Revista Brasileira de Informática na Educação, Volume 24, Número 2, 2016

An Ontology Framework to Apply Gamification in CSCL Scenarios as Persuasive Technology

Geiser Chalco Challco
University of São Paulo, ICMC
São Carlos, SP, Brazil
geiser@usp.br

Riichiro Mizoguchi
Japan Advanced Institute of Science and Technology, JAIST
Nomi, Asahidai, Japan
mizo@jaist.ac.jp

Seiji Isotani
University of São Paulo, ICMC
São Carlos, SP, Brazil
sisotani@icmc.usp.br

Resumo *O uso de scripts de Aprendizagem Colaborativa com Suporte Computacional é uma abordagem eficaz para apoiar interações significativas e melhorar a aprendizagem. Infelizmente, em algumas situações, a colaboração scripts diminue a motivação e engajamento dos alunos, o que torna mais difícil seu uso ao longo do tempo. Para lidar com esse problema, propomos aplicar Gamificação como Tecnologia Persuasiva para induzir a os alunos a seguirem os scripts de maneira adequada sem a sensação de obrigação, evitando dessa forma os problemas de motivição. Para atingir este objetivo, é necessário um conhecimento exaustivo da Gamificação e seu impacto na aprendizagem colaborativa. Assim, estamos desenvolvendo uma ontologia para proporcionar uma sistematização formal do conhecimento sobre a gamificação e sua adequada aplicação em cenários de aprendizagem colaborativa. Neste artigo, nos concentramos na formalização dos conceitos básicos relacionados à gamificação como Tecnologia Persuasiva em cenários de Aprendizagem Colaborativa. Além disso, para demonstrar a aplicabilidade da nossa abordagem, apresentamos um estudo de caso, no que construímos e aplicamos um modelo de gamificação personalizado com base nas estruturas ontológicas definidas aqui.*

Palavras-Chave: *Gamification, Tecnologia Persuasiva, Estratégias Persuasivas, Aprendizagem Colaborativa, Cenários de Aprendizagem, Scripts.*

Abstract *The use of Computer-Support Collaborative Learning (CSCL) scripts is an effective approach to support meaningful interactions and better learning. Unfortunately, in some situations, scripted collaboration decreases the motivation and engagement of students, which makes more difficult to use it over time. To deal with this problem, we propose to apply gamification as Persuasive Technology (PT) to induce the students to follow the scripts in the proper way without the sensation of obligation, avoiding in this way the motivation problems. To achieve this goal, it is necessary an exhaustive knowledge on gamification and its impact on Collaborative Learning (CL). Thus, we are developing an ontology to provide a formal systematization of the knowledge on gamification and its proper application in CL scenarios. In this paper, we focus in the formalization of basic concepts related to gamification as a PT in CL scenarios. Furthermore, to demonstrate the applicability of our approach, we present a case study, where we built and apply a personalized gamification model based on the ontological structures defined here.*

Keywords: *Gamification, Persuasive Technology, Persuasive Strategies, Collaborative Learning, Learning Scenarios, Scripts.*

DOI: 10.5753/RBIE.2016.24.02.67

1 Introduction

Despite the successful use of Computer-Support Collaborative Learning (CSCL) scripts to support the design and execution of collaborative learning activities, there are situations in which these scripts may lead to motivation problems [4], [8], [13]. Sometimes, a learner neglects his behavior and does not perform the task as it is requested by the script because he wants to complete the task quickly, and other times, the lack of choice with respect to the next interaction in the sequencing of activities increases the sense of obligation.

The motivation problems in the CSCL scripts negatively influence the learners' attitudes and behaviors, degrade classroom group dynamics, and result in a long-term negative learning outcomes [8]. To deal with these problems, in recent years, the researches and practitioners are seeing gamification at possible solution to motivate and engage the students in learning scenarios [16]. However, gamification may fail, primarily due to poor design [27], because its effects depend greatly on the context in which this technology is applied [12]. Thus, our goal is to build a formal framework to support the design of Collaborative Learning (CL) scenarios in which game elements will be introduced and customized for each student. This customization will increase the chances of learners to willingly follow the tasks and roles defined in a script with a positive attitude and behavior.

Instead to set the same game elements with the same settings for all students, we need to adequately customize each of them for each student. This task will be done by selecting the proper game elements and deploying them with particular settings to motivate and persuade the students to complete CL activity in a proper way. Thus, it is necessary to take into consideration the theories of game design, motivation, and human behavior, where the specialists describe how psychological, anthropological and pedagogical factors influence the people and connect them with proper instructional and learning theories to identify the expected benefits provided by the gamification in CSCL contexts [11], [16], [23], [28].

To support the development of well-thought-out gamified CL scenarios based on these theories, we propose a formalization of the knowledge described on them represented as an ontology framework, referred to as (***hidden for pair revision***). In this paper, we propose to extend it by adding concepts and semantic relations related to gamification from the perspective of applying Persuasive Technology (PT) in CL scenarios in order to motivate and persuade students to interact properly while learning in group. We define **Gamification as Persuasive Technology** (PT) as "*the use of game design elements for the purpose to change peoples' attitudes and behaviors through persuasion and social influence without using coercion and/or deception*."

The paper is divided as follows, in Section 2, we present the related works. Section 3 presents the methodology employed to conduct this research and detail the ontological structures obtained by the methodology. In Section 4, we present a case study to describe how the ontological structures proposed in this paper can be used to build a personalized gamification model, and how this new model may be applied in the context of a CSCL Script. Finally, Section 5 presents the conclusion and future steps.

