# An Ontological Model to Apply Gamification as Persuasive Technology in Collaborative Learning Scenarios

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Abstract. The use of Computer-Support Collaborative Learning (CSCL) scripts is an effective approach to support meaningful interactions and better collaborative learning (CL). 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 the use of gamification as Persuasive Technology (PT) to induce the students to follow the intended learning behavior specified by CSCL scripts, with a positive change in the learners' attitude. Nevertheless, to achieve this goal, it is necessary an exhaustive knowledge on gamification and its impact on 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 in CL scenarios, we present a case study, where we built and apply a personalized gamification model based on the ontological structures defined in this work.

## 1. Introduction

In the field of CSCL, despite the success of design scripts to support CL activities, there are situations in which these scripts may lead to demotivation. Sometimes, a learner may neglect his personal behavior to get the task completed as the script requests it and, other times, the lack of choice with respect to the sequence of activities may increase the sense of obligation. The demotivation negatively influence the learner's attitudes and behaviors, degrade classroom group dynamics and teacher's motivation, and result in widespread and long-term negative learning outcomes [Falout et al. 2009]. Thus, in recent years, the researches and practitioners are seeing gamification as solution to motivate and engage the student in learning scenarios [Kapp 2012]. However, gamification can fail, primarily due to poor design [Webb 2013], because its effects depend greatly on the context in which this technology is applied [Hamari et al. 2014].

In this sense, instead of offering and giving the same game-rewards for all students to do the activities defined by the CSCL scripts, our goal is to build CL scenarios in which the game elements induce the learners to freely decide to do the tasks in a proper way, following the intended learning behavior defined by the scripts. This

change of learners' attitude and behavior will be only obtained through an appropriate combination of different game elements for each student. To obtain this combination is necessary take in consideration the students' individual preferences and the psychological, anthropological and pedagogical factors that may influence the expected benefits provided by the gamification, which are described in various theories of motivation, human behavior and game design [Werbach and Hunter 2012]. Thus, we propose the formalization of the knowledge described in these theories into an ontology called *OntoGaCLeS* - an *Ontology to Gamify Collaborative Learning Scenarios*.

In this paper, we details the definition of basic concepts and semantic relations presented in [Challco et al. 2015]. These ontological structures allow us the formalization and organization of knowledge related to gamification as a Persuasive Technology (PT) in CL scenarios. In Section 2, we present the related works. Section 3 presents the methodology employed in this work and the ontological structures obtained using this methodology is detailed in Section 4. Section 5 describes how these ontological structures allow us to build and apply a personalized gamification model based on Persuasive Strategies (PSs), validating its applicable. Finally, in Section 6, we present the conclusion and future steps.

# 2. Related Works

Currently, to the best of our knowledge, no other ontology has proposed to specifically provide computational models or frameworks to gamify CL scenarios. In the literature, field of education, there are few models and frameworks [De Sousa Borges et al. 2014] that help instructional designers to choose proper game elements for different scenarios based in learners' preference and individual traits [Domínguez et al. 2013], [Simões et al. 2013]. These studies proposed gamification frameworks that relate game elements and human desires, in which each element satisfies a set of human desires. Our work will extend the achievements of these frameworks by proposing concepts in a formal ontology that can be used by humans and computers to gamify CL scenarios.

In the past years, Gamification has been applied by many researches in different educational contexts [De Sousa Borges et al. 2014]. However, in some of these scenarios, gamification is applied as *pointsification* or *exploitationware*, focusing heavily on the rewards or making the learning scenarios more stressful instead of more enjoyable. To obtain well-thought-out gamified CL scenarios, we propose to apply gamification as PT that focus on the design and proper application of game elements to change learners' attitudes and behaviors through persuasion and social influence without using coercion or deception.

## 3. Methodology: Ontology Engineering and Model of Roles

To establish the concepts and semantic relations as ontological structures, we used the ontology engineering [Mizoguchi 2004] and the model of roles [Mizoguchi et al. 2007]. The ontological structures obtained in this work have been developed using the Hozo Ontology editor [Kozaki et al. 2002], and they are available in the ontology OntoGaCLeS at *http://labcaed.no-ip.info:8003/ontogacles/*. Later, these structures will be used to provide computation support for the definition of a personalized gamification model inspired by PSs.

