

Gamification of Collaborative Learning Scenarios: Structuring Persuasive Strategies Using Game Elements and Ontologies

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Abstract. This work presents an ontological model for the formal systematization and representation of knowledge that describes concepts from gamification and its use as Persuasive Technology (PT) in Collaborative Learning (CL) scenarios. This model enables the creation of intelligent systems that can personalize and apply the gamification techniques in group learning contexts in which the scripted collaboration decreases the motivation and engagement of students. Thus, our approach proposes to formalize the connection of concepts from theories and models to design PT in order to specify gamified CSCL scripts that induce students to willingly follow an intended learning behavior. To demonstrate the applicability of our approach, we also present a case study that shows how our ontological model could be used by in an intelligent theory-aware system to build better personalized gamified CL scenarios.

Keywords: Ontologies · Gamification · Persuasion · Persuasive strategies · Collaborative learning · CSCL scripts

1 Introduction

Despite the success in the design of Computer-Supported Collaborative Learning (CSCL) scripts to support the design of collaborative learning (CL) activities, there are situations in which these scripts may lead to demotivation [4, 6, 15]. Sometimes, a learner may neglect his personal behavior to get the task completed because he feels forced by the script and, other times, the lack of choice with respect to the sequence of activities may increase the sense of obligation. The demotivation negatively influences the learners' attitudes and behaviors, degrade group dynamics, and as a result produces long-term negative learning outcomes [6]. Thus, in recent years, the researches and practitioners are seeing gamification as a possible solution to motivate and engage the students in learning situations [11, 31].

Gamification is the use of game design elements in non-game contexts [11] in which the game design theories and models are sources of verified techniques, strategies and principles to gamify an scenario. One important part of these theories and models are related to the design of Persuasive Technology (PT) that focuses on the design of interactive computing products created to change peoples' attitudes and behaviors through persuasion and social influence without using coercion and/or deception [8].

The task to apply Gamification as PT to design well-thought-out gamified CL scenarios is not an easy task, in particular for an instructional designer who is a non-expert in game design and persuasion. To do this task, it is necessary to assemble persuasive game design strategies based on deeper knowledge about principles, methods and techniques defined in the theories and models to design PT. The persuasive game design strategies are Persuasive Strategies (PSs) that consist in rules and prescriptions that define how to use the game elements for the changing of attitudes/behaviors. For example, the use of slang names in messages of a "*progress bar system*" to change the affinity of a person from "*not feeling an affinity*" to "*feeling affinity*" is a persuasive game design strategy based on the PS of suggestion.

As the attitudinal/behavioral states of persons change over time and they are dependent of a context in which the individual is in, it is necessary to look into the different PSs to decide what it is the most appropriate for each student, scenario and situation [1, 16, 23]. Nowadays, such a decision is embedded in the persuasive systems and it is realized implicitly by them, so that it only remains in the minds of designers. This fact causes difficulties in the management, modifications and evolution of PSs. Therefore, in this work, we propose an ontological model to structure and organize the PSs into the ontology **OntoGaCLeS** (an *Ontology to Gamify Collaborative Learning Scenarios*) that is available at the website: <http://labcaed.no-ip.info:8003/ontogacles/>.

In the following sections, we present the related works and an overview of current version of our ontology OntoGaCLeS. Next, we detail an ontological model for the conceptualization and structuration of PSs, we present a case study that describes how our proposed model can be used by an intelligent theory-aware system in the gamification of a CL scenario. Finally, the last section presents the conclusion and future work.

2 Related Works

To the best of our knowledge and by exploring different literature reviews [10, 18, 35, 36], no ontology has been proposed to offer a formal systematization of theories and models for designing PT. The search of terms "*Persuasive Technology*" and "*Ontology*" in the Scopus database returns 89 studies, of which only one study [32] proposes an ontology to represent the knowledge of literature related to human-behavior changes. This knowledge is structured in the ontology under the semantic relations and concepts of problem types, barriers, principles, strategies, mechanisms and applications. Although this ontology allows to identify PSs for solving behavior-changes problems, it is not specific for the Gamification of CL scenarios. Thus, in this study, we propose an ontological model that can be viewed as an extension of an ontology to represent

behavior-change literature [32] in which we include knowledge about how the PSs must be applied using game elements.