2 Related Works

In the past years, Gamification has been applied by many researches in different educational contexts [13]. However, in some of these scenarios, gamification is applied as pointification or exploitationware, focusing heavily on the rewards and making the learning scenarios more stressful instead of more enjoyable. In the literature, there are few models and frameworks that help instructional designers to choose proper game elements for different scenarios [4][7]. These studies proposed gamification frameworks that link game elements with different factors related to the environment and users, such as the psychological, cultural anthropological, and pedagogical preferences of people. For example, in Bunchball [2], it is proposed a framework that relates game mechanics to human desires, in which each game mechanics satisfies a set of human desires.

Currently, to the best of our knowledge, there are no other ontologies have been proposed to specifically provide computational models or frameworks to gamify CL scenarios. Thus, our work propose to extends the achievements of the different models and frameworks for gamification. We will extend these works, proposing a set of concepts in a formal ontology that can be used by humans and computers to gamify CL scenarios.

3 Ontological Frameworks

To establish the concepts and semantic relations related to the gamification as PT, we used an ontology engineering approach [20] and the model of roles [21]. The ontological structures in this ontology have been developed using the Hozo Ontology editor [18], and they are available at *http://ontogacles.caed-lab.com*

The current formalization of our ontology defines the concepts and terms shown in Figure 1 (a), where: ***I-mot goal*** is the *individual motivational goal* of the person in focus (*I*). These goals should be satisfied by the use of a motivational strategy (e.g. the changes in the individual psychological needs, motivational state, attitudinal state, and/or behavioral state). ***I-player role*** is the *player role* defined for the person in focus (*I*). ***You-player role*** is the *player role* defined for the person (*You*) who is interacting with the person in focus (*I*). ***Y<=I-mot goal*** is the *motivational strategy* (*Y<=I-goal*) that enhances the learning strategy defined for the student in focus (*I*). And, the term ***I-gameplay*** is the *gameplay strategy* that defines the rational arrangement of player role, motivational strategy and game elements for the student in focus (*I*). ***W(A)-gameplay*** is the *CL gameplay* that represent the interactions between students and game elements. Figure 1 (b) shows as example the space of interactions for the students L_A and L_B.

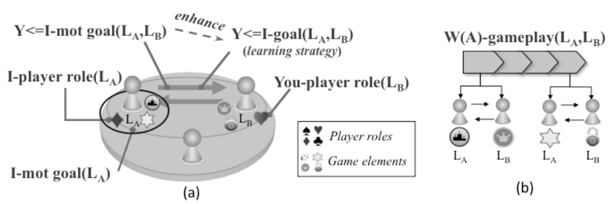

Figure 1: Concepts and terms defined in gamified CL scenarios.

3.1 Models to Personalize Gamification

In previous papers [13]–[15], we defined a set of ontological structures showed in Figure 2 using the concepts presented in Figure 1. These structures allow for the creation of ontological models to personalize the gamification of CL scenarios by properly defining player roles and game elements for each student and considering their individual differences.

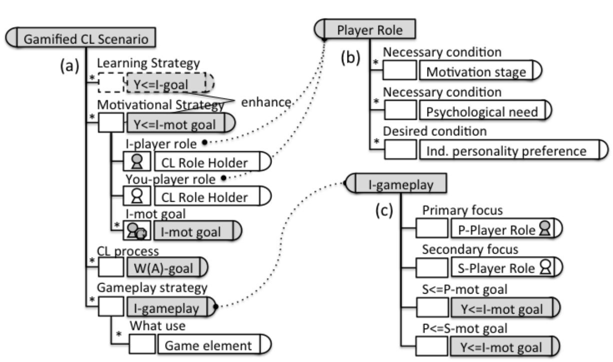

Figure 2: Ontological structures to represent a gamified CL scenario.

To represent gamified CL scenarios, the ontological structure shown in Figure 2 (a) extends the structure to represent CL scenarios proposed in [13]–[15]. In our new ontological structure, the *motivational strategy* (*Y<=I-mot goal*) is the application of gamification for the student in focus (*I*). This strategy has the goal of motivate, engage and persuade the student (*I*) to follow the intended learning behavior defined by a script. Thus, the motivational strategy is a concept that indicates how a student "*I*" can use a specific player role (*I-player role*) to interact with another student "*You" that plays a complementary role* (*You-player role*) in order to achieve his/her individual motivational goals (*I-mot goal*).

Figure 2 (b) shows the ontological structure for *player roles* that allows us to classify the students in different player types. This classification depends on the *necessary* and *desire condition*. In the current version of our ontology, these conditions are: the individual personality preferences (e.g. playing styles, cognitive styles), current motivational states, and current psychological needs.

The ontological structure shown in Figure 2 (c) represents the *gameplay strategy* for the student in focus (*I*), in which the arrangement is defined by the player role of student in focus "*I*" (*Primary focus*), the player role of student "*You*" who is interacting with the student "*I*" (*Secondary focus*), the motivational strategy for the student "*I*" (*S<=P-mot goal*), the motivational strategy for the student "*You*" (*P<=mot goal*), and the game elements for the student "*I*" (*What use*) in a Gamified CL Scenario.

Employing the ontological structures of Figure 2, we can define ontological models to personalize the gamification in CL scenarios. Due to space limitation, we do not detail the complete process of how to build these models. Nevertheless, an extended description of this process is presented in [4].

To give a concrete example about how to use the defined ontology, in Figure 3, we describe the gamification concepts extracted from Marczewski's framework [19] as classes in our model. According to Marczewski, there are four basic intrinsic player types (also called user types): achiever, socializer, philanthropist, and free-spirit. These player types are user intrinsic motivated by the needs of mastery, relatedness, purpose, and autonomy, respectively. Socializers want to interact with others players to satisfy the need of relatedness. Thus, game elements based on social mechanics guilds/teams, as social network/connections, social status, social discovery, social pressure and competition are defined as essential in the framework for the engagement of socializers.