# **4. Result: Ontological Structures to Formalize and Organize Knowledge Related to Gamification as Persuasive Technology in CL Scenarios**

In previous paper [Challco et al. 2014], we defined concepts and semantic relations that allow the proper definition and selection of player roles and game elements. To achieve this goal, we defined the concepts and terms shown in Figure 1 (a), where: **I-mot goal** is the individual motivational goal of the person in focus (*I*). **Y**<=**I-mot goal** is the motivational strategy that enhances the learning strategy (Y <= I-goal). **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 in focus (*I*). And **I-gameplay** is the gameplay strategy that contains a set of game mechanics that will be used to provide an adequate environment for the person (*I*).



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

The new structure of gameplay strategy (*I-gameplay*) also allows us to include the description of other types of game elements, such as game dynamics, game mechanics and game components. Thus, we introduce the term W(A)-gameplay defined as *CL gameplay* to represent the gameplay space in a *CL scenario*. This gameplay space, as we show in Figure 1 (b), also includes the description of how to apply the game elements previously selected in the gameplay strategy (*I-gameplay*).



Fig. 2: (a) Ontological structures to represent gamified CL scenarios and gamified influential I\_L events. (b) Elements of a gamified influential I\_L event.

Figure 2 (a) shows the ontological structures developed in this work to represent gamified CL scenarios. It extends our previous structure of gamified CL scenarios and consists in the inclusion of structure W(A)-gameplay as the CL gameplay space. The rational arrangement of gameplays (W(A)-gameplay) contains the description of what will occur considering a designed game structure. This description is defined in the ontological structure as CL game dynamic playing the role of "how to play" and the game structure is composed by game mechanics and game components. As the game dynamic is the run-time behavior of game dynamic in a gamified CL scenario as a sequence of gamified influential  $I_L$  events that play the role of necessary or complementary interactions. Thus, the game components and the game mechanics are defined as part of gamified influential  $I_L$  events to drive the learners' actions in a CL scenario, generating the player engagement.

Each gamified influential  $I_L$  event as showed in Figure 2 (a) contains a gamified instructional event and a gamified learning event to describe the designed game structure in a CL scenario. We obtained this game structure after applying gamification as PT in each instructional and learning event defined in the CL scenario. Basically, we based on the Fogg's Behavior Model and the reinforcement theory to gamify the instructional/learning events of influential I\_L events defined as interaction pattern in the structure "W(A)-goal" of a CL scenario.

According to Fogg's Behavior Model [Fogg 2009], for a behavior to occur, the motivation, ability, and trigger must converge at the same moment reaching the activation threshold. In this sense, the definition of proper triggers at the right moment will tell and lead the learners to carry out the intended learning behavior in a predictable way. Thus, for us, as showed in Figure 2 (b), the game components ( $G_1$  and  $G_3$ ) play the role of trigger in which the actions taken by them will persuade the learner's actions defined in the instructional and learning events, respectively. The game components are the basic parts of the game world manipulated by the players or the system and they are probably the most concrete category of game elements, such as points, badges, and leaderboards [Bjork and Holopainen 2006]. Employing this definition, as shown in Figure 2 (a), the ontological structure that represents a gamified instructional event contains a game event playing the role of trigger event, where: the game component plays the trigger role, and the game actions are related by the relationship "persuade" to the actions of students, who play the role of instructor or learner.

According to the reinforcement theory [Skinner 1976], 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 we showed in Figure 2 (b), the game components ( $G_2$  and  $G_4$ ) plays the role of operant conditioning for the learners' actions defined in instructional and learning events. The game actions taken by these game components follow the learners' actions to reinforce the intended learning behavior defined by the script. Based in this definition, the ontological structure of a gamified instructional event showed in Figure 2 (a) contains a game event playing the role of operant conditioning event. In this game event (as is shown in Figure 2 (a)), the game component plays the operant conditioning role, the actions taken by the game component plays the role of game effect that produce a change in the game state. As the game actions of game events produce changes in the game state, the learners' actions defined in the instructional/learning events become game mechanics. The game mechanics are methods invoked by agents (in this case, the

learners), designed for the interaction with the game state [Sicart 2008]. Thus, as we show in Figure 2 (a), the instructional/learners events (I/L events) play the role of *game mechanics event* in the ontological structure of gamified instructional/learning events. 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. Finally, we define the relation "*attain*" to the *game effects* defined in the *operant condition event*.