Despite the grounding number of studies related to PT in the last years [10], and the development of many successful persuasive games, such as the HIV Roulette [8], OrderUP! [9] and Smoke? [20]; there are few generic models and frameworks to design PT, such as the Design with Intent [22] and the Persuasive System Design (PSD) model [27, 28]. Currently, the PSD model is the most complete comprising many theories and models previously developed to design PT, such as the Reasoned Action's theory [7], the Elaboration Likelihood model [30], and the Fogg's principles [8] used to define the change types of intent, the routes of persuasive messages, and the PSs, respectively. However, the PSD model lacks the information to analyze and personalize the PSs for each user. In this sense, based on the current attitudinal and behavioral states of individuals, the ontological model in this work includes structures for the representation and personalization of PSs defined in the PSD model.

In the literature, researchers and practitioners have proposed their own PSs to deal with specific problems in different contexts, such as the PSs for tailoring persuasive text messages proposed by Kaptein et al. [16], and the PSs for players of collectivist cultures developed by Khaled et al. [19]. These PSs and those that are defined in other specific frameworks and models to design PT, such as the theoretical framework of Sundar et al. [34], the model of Yusoff and Kamsin [37], and the model-driven approach of Orji, et al. [29], do not use a set of consistent terms and vocabulary to be represented and employed by computational systems. In this sense, this work provides a common vocabulary and ontological structures that could be used to represent these PSs. Thus, a semantic web system that gives an intelligent theory-based guidance during the gamification of CL scenarios based on these PSs could be created.

3 Overview of the Ontology to Gamify CL Scenarios

Figure 1 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 step (1), the designer sets the proper player roles and game elements for each student. In the step (2), he designs the CL gameplay as a set of CL game dynamics employing the player roles and game elements that were setting in the first phase. Finally, in the step (3), the designer makes an interaction analysis over the obtained gamified CL scenarios to propose better solutions by the meaningful result obtained during the run-time of CSCL scripts.

In previous works [2, 4, 5], we define ontological structures that allow us to accomplish the step (1) by the building of models that personalize gamification based on the individual differences of students, such as current motivation stages, psychological needs and individual personality preferences. To accomplish the step (2), the work [3] propose a set of ontological structures to represent the application of PSs in CL scenarios. To establish these structures employing concepts and semantic relations in our ontology, we use the ontology engineering techniques [24], the Hozo Ontology editor [21], and the model of roles proposed by Mizoguchi *et al.* [26].

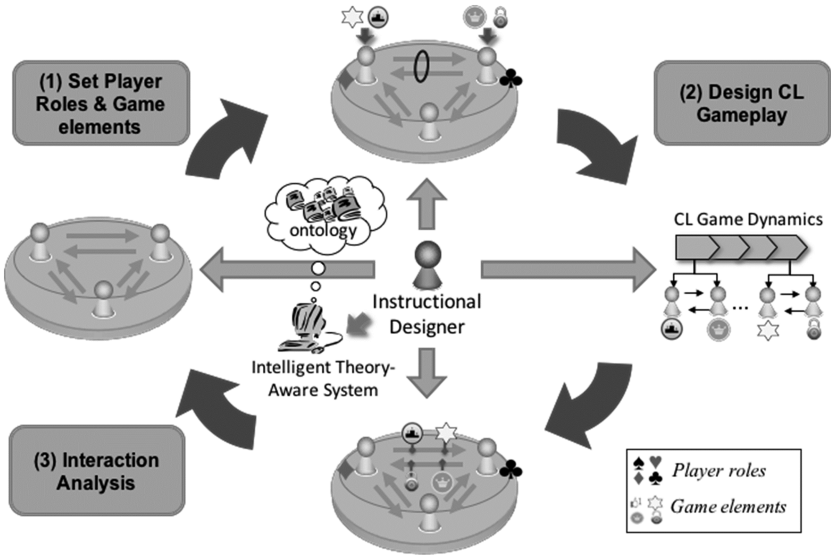


Fig. 1. Flow to gamify a CL scenario in an intelligent theory-aware system.

Thus, the current formalization of our ontology defines the terms and concepts shown in Fig. 2 (a), where ***I-mot goal*** is the individual motivational goal of the “person in focus” (*I*) that is to be satisfied by a motivational strategy; ***I-player role*** is the player 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*); **$Y \leq I\text{-mot goal}$** is the motivational strategy ($Y \leq I\text{-goal}$) that enhances the learning strategy defined for the student in focus (*I*); ***I-gameplay*** is the gameplay strategy that defines the rational arrangement among player role, motivational strategy and game elements for the student in focus (*I*); and ***W(A)-gameplay*** is the CL gameplay that represents the interactions between students and game elements. Figure 2 (b) exemplifies a CL gameplay for the students L_A and L_B in which different game elements are setting for each student.