Based on the information of socializers provided by Marczewski's framework, Figure 3 shows the ontological structure that can be used to define gamified CL scenarios for students who can be socializers. Based on the assertion of Marczewski's who says that the "Socializer wish to interact with people and the socializer's reward is knowing who is interacting with him/her"[1], we define in Figure 3 (a) that there is a motivational strategy of "*gamifying for socializes*" (*Y<=I-mot goal*) in which the relatedness need (*I-mot goal*) of a student (*I*) who plays the socializer role is satisfied by interacting with other socializer. Next, in the CL scenario that is being gamified, we define that there is a possible gameplay strategy (*I-gameplay*) to implement the "gamifying for socializers" in which it is necessary the use of the game elements "*social status*" and "*social connection*" to provide information about who is interaction with who.

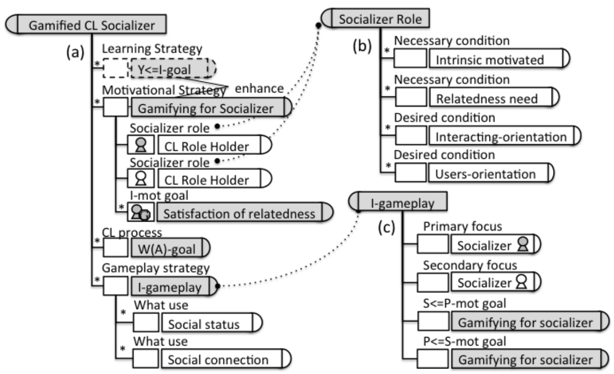

Figure 3: Ontological structures for socializers in a CL scenario.

The structure shown in Figure 3 (b) represents that for a student to play the socializer role, it is necessary that he/she must to be *intrinsic motivated* with the *relatedness need*, and it is desirable that he/she has the individuality personality preferences of interacting in the game (*interacting-orientation*) with other players (*user-orientation*). And the gameplay strategy shown in Figure 3 (c) defines that the student "*I*" (who plays the role of socializer, *Primary focus*) must employ the gameplay strategy *Gamifying for socializer* (*S<=P-mot goal*) to interacting with the student "*You*" (who plays the socializer role, *Secondary focus*).

3.2 Models to Apply Gamification as PT

In the paper [3], we define an ontological model that allow us to represent the application of Persuasive Strategies (PSs) using game elements in CL scenarios. In this previous work, we proposed the structuration and organization of the concepts related to the PSs and their application based on the Fogg's Behavior Model [9] and Skinner's Operant Conditioning theory [26]. In this work, we extend our previous work making them independent of any model and theory for the structuration and organization of the PSs and their application. Thus, Figure 4 (a) shows our new ontological structures to represent a gamified CL scenario in which it is applied the PSs using game elements. In these structures, we redefine the role of *CL process* for a role of *CL Gameplay*, where the ontological structure *W(A)-gameplay* (*CL process*) replaces the structure *W(A)-goal* (*CL Gameplay*).

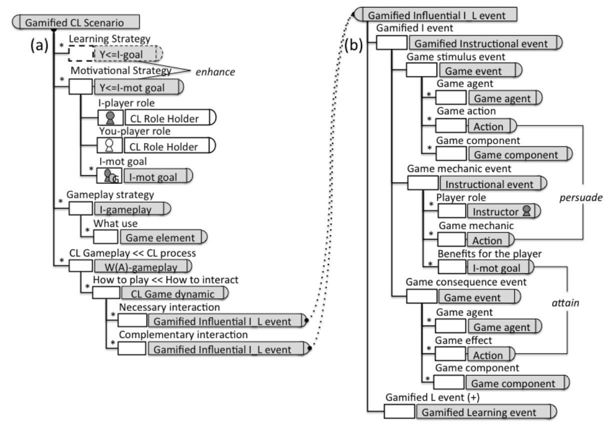

Figure 4: Ontological structures to represent a gamified CL scenarios in which it is applied the persuasive strategies using game elements.

While the *I-gameplay* (*Gameplay strategy*) defines "*what are the best game elements for each student*," the *W(A)-gameplay* (*CL Gameplay*) defines the "*how to use the selected game element to attain the individual motivational goals*." As the *game dynamic* is the run-time behavior of game mechanics acting on player inputs over time [24], the *CL Gameplay* of a gamified CL scenario is composed by a set of *CL Game dynamics* that define the "*How to play*" for the students who become players, and their necessary and complementary interactions become *Gamified Influential I_L events*, see Figure 4 (a).

In the CL ontology [13]–[15], each interaction of a CSCL script is represented by two parts: an instructional event and a learning event. Thus, in our ontology, the *Gamified Influential I_L event* is also composed by two parts: a *gamified instructional event* and a *gamified learning event*. Because Sicart [25] defines the *game mechanics* as methods invoked by agents (e.g. players, and artificial enemies) designed for the interaction with the game state, the instructional and learners events (*I/L events*) play the role of game mechanics event in the ontological structure for a gamified instructional event and a gamified learning events that is shown in Figure 4

[1] Appendix of Possible Interactions for the player types, available at http://www.gamified.uk/user-types/ (Retrieved in January, 2016)

(b). When an instructional or learning event becomes a game mechanics event, as we can see in the ontological structure, the instructor or learner plays the *player role*, his/her actions become game mechanics, and a set of *individual motivational goals* (*I-mot goal*) are included as "*benefits for the player*" in this structure.