# 5. Case Study: Building and Appling of a Personalized Gamification Model

In this section, to demonstrate the applicability of our ontological structures presented in the previous section, we built a personalized gamification model based on the information defined in [Orji et al. 2014]. Thus, we made Table 1 through the combination of PSs for each pair of player roles (gamer types). The reason being that there are two students playing the role of instructor (*P-Player*) and learner (*S-Player*) in each I\_L events of CL scenarios. In the case of PSs that require interaction among all participants, we verified if these strategies have negative influence (contra-persuasive). The competition/comparison and cooperation strategies are contra-persuasive for daredevil and survivor, respectively. Furthermore, we cannot use the cooperation and competition/comparison strategies in the same CL scenario, so we decide to select the most persuasive for *P-Player*. In Table 1, we indicated these two restrictions using a line (strikethrough). It's not possible to use competition and cooperate at the same CL scenario because two or more agents can't compete and cooperate at the same time.

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

Table 1. Player roles and Persuasive Strategies to gamify influential I\_L events.

Socializer	COOP, <del>CMPT/CMPR</del> x COOP, REWD, SEMT/SUGG	COOP, CMPT/CMPR X CMPT/CMPR, SIML, PERS, SEMT/SUGG	COOP, <del>CMPT/CMPR</del> x SIML	COOP, CMPT/CMPR x SEMT/SUGG, CMPT/CMPR, PERS, SIML, CUST	COOP, CMPT/CMPR X CUST, PERS, CMPT/CMPR, PRAS	COOP, <del>CMPT/CMPR</del>	CMPT/CMPR x SEMT/SUGG, CMPT/CMPR
Survivor	SEMT/SUGG, CMPT/CMPR x <del>COOP</del> , REWD, SEMT/SUGG	SEMT/SUGG, CMPT/CMPR x CMPT/CMPR, SIML, PERS, SEMT/SUGG	SEMT/SUGG, <del>CMPT/CMPR</del> 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

As is shown in Table 1, we can employ more than one PS to influence changes in the attitudes and behaviors of learners. For example, in a CL scenario, the cooperation, reward and self-monitoring & suggestion strategies can be used to persuade a student who is playing the player role of achiever, while there is no one other students playing the player role of survivor (see first row in Table 1).



Fig. 3: Storyboard illustrating the cooperation (top), reward (middle) and self-monitoring & suggestion (bottom) strategies in a CL scenario.

Figure 3 shows a storyboard illustrating the combination of these three PSs in which the game components of unlockable content, points, and progression bar employ these strategies to persuade a student to guide other students towards the solution of problems (intended learning behavior). In this storyboard, the unlockable content and progress bar play the role of trigger during step (0) when the game actions of "show condition to unlock content" and "give suggestion" respectively persuade the learner to take the action of "give information about how to solve a problem." After the learner takes this action, the game component of points plays the role of operant conditioning

when it gives 10 points during step (1), and the progress bar plays the role of trigger through the game action of "give suggestion." Finally, after step (n) when the learner will received acceptance, the unlockable content plays the operant conditioning role through game action of "unlock content."

Based on the mapping of PSs to *game features*<sup>1</sup> detailed in [Orji et al. 2014] and the combination of persuasive strategies obtained in Table 1, the second step is developing and formalizing a set of game events to play the role of trigger and operant condition in gamified I\_L events of CL scenarios. Currently, we are working in the definition of these game events, and due to space limits, Table 2 only shows a partial list. The complete list of game events is available at https://goo.gl/lkaU8O, and it is open to discussion for future changes.

	Game event as trigger event		Game even	Based on		
Persuasive Strategy	Game Component	Action as Game action	Game Component	Action as Game effect	Changes in the game state	observation of game design
	Unlockable content	Show condition	Unlockable content	Unlock content	Increase contents	Communal discovery
COOP	Virtual item	Show condition	Virtual items	Give virtual item as gift	Increase virtual items	Social fabric of games
СМРТ	Leaderboard	Display scores				Leaderboard
/CMPR	Status	Rank progress				Envy
			Virtual items	Give random item	Increase virtual items	Lottery
REW	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).

Finally, the third step is the definition of ontological structures based on the structure presented in Figure 2 (a) employing the information of Table 1 and Table 2.

#### Appling of Personalized Gamification Model in Semantic Web Authoring Tools

Figure 4 shows the ideal flow to gamify a CL scenario in semantic web intelligent theory-aware authoring tools, in which the first stage (1) is to set proper player roles for each student based on current psychological needs and gameplay styles. The second stage (2) is to design the CL gameplay as CL game dynamics based on a set of gamified influential I\_L events. The third stage (3) is to make and interaction analysis of game events and their influences over activities to identify whether the gameplay design was adequate or not. The third stage consists in proposing better solutions using the meaningful results obtained during the run-time of gamified CL scenario.

