, K. Sehaba and S. George, Identifying Learner's Engagement in Learning Games: a Qualitative Approach based on Learner's Traces of Interaction. *5th International Conference on Computer Supported Education*, Aachen, Germanym, 2013.
21. L. Cheng, S. Shami, C. Dugan, M. Muller, J. DiMicco, J. Patterson, S. Rohall, A. Sempere and W. Geyer, Finding moments of play at work, in: *CHI 2011 Workshop (2–5)*. Vancouver: Canada, 2011.
22. G. Uchyigit and M. Ma, *Personalization Techniques and*

Recommender Systems. Series in Machine Perception and Artificial Intelligence. Word Scientific Publishing. Singapore, 2008.
23. A. R. Gadiyar, *Gamification 3.0: The Power of Personalization*. White paper. Cognizant's Global Technology, 2014.
24. I. Myers- Briggs, *The Myers-Briggs Type Indicator: Manual*, Palo Alto, CA, US: Consulting Psychologists Press. ii 110 pp, 1962.
25. J. O. Prochaska, S. Butterworth, C. A. Redding, V. Burden, N. Perrin, M. Lea, R. M Flaherty and J. M. Prochaska, Initial efficacy of MI, TTM tailoring, and HRI's in multiple behaviors for employee health promotion. *Preventive Medicine*, **46**, pp. 226–231, 2008.
26. A. Kolb and D. Kolb, Learning Styles and Learning Spaces: Enhancing Experiential Learning in Higher Education, *Academy of Managenment, Learning & Education*, **4**(2) 2005, pp. 193–212.
27. V. Muñoz, Diseño e Implementación de planificadores instruccionales en sistemas tutoriales inteligentes mediante el uso combinado de metodologías borrosa y multiagente. Ph.D. thesis. University of La Laguna, 2007.
28. G. Challco, D. Moreira, R. Mizoguchi and S. Isotani, Towards an Ontology for Gamifying Collaborative Learning Scenarios. Intelligent Tutoring Systems. *Lecture Notes in Computer Science*, Volume 8474, 2014, pp. 404–409.
29. C. González González, M. Noda, A. Bruno, L. Moreno and V. Muñoz, Learning subtraction and addition through digital boards: a Down syndrome case, *International Journal of Universal Access in the Information Society—UAIS*, 2013.

C. S. González González, received her PhD degree in Computer Science in 2001 from the University of La Laguna. She is associated professor at Computer Engineering Department of University of La Laguna. Her main focus areas in research are related with human computer interaction (HCI), natural and adaptive interfaces, serious games and gamification in Education and gender in HCI. Also, she has a widely experience in e-learning best practices and LMS systems.

P. Toledo Delgado received the M.S. degree in Computer Science Engineering from the University of La Laguna (Spain) in 2004. He is a Ph.D. student at the same university since 2004, in the Computer Engineering Department of University of La Laguna. His current research interests include Reinforcement Learning, Graph Mining, and Workflow Induction.

V. Muñoz Cruz, received her MS degree in Computer science in 2001 and her PhD degree in Computer Science in 2007 from the University of La Laguna. She is professor in the Computer Engineering Department of University of La Laguna, Canary Islands, Spain. Her current research interests are decision-making, discrete event simulation, intelligent agents, intelligent tutorial systems and computer education.