The gamified instructional and learning events do not only contain the intended learning behavior defined by a CSCL script as actions for students who play the role of instructor or learner. In the gamified instructional and learning events, as it is shown in Figure 5, we also describe two kind of actions:

- Game actions that "*stimulate*" the students to do the actions that are defined in the instructional and learning events; and
- Game actions as *game effects* that follow the actions defined in the instructional and learning events and allow the students to "*attain*" their individual goals.

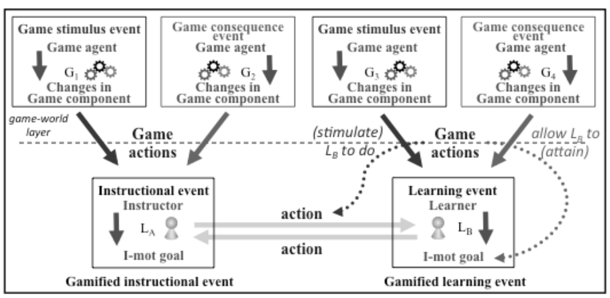

Figure 5: Elements in a gamified influential I_L event.

Based on theories of humans behavior and learning, the game actions defined in gamified instructional and learning events are structuring and organizing into: *game stimulus events* and *game consequence events*.

In a gamified CL scenario, the proper stimulus given by actions of game agents using game components at the right moment tells and leads the students to carry out the intended learning behavior in a predictable way. For us, the *game components* are the basic parts of the game world layer manipulated by the game agents [1], such as points, badges, and virtual coins. As shown in Figure 5, the *game agents* (G_1 and G_3), their *actions* that stimulate the students' actions (defined in the instructional/learning events), and the *game components* used by these agents are represented in game events that play the role of *game stimulus events* in the ontological structure of gamified instructional and learning events.

As it is shown in Figure 5, the gamified instructional and learning events also contain game events that play the role of *game consequence events*, where the *actions* (as *game effects*) of *game agents* (G_2 and G_4) using *game components* produce changes in the students' attitudes and behaviors. These actions follow the students' actions to reinforce the intended learning behavior defined by the script. Thus, the game actions defined in these game events allow the students to attain the individual motivational goals.

3.3 Example: Gamified Influential I_L events

Employing our formalization of *Gamified Influential I_L events* proposed here (in this paper), Figure 6 shows an example of representation and ontological structure for the application of PS "*reward*" over the interaction "*instigating discussion*," where we detailed the elements for the gamified learning event "*expose opinion*." The reward strategy consists in giving positive feedback to increase the frequency of a target behavior [10].

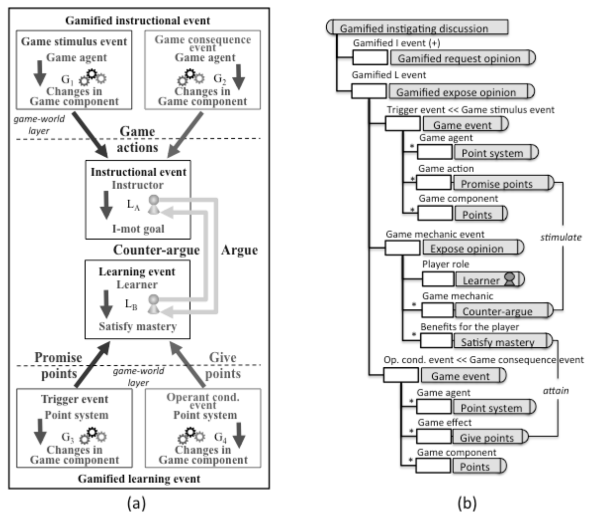

Figure 6: Example for the application of persuasive strategy "*reward*" over the interaction "*instigating discussion*."

In our example showed in Figure 6, the game events are structure based on the Fogg's Behavior Model [9] and Skinner's reinforcement theory [26]. According to Fogg's Behavior Model, for a behavior to occur, the motivation, ability, and trigger must converge at the same moment reaching the activation threshold. Thus, as it is shown in Figure 6 (a), the game stimulus event becomes a trigger event, and the application of the PS "*reward*" in the learning event "*expose opinion*" to persuade a learner to do an "*counter-argument*" consists in *promise points* (*Game action*) that must be done by a *point system* (*Game agent*) using the *points* (*Game component*). Figure 6 (b) shows the ontological structure to represent this fact as a game event that plays the role of trigger event.

According to Skinner, the change in the learners' attitudes and behaviors is learned by operant conditioning, where the consequences of humans' actions modify the tendency to repeat a behavior. Thus, as it is shown in Figure 6 (a), the game stimulus becomes a operant conditioning event for the application of the PS "*reward*" over the learning event "*expose opinion*." As result, the action "*give point*" (*Game action*) becomes a positive reinforcement for the counter-argue of a student who plays the role of learner. This action is done by the *point system* (*Game agent*) using the points (*Game component*) and allows the learner to satisfy his need of mastery (*Benefits for the player*). Finally, Figure 6 (b) shows the ontological structure to represent this fact as a game event that plays the role of operant conditioning event.

4 Case Study

In this section, to demonstrate the applicability of our ontological structures presented in the previous section, we built a personalized gamification model that allow us to apply gamification as PT. To build this model, we employed the information defined by Orji *et al*. in [22].

In the first step to build our model of gamification, we made the Table 1 through the combination of PSs for each pair of player roles (*gamer types*). Thus, the students who play the role of instructor become primary players (*P-Player*), and the students who play the role of learner become secondary players (*S-Player*) in a CL scenario.