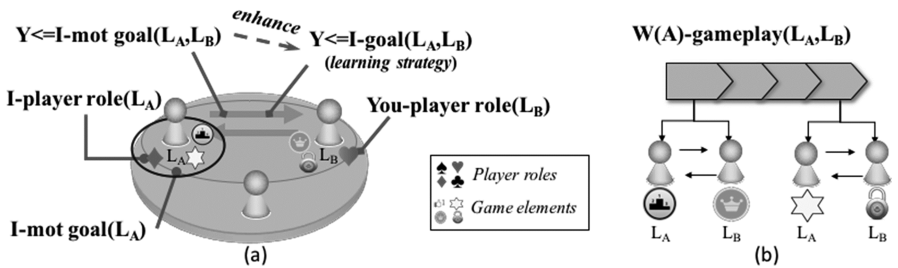


Fig. 2. (a) Terms and concepts for gamified CL scenarios; and (b) example of a CL gameplay.

Based on the concepts and terms presented above, Fig. 3 (a-d) shows the current ontological structures that we define to represent gamified CL scenarios. This

representation extends the ontological structure for CL scenarios proposed in [13–15]. In the structure shown in Fig. 3 (a), the motivational strategy ($Y \leq I\text{-mot goal}$) is the gamification for the student in focus (I) that depends on the player role ($I\text{-player role}$) for the student in focus “ I ,” the player role ($You\text{-player role}$) for the student “ You ” who interacts with the student in focus, and the individual motivational goals ($I\text{-mot goal}$) for the student in focus “ I .” Next, the gameplay strategy ($I\text{-gameplay}$) defines “*what are the best game elements for each student*,” and the CL gameplay ($W(A)\text{-gameplay}$) defines the “*how to use the selected game*.” This gameplay consists in a set of CL Game dynamics that define a sequence of necessary and complementary interactions represented by *Gamified Influential I_L events*.

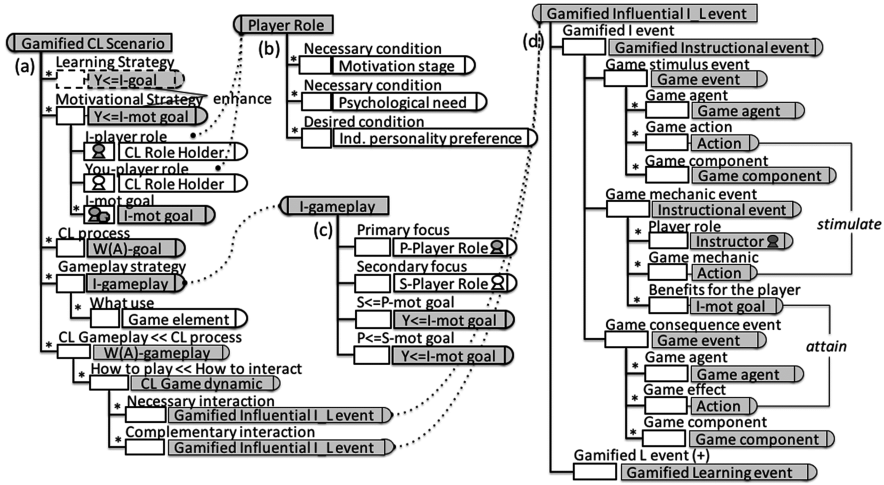


Fig. 3. Ontological structures to represent gamified CL scenarios.

The ontological structure, shown in Fig. 3 (b), allows the classification of students in different player types employing *player roles* that depend on the necessary and desire condition, such as the *motivational states*, *psychological needs*, *individual personality preferences* (e.g. playing styles, cognitive styles). Figure 3 (c) represents the *gameplay strategy* as a rational arrangement for: the player role of student in focus “ I ” (*Primary focus*), the player role of student “ You ” who is interacting with student “ I ” (*Secondary focus*), and the motivational strategy for the student “ I ” ($S \leq P\text{-mot goal}$), the motivational strategy for the student “ You ” ($P \leq \text{mot goal}$). Figure 3 (d) represents each interaction of CSCL script as two parts: a gamified instructional event and a gamified learning event. These two events play the role of game mechanics events, where: the instructor and learner play the player role, his actions become game mechanics, and his individual motivational goals ($I\text{-mot goal}$) are the *benefits for the player*. The gamified instructional and learning events also describe in a *game stimulus event* and in a *game consequence event*: the game actions that “*stimulate*” the students to do the actions defined in the instructional and learning events; and the game actions that follow the actions of students and allow them to “*attain*” their individual goals. Thus, the elements of a game event