<sup>&</sup>lt;sup>1</sup> In [Orji et al. 2014], the authors claimed a mapping of PSs to game mechanics, but they did in reality a mapping to game features, because the game mechanics are simple actions or rules with defined outcomes.



Fig. 4: Flow to gamify CL scenarios in semantic web authoring tools

In [Challco et al. 2014], we defined a pseudo-algorithm to set the player roles according to current psychological needs and gameplay styles. Thus, 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 CL scenario. This definition of CL gameplay will be made employing ontological structures of *CL Game dynamic*. Table 3 show the result of definition of CL gameplay for a CL scenario based on the theory of Cognitive Apprenticeship, in which the player roles of achiever and socializer are defined for students that are playing the role of master and apprentice, respectively. In Table 3, for the masters  $l_1$  and  $l_2$  who play the player role of achiever, the PSs are the cooperation, reward and self-monitoring & suggestion, and the PS of cooperation is defining for the apprentices  $l_3$  and  $l_4$  who play the player role of socializer.

I_L events (I event/L event)	Persuasive Strategies	Game Events for Achiever and Game Events for Socializer Masters: $l_1$ and $l_2$ - Apprentices: $l_3$ and $l_4$
	COOP	Unlockable content: (Show condition / )
(n) Setting up the learning context (Giving information / Receiving	REWD	Points: (Promise points / Give points – add 10 points)
information)	SEMT/SUGG	Progress bar: (Give suggestion / Increase Progress - add 10%)
	COOP	Unlockable content: (Show condition / )
(Demonstration / Observing	REWD	Points: (Promise points / Give points - add 100 points)
demonstration)	SEMT/SUGG	Progress bar: (Give suggestion / Increase Progress - add 40%)
	COOP	Unlockable content: (Show condition / )
(n) Monitoring (Checking / Being checked)	REWD	Points: (Promise points / Give points – add 10 points)
(Checking / Deing checked)	SEMT/SUGG	Progress bar: (Give suggestion / Increase Progress - add 40%)
(d) Clarifying the problem	COOP	Unlockable content: (Show condition / )
(Identifying learner's problem / Externalization of problem)	SEMT/SUGG	Progress bar: (Give suggestion / )
(d) Notifying how the learner is	COOP	Unlockable content: (Show condition / )
(Giving information / Receiving	REWD	Points: (Promise points / Give points – add 10 points)

Table 3.	Game events t	o gamify a CL	. scenario basec	d on Cognitive	Apprenticeship
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information)	SEMT/SUGG	Progress bar: (Give suggestion / )
	COOP	Unlockable content: (Show condition / )
(d) Instigating thinking (Argumentation / Receiving arguments)	REWD	Points: (Promise points / Give points – add 10 points)
(Algumentation / Receiving arguments)	SEMT/SUGG	Progress bar: (Give suggestion / )
(d) Requesting problem's details	COOP	Unlockable content: (Show condition / )
(Asking problematic understanding / Externalization of problems)	SEMT/SUGG	Progress bar: (Give suggestion / )
	COOP	Unlockable content: (Show condition / )
(d) Showing a solution (Explanation / Receiving explanation)	REWD	Points: (Promise points / Give points – add 100 points)
	SEMT/SUGG	Progress bar: (Give suggestion / )
(n) Affirmative reaction	COOP	Unlockable content: ( / Unlock content – Increase new problems)
(Acceptance / Receiving acceptance)	SEMT/SUGG	Progress bar: (/ Increase Progress - add 10%)

Legends: (n) necessary; (d) desired; Game event - game component: (game action/game effect - change in game state)

#### 6. Conclusions and Future Research

In this paper, we presented ontological structures that will able the organization and formalization of knowledge related to gamification as PT in CL scenarios. We defined the concepts of gamifed influential I\_L events, game dynamics for CL scenarios, and gameplay for CL scenarios. These structures allow us to formalize game events based on PSs. 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 in [Orji et al. 2014]. 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/recommendation for the gamification of CL scenarios, making them more motivating and engaging to the learners. Our next steps are the formalization of concepts related to Flow Theory, player's journey, and fun for game design.

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