P-Player\ S-Player	Achiever	Conqueror	Daredevil	Mastermind	Seeker	Socializer	Survivor
Achiever	COOP, REWD, SEMT/SUGG	COOP, REWD, SEMT/SUGG x ~~CMPT/CMPR~~, SIML, PERS, SEMT/SUGG	COOP, REWD, SEMT/SUGG x SIML	COOP, REWD, SEMT/SUGG x SEMT/SUGG, ~~CMPT/CMPR~~, PERS, SIML, CUST	COOP, REWD, SEMT/SUGG x CUST, PERS, ~~CMPT/CMPR~~, PRAS	COOP, REWD, SEMT/SUGG x COOP, ~~CMPT/CMPR~~	COOP, REWD, SEMT/SUGG x SEMT/SUGG, CMPT/CMPR
Conqueror	CMPT/CMPR, SIML, PERS, SEMT/SUGG x COOP, REWD, SEMT/SUGG	CMPT/CMPR, SIML, PERS, SEMT/SUGG	~~CMPT/CMPR~~, SIML, PERS, SEMT/SUGG x SIML	CMPT/CMPR, SIML, PERS, SEMT/SUGG x SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST	CMPT/CMPR, SIML, PERS, SEMT/SUGG x CUST, PERS, CMPT/CMPR, PRAS	CMPT/CMPR, SIML, PERS, SEMT/SUGG x ~~COOP~~, CMPT/CMPR	CMPT/CMPR, SIML, PERS, SEMT/SUGG x SEMT/SUGG, CMPT/CMPR
Daredevil	SIML x COOP, REWD, SEMT/SUGG	SIML x ~~CMPT/CMPR~~, SIML, PERS, SEMT/SUGG	SIML	SIML x SEMT/SUGG, ~~CMPT/CMPR~~, PERS, SIML, CUST	SIML x CUST, PERS, ~~CMPT/CMPR~~, PRAS	SIML x COOP, ~~CMPT/CMPR~~	SIML x SEMT/SUGG, ~~CMPT/CMPR~~
Mastermind	SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST x ~~COOP~~, REWD, SEMT/SUGG	SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST x CMPT/CMPR, SIML, PERS, SEMT/SUGG	SEMT/SUGG, ~~CMPT/CMPR~~, PERS, SIML, CUST x SIML	SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST	SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST x CUST, PERS, CMPT/CMPR, PRAS	SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST x ~~COOP~~, CMPT/CMPR	SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST x SEMT/SUGG, CMPT/CMPR
Seeker	CUST, PERS, CMPT/CMPR, PRAS x ~~COOP~~, REWD, SEMT/SUGG	CUST, PERS, CMPT/CMPR, PRAS x CMPT/CMPR, SIML, PERS, SEMT/SUGG	CUST, PERS, ~~CMPT/CMPR~~, PRAS x SIML	CUST, PERS, CMPT/CMPR, PRAS x SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST	CUST, PERS, CMPT/CMPR, PRAS	CUST, PERS, CMPT/CMPR, PRAS x ~~COOP~~, CMPT/CMPR	CUST, PERS, CMPT/CMPR, PRAS x SEMT/SUGG, CMPT/CMPR
Socializer	COOP, ~~CMPT/CMPR~~ x COOP, REWD, SEMT/SUGG	COOP, ~~CMPT/CMPR~~ x ~~CMPT/CMPR~~, SIML, PERS, SEMT/SUGG	COOP, ~~CMPT/CMPR~~ x SIML	COOP, ~~CMPT/CMPR~~ x SEMT/SUGG, ~~CMPT/CMPR~~, PERS, SIML, CUST	COOP, ~~CMPT/CMPR~~ x CUST, PERS, ~~CMPT/CMPR~~, PRAS	COOP, ~~CMPT/CMPR~~	CMPT/CMPR x SEMT/SUGG, CMPT/CMPR
Survivor	SEMT/SUGG, CMPT/CMPR x ~~COOP~~, REWD, SEMT/SUGG	SEMT/SUGG, CMPT/CMPR x CMPT/CMPR, SIML, PERS, SEMT/SUGG	SEMT/SUGG, ~~CMPT/CMPR~~ x SIML	SEMT/SUGG, CMPT/CMPR x SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST	SEMT/SUGG, CMPT/CMPR x CUST, PERS, CMPT/CMPR, PRAS	SEMT/SUGG, CMPT/CMPR x CMPT/CMPR	SEMT/SUGG, CMPT/CMPR

CMPT/CMPR: competition & comparison, COOP: cooperation, CUST: customization, PERS: personalization, PRAS: praise, SEMT/SUGG: self-monitoring & suggestion, SIML: simulation, REWD: reward

Table 1: Player roles and Persuasive Strategies to Gamify influential I_L events

During the building of the Table 1, we verified if the PSs have negative influence (*contra-persuasive*) between the primary and secondary player roles. For example, the competition/comparison and cooperation strategies are contra-persuasive for students who play the player roles of *daredevi*l and *survivor*, respectively. To simplify our example, we also define that it is not possible to use the PSs of cooperation and competition/comparison in the same CL scenario at the same time, selecting the most persuasive for students who play the primary player role (*P-Player*). Finally, we indicated these restriction in the Table 1 by a line (*strikethrough*) in the PSs.

As it is shown in Table 1, our model also proposes that we will be able to employ more than one PS using game elements to influence changes in the attitudes and behaviors of students. For example, the first row defines that the PSs "*cooperation*," "*reward*" and "*self-monitoring & suggestion*" can be used to apply gamification as PT for a group of students who play the player role of achiever, if there is no one student who plays the player role of survivor.