are: the “*game agents*” (e.g. point system, badge system); their “*game actions*” that stimulate the actions defined in the instructional/learning event; and their *game components* that are basic parts of game world manipulated by game agents (e.g. points, badges).

4 Conceptualization of Persuasive Game Design Strategies

The personalization of PT and Gamification have been shown effectivity to increase the motivation and engagement of users in different systems [1, 17, 29]. Our current ontological structures enable to represent this personalization for CSCL scripts in which the game elements are introduced to deal with the demotivation problem.

The semantic relations in the motivational strategy ($Y \leq I\text{-}mot\ goal$) represent the dependence between the goals of CL roles and those goals of player roles that can be used to enhance a particular learning strategy. The ontological structure *gameplay strategy* ($I\text{-}gameplay$) reflects the personalization of game elements defined by different models of player types, so that different game elements are associated for each player role of a CL scenario. Finally, to reduce the feeling of obligation imposed by the sequencing of interactions, we represent the CL process as a sequence of gamified I_L events that represent the application of PSs using game elements for each interaction defined in a CSCL script.

The current ontological structures in our ontology does not represent the PSs themselves, they represent the application of PSs over the sequence of interactions defined in CSCL scripts. It means that to build a model of gamification for CL scenarios, system developers have to interpret theories and models to design PT by an expert in gamification and CSCL. This interpretation only remains in their minds, causing difficulties to manage the PSs, avoiding the definition, modification and evolution of PSs. Therefore, to overcome this issue, we introduce a new stakeholder named “*Gamify Expert*” in the activity flow to gamify CL scenarios as shown in Fig. 4. We define this flow as an extension of our previous activity flow of Fig. 1 that is now defined in an in a reference architecture for semantic-web intelligent theory-aware systems.

In the new activity flow of Fig. 4, the *Gamify expert* employs a “*Gamification-framework editing environment*” to do the maintenance of PSs employing a PSs manager system that stores the PSs into a WAY-knowledge base. Next, employing an “*Intelligent theory-aware environment*” in the design of the CL gameplay, the instructional designer will find in the WAY-knowledge base for previous PSs that they have used, have experienced, or have seen applied as solution in others similar scenarios or situation. After the selection of PSs, the instructional designer will be able to apply them in the CL scenario using a CL Gameplay Design Support System, following advice and recommendation given by this system.

To build a WAY-knowledge base that covers the different PSs, we propose to make an engineering approximation of PSs in terms of the changes in attitudinal states and behavioral states. This approximation is done in two steps. The first step is to identify the similarities and differences in the theories and models to design PT and the second step is to describe the PSs as WAY-Structures.

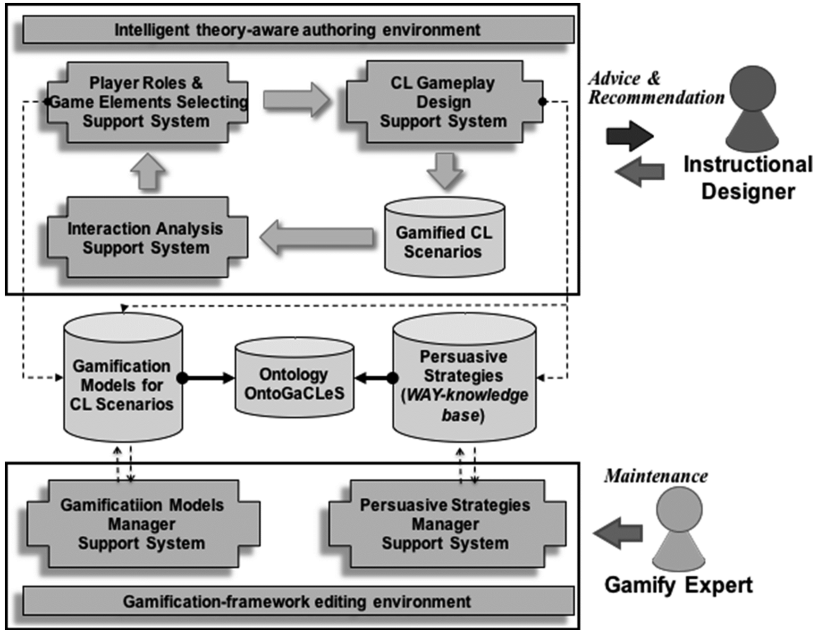


Fig. 4. Activity flow to gamify CL scenarios in a reference architecture for semantic-web intelligent theory-aware systems that will employ the ontology OntoGaCLeS