Based in the combination of PSs defined in Table 1, the second step consists in developing storyboards that shows how each strategy is applied using the different game elements. Thus, for example, Figure 6 shows a storyboard illustrating how the combination for the PSs of "*cooperation*," "*reward*" and "*self-monitoring & suggestion*" is applied in a CL scenario using the game components of "u*nlockable content*," "*points*" and "*progression bar*." These game components are respectively employed by the game agents "*unlockable system*," "*point system*" and "*progress bar system*" to persuade a student to "*guide other students towards the solution of problems*" (intended learning behavior).

According to the storyboard, during the step (0), when the game actions of "*show condition to unlock content*" and "*give suggestion*" are respectively done by the "*unlockable system*" and "*progress bar system*" to stimulate the student to take the action of "*give information about how to solve a problem*" then them become game stimulus events. After the students gives the information, during the step (1), the point system gives 10 points to the student plays become a game consequence event. During the step (1), the action of the progress bar system plays the role of game consequence event through the game action of "*give suggestion*." Finally, after step (n) when the learner will received acceptance, the "*unlockable system*" plays the game consequence event through game action of "*unlock content*."

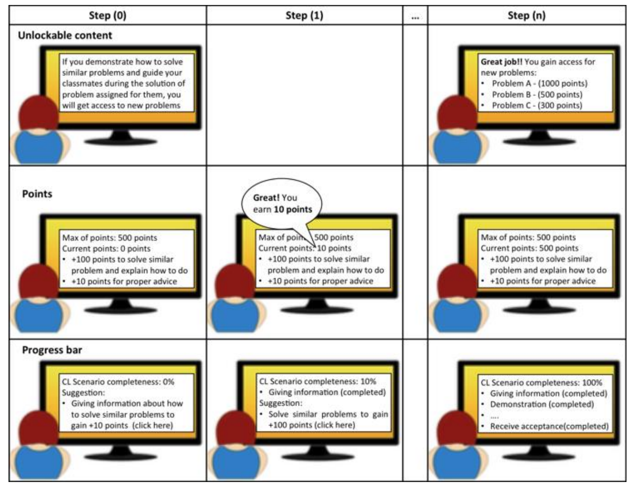

Figure 6: Storyboard illustrating the cooperation (top), reward (middle) and self-monitoring & suggestion (bottom) strategies in a CL scenario.

In the third step, employing the storyboards that represent the application of PSs using game elements, we develop and formalized a set of game events that play the role of stimulus and consequence events. Due to space limits, Table 2 only shows a partial list of these game events that we are currently developing. The complete list is available at https://goo.gl/lkaU8O, and it is open to discussion and future changes.

The fourth and last step is the definition of ontological structures that represent the application of PSs using game elements for each interaction of a CSCL script. Thus, we extend the ontological structures shown in Figure 4 employing the information of Table 1 and Table 2.

Persuasive Strategy	*Game event as stimulus event*		*Game event as consequence event*			*Observation of game design*
	Game Component	*Game action*	*Game Component*	*Game action (effect)*	*Changes in game state*	
COOP	Unlockable content	Show condition	Unlockable content	Unlock content	Increase contents	Communal discovery
	Virtual item	Show condition	Virtual items	Give virtual item as gift	Increase virtual items	Social fabric of games
CMPT /CMPR	Leaderboard	Display scores				Leaderboard
	Status	Rank progress				Envy
REWD			Virtual items	Give random item	Increase virtual items	Lottery
	Virtual items	Promise virtual items	Virtual items	Give virtual items	Increase virtual items	Virtual items

	Points	Promise points	Points	Give points	Increase points	Points
PRAS	Virtual item	Highlight obtained virtual items				Pride
SEMT /SUGG	Progress bar	Give suggestion	Progress bar	Increase progress	Change percentage	Achievement

Table 2: Mapping of Persuasive Strategies to game events (partial list)

Applying Personalized Gamification Model

Figure 7 shows the ideal flow to gamify CL scenarios from the viewpoint of an instructional designer who employs an intelligent theory aware system based on our ontology. In the first step (1), the designer sets the proper player roles and game elements for each student. In the second step (2), he designs the CL gameplay as a set of CL game dynamics employing the player roles and game elements that were set in the first phase. Finally, in the third step (3), the designer makes an interaction analysis over the obtained gamified CL scenarios. The purpose of third step is identify if the game events and their influences are adequate or not, proposing better solutions by the meaningful result obtained during the run-time of a CSCL script.

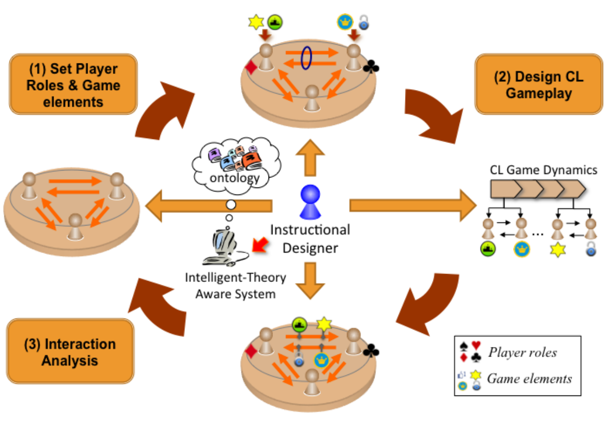

Figure 7: Flow to gamify CL scenarios in semantic web authoring tools

In the paper [4], we defined a pseudo-algorithm to set the proper player roles and game elements according to current motivational stage, psychological needs, and individual personality preferences that are defined as necessary and desired condition in the structure "*player role*," see Figure 2 (b). After this setting, in a authoring tool, the next step (2) is the use of ontological structures *W(A)-gameplay* defined in the personalized gamification model to define the *CL gameplay* that will be employed in a gamified CL scenario. The definition of this CL gameplay will be made employing the ontological structures of *CL Game dynamic* and *Gamified Influential I_L events*. As example, Table 3 shows the definition of a CL gameplay for a CSCL script based on the theory of Cognitive Apprenticeship, in which the player role of "*achiever*" is defined for students "*l1*" and "*l2*" who play the role of "*master*", and the player role of "*apprentice*" is defined for students "*l3*" and "*l4*" who play the role of socializer. In this CL scenario, the PSs of "*cooperation*" (*COOP*), "*reward*" (*REWD*), and "*self-monitoring & suggestion*" (*SEMT/SUGG*) are applied for the interactions of students who play the role of achiever. And the PS of "*cooperation*" (*COOP*) is applied for the interactions of students who play the role of socializer.

I_L events (I event/L event)	***Persuasive Strategies***	***Game Events for Masters: l1 and l2 (Achiever role)***	***Game Events for Apprentices: l3 and l4 (Socializer role)***
(n) Setting up the learning context (Giving information / Receiving information)	COOP	Unlockable system - Unlockable content: (Show condition /)	Unlockable system - Unlockable content: (Show condition /)
	REWD	Point system - Points: (Promise points / Give points - add 10 points)	
	SEMT/SUGG	Progress bar system - Progress bar: (Give suggestion / Increase Progress - add 10%)	
(n) Demonstrate how to solve problem (Demonstration / Observing demonstration)	COOP	Unlockable system - Unlockable content: (Show condition /)	Unlockable system - Unlockable content: (Show condition /)
	REWD	Point system - Points: (Promise points / Give points - add 100 points)	
	SEMT/SUGG	Progress bar system - Progress bar: (Give suggestion / Increase Progress - add 40%)	
(n) Monitoring (Checking / Being checked)	COOP	Unlockable system - Unlockable content: (Show condition /)	Unlockable system - Unlockable content: (Show condition /)
	REWD	Point system - Points: (Promise points / Give points - add 10 points)	
	SEMT/SUGG	Progress bar system - Progress bar: (Give suggestion / Increase Progress - add 40%)	
(d) Clarifying the problem	COOP	Unlockable system - Unlockable content: (Show condition /)	Unlockable system - Unlockable content: (Show condition /)

(Identifying learner's problem / Externalization of problem)	SEMT/SUGG	Progress bar system - Progress bar: (Give suggestion /)	
(d) Notifying how the learner is (Giving information / Receiving information)	COOP	Unlockable system - Unlockable content: (Show condition /)	Unlockable system - Unlockable content: (Show condition /)
	REWD	Point system - Points: (Promise points / Give points - add 10 points)	
	SEMT/SUGG	Progress bar system - Progress bar: (Give suggestion /)	
(d) Instigating thinking (Argumentation / Receiving arguments)	COOP	Unlockable system - Unlockable content: (Show condition /)	Unlockable system - Unlockable content: (Show condition /)
	REWD	Point system -Points: (Promise points / Give points - add 10 points)	
	SEMT/SUGG	Progress bar system - Progress bar: (Give suggestion /)	
(d) Requesting problem's details (Asking problematic understanding / Externalization of problems)	COOP	Unlockable system - Unlockable content: (Show condition /)	Unlockable system - Unlockable content: (Show condition /)
	SEMT/SUGG	Progress bar system - Progress bar: (Give suggestion /)	
(d) Showing a solution (Explanation / Receiving explanation)	COOP	Unlockable system - Unlockable content: (Show condition /)	Unlockable system - Unlockable content: (Show condition /)
	REWD	Point system - Points: (Promise points / Give points - add 100 points)	
	SEMT/SUGG	Progress bar system - Progress bar: (Give suggestion /)	
(n) Affirmative reaction (Acceptance / Receiving acceptance)	COOP	Unlockable system - Unlockable content: (/ Unlock content - Increase new problems)	Unlockable system - Unlockable content: (/ Unlock content - Increase new problems)
	SEMT/SUGG	Progress bar system - Progress bar: (/ Increase Progress - add 10%)	

Table 3: Game events to Gamify a CL scenario based on the theory "Cognitive Apprenticeship"

In the Table 3, the necessary interaction has the prefix "*(n)*," the desire interaction has the prefix of "*(d)*," and the *game event* is represented by the form "*GA - GC: GAs/GAe – C*," where *GA* is a game agent, *GC* is the game component, *GAs* is the game action for a game stimulus event, *GAe* is the game action defined as game effect for a game consequence event, and *C* is the change in the game world layout as result of this game effect.

5 Conclusion an Future Research

In this paper, we presented a set of ontological structures that will able the organization and formalization of knowledge related to gamification as PT in CL scenarios. We defined the concept related to *CL gameplay*, *CL game dynamic*, and *gamifed influential I_L event*. These structures allow us to formalize and structure the application of PSs using game elements for each interaction of CSCL scripts. To demonstrate the applicability of our approach, we developed an ontological personalized gamification model in Section 5. This model was based on the mapping of PSs and game features proposed by Orji *et al*. in [22]. And we believe that the results of this work are the first steps in order to create new semantic web authoring tools that will provide assistance and recommendation to gamify CL scenarios, making them more motivating and engaging to the learners. Our next steps are the formalization of concepts related to Flow Theory [6], player's journey [7], and fun for game design [17].

Acknowledgements

The authors would like to thank CAPES, CNPq and FAPESP for supporting this research.

References

[1] S. Bjork, J. Holopainen. Games and design patterns, *The Game Design Reader*, páginas 410–437, 2006.

[2] G. C.Challco, D. A.Moreira, I. I.Bittencourt, *et al.* Personalization of Gamification in Collaborative Learning Contexts using Ontologies, *IEEE Latin America Transactions*, 13(6): 1995–2002, 2015.