4.1 Identifying Similarities and Differences of Theories and Models to Design Persuasive Technology

The first part consists in the structuration and organization of terms, concepts and principles used in the theories and models to design PT into a set of ontological structures that define these elements as part of a whole as is shown in the nested structure of Fig. 5(a).

According to the Fig. 5(a), the gamification theories and models explain the game design process that has the purpose to obtain a plan/design of game events that will be introduced in a non-game context to gamify it. Next, the plan/design of game events is explained by theoretical justifications that have source in the game design theories and models. The purpose of the game events is to produce/induce changes in attitudinal and behavioral states of individuals in the non-game events. Finally, these changes in non-game events are explained by theories of motivation and human behavior.

Based on the nested structure mentioned above, the ontology OntoGaCLeS is categorized into the following basic concepts: Common world, Non-game world, Game world, Gamification world, as well as Theory and Model. The theories and models to design PT are defined in an ontological “*is-a*” hierarchy structure according to firstly the domains and then according to the paradigms defined in each domain. During this task, we identify the properties of theories and models, such as their principles, hypothesis, and evidences. Figure 5(b) shows part of this “*is-a*” hierarchy structure in which the concept of “*persuasive design models*” is a concept of a “*game design model*.”

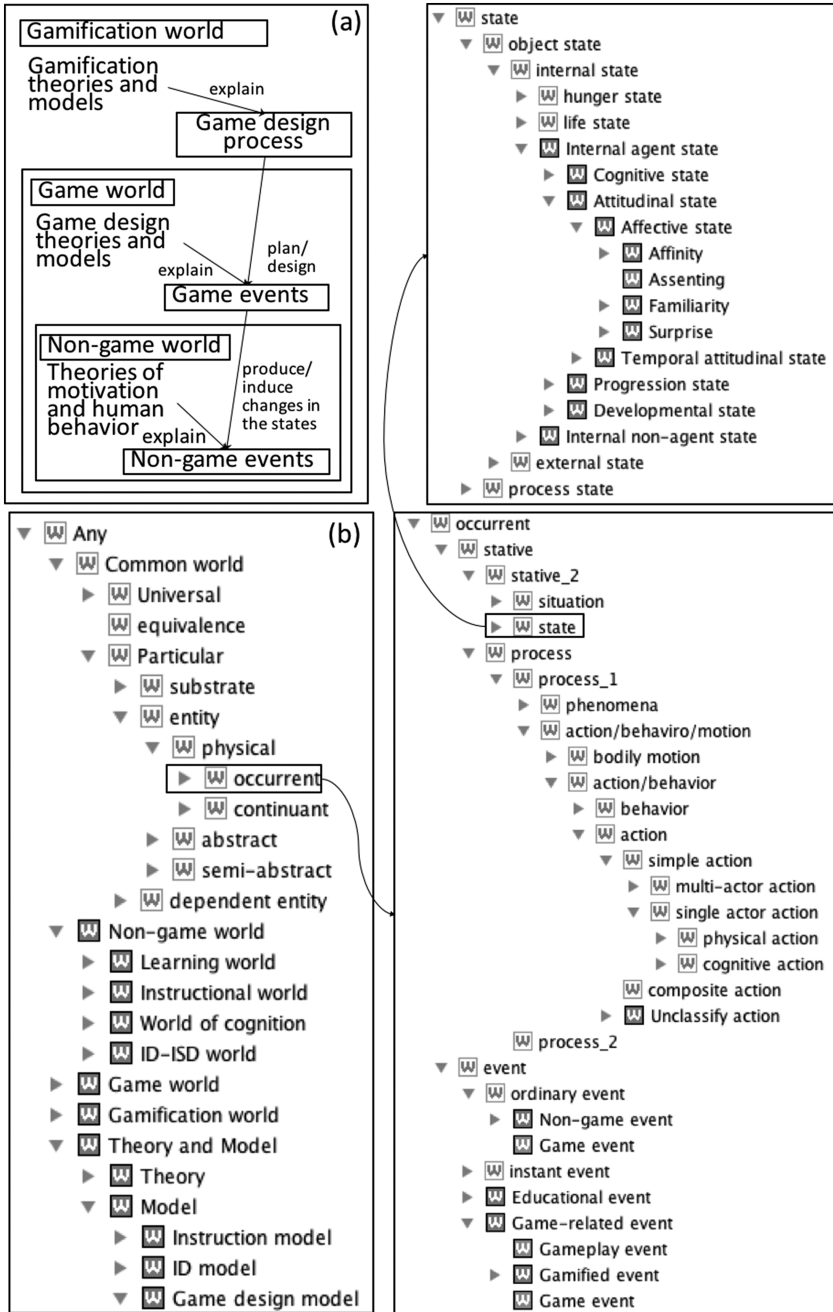


Fig. 5. (a) Nested structure of gamification, game and non-game worlds; and (b) part of the “is-a” hierarchy structure in the ontology OntoGaCLoS.

The concepts in the common world are built taking as base the upper-level ontology YAMATO [25]. These concepts are common to the other worlds (i.e., Learning world, Game Design and Gamification worlds) and they are employed to define particular concepts in their respective worlds. Figure 5(b) shows the “*is-a*” hierarchy structure of concepts defined in the common world that will be employed to represent PSs. In the concept of state, we define the attitudinal and behavioral states as an internal agent state. In the concept of events, the concept of ordinary event is divided in game event and non-game event, and we define the concept of game-related event to describe the meaning of actions in the context of game-like products, so that we currently classify events of this type in Gameplay event, Gamified event, and Game event.