[3] G. C. Challco, F. Andrade, T. Oliveira, *et al.* An Ontological Model to Apply Gamification as Persuasive Technology in Collaborative Learning Scenarios, In *Anais do XXVI Simpósio Brasileiro de Informática na Educação*, 2015, 26: 499–508, páginas 499–508.

[4] G. C. Challco, D. A. Moreira, R. Mizoguchi, *et al.* An Ontology Engineering Approach to Gamify Collaborative Learning Scenarios, in *20th International Conference on Collaboration and Technology*, páginas 185–198, N. Baloian, F. Burstein, H. Ogata, F. Santoro, and G. Zurita (eds.) Springer, 2014, páginas 185–198.

[5] G. C. Challco, D. Moreira, R. Mizoguchi, *et al.* Towards an Ontology for Gamifying Collaborative Learning Scenarios, in *12th International Conference on Intelligent Tutoring Systems*, páginas 404–409, S. Trausan-Matu, K. E. Boyer, M. Crosby, and K. Panourgia (eds.) Springer, 2014, páginas 404–409.

[6] M. Csikszentmihalyi. *Flow: The Psychology of Optimal Experience*, 1ST edition. New York: Harper Perennial Modern Classics, 2008.

[7] M. Eladhari. The Player's Journey, *The Players' Realm: Studies on the Culture of Video Games and Gaming*, páginas 171–87, 2007.

[8] J. Falout, J. Elwood, M. Hood. Demotivation: Affective states and learning outcomes, *System*, 37(3): 403–417, 2009.

[9] B. Fogg. A Behavior Model for Persuasive Design, In *Proceedings of the 4th International Conference on Persuasive Technology*, New York, NY, USA, 2009, páginas 40:1–40:7, páginas 40:1–40:7.

[10] B. J. Fogg. *Persuasive Technology: Using Computers to Change What We Think and Do*, 1st ed. Morgan Kaufmann, 2002.

[11] F. Groh. Gamification: State of the art definition and utilization, *Institute of Media Informatics Ulm University*, 39, 2012.

[12] J. Hamari, J. Koivisto, H. Sarsa. Does Gamification Work?–A Literature Review of Empirical Studies on Gamification, In *Proceedings of the 2014 47th Hawaii International Conference on System Sciences*, 2014, páginas 3025–3034, páginas 3025–3034.

[13] S. Isotani, A. Inaba, M. Ikeda, *et al.* An ontology engineering approach to the realization of theory-driven group formation, *International Journal of Computer-Supported Collaborative Learning*, 4(4): 445–478, 2009.

[14] S. Isotani, R. Mizoguchi, S. Isotani, *et al.* An Authoring Tool to Support the Design and Use of Theory-Based Collaborative Learning Activities, in *Intelligent Tutoring Systems*, páginas 92–102, V. Aleven, J. Kay, and J. Mostow (eds.) Springer, 2010, páginas 92–102.

[15] S. Isotani, R. Mizoguchi, S. Isotani, *et al.* A Semantic Web-based authoring tool to facilitate the planning of collaborative learning scenarios compliant with learning theories, *Computers & Education*, 63: 267–284, 2013.

[16] K. M. Kapp. *The gamification of learning and instruction: game-based methods and strategies for training and education*. San Francisco, CA: Pfeiffer, 2012.

[17] R. Koster. *A Theory of Fun for Game Design*, 1 edition. Scottsdale, AZ: Paraglyph Press, 2004.

[18] K. Kozaki, Y. Kitamura, M. Ikeda, *et al.* Hozo: An Environment for Building/Using Ontologies Based on a Fundamental Consideration of "Role" and "Relationship," in *13th International Conference on Knowledge Engineering and Knowledge Management, EKAW 2002*, páginas 213–218, A. Gómez-Pérez and V. R. Benjamins (eds.) Springer, 2002, páginas 213–218.

[19] A. Marczewski. *Even Ninja Monkeys Like to Play: Gamification, Game Thinking & Motivational Design*, 1 edition. Gamified UK, 2015.

[20] R. Mizoguchi. Tutorial on ontological engineering Part 2: Ontology development, tools and languages, *New Generation Computing*, 22(1): 61–96, 2004.

[21] R. Mizoguchi, E. Sunagawa, K. Kozaki, *et al.* The Model of Roles Within an Ontology Development Tool: Hozo, *Applied Ontology - Roles, an interdisciplinary perspective*, 2(2): 159–179, 2007.

[22] R. Orji, J. Vassileva, R. L. Mandryk. Modeling the efficacy of persuasive strategies for different gamer types in serious games for health, *User Modeling and User-Adapted Interaction*, 24(5): 453–498, 2014.

[23] R. Reis, C. Rodriguez, G. C. Challco, *et al.* Relação entre os Estados Afetivos e as Teorias de Aprendizagem na Formação de Grupos em Ambientes CSCL, In *Anais do Simpósio Brasileiro de Informática na Educação*, 2015, 26: 1012, páginas 1012.

[24] H. Robin, L. Marc, Z. Robert. MDA: A Formal Approach to Game Design and Game Research, 2004.

[25] M. Sicart. Defining game mechanics, *Game Studies*, 8(2): 1–14, 2008.

[26] B. F. Skinner. *About Behaviorism*, 1 edition. New York: Vintage, 1976.

[27] E. N. Webb. Gamification: When It Works, When It Doesnt, in *Design, User Experience, and Usability. Health, Learning, Playing, Cultural, and Cross-Cultural User Experience*, páginas 608–614, Springer, 2013, páginas 608–614.

[28] K. Werbach, D. Hunter. *For the win: How game thinking can revolutionize your business*. Wharton Digital Press, 2012.