Figure 6(a) shows the ontological structure to represent a *game event* that is constituted by two agents who plays the role of “*player*” and “*game agent*,” a set of “*game actions*” of game agent, the “*game components*” that are objects employed by the game agent, and the explanations (*Explain by*) for the game event that can be a game design theory or game design model. In the game event, the changes in the state of players are not defined as part of it because the “*Game design world*” is separate from the “*Non-game world*,” so that we will define this change in the concept of *gameplay event*.

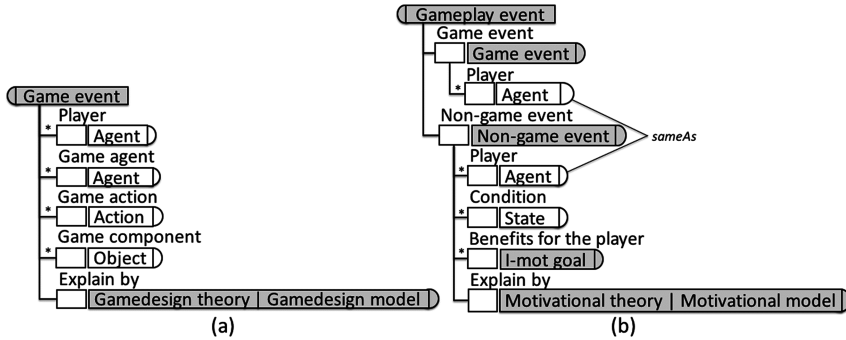


Fig. 6. Ontological structures to represent (a) Game events and (b) Gameplay events.

Figure 6(b) shows the ontological structure to represent a *gameplay event* that is used to define the relationship between a game event and a non-game event. In the non-game event, the “*condition*” is a state that will be employed to define: a “*precondition*” to apply a game event, and a “*terminal state*” that is obtained after to execute a game event. The expected “*benefits for the player*” in the non-game event is described employing a set of individual motivational goals (*I-mot goal*). In the non-game event, the theoretical justification that explains (*Explain by*) the changes can be a motivational theory/model. The definition of “*Game events*” and “*Non-game events*” separately in the *gameplay event* allows the building of various the combinations of these two events. These combinations are the core of the WAY-structures that will be detail in the next subsection.

4.2 Describing Persuasive Strategies as WAY-Structures

The description of PSs as WAY-structures consists in the conceptualization of ways to attain the expected changes in attitudinal and behavioral states employing a sequence of game events that influence and produce these changes. Thus, as shown in Fig. 7(a), the ontological structure “WAY-knowledge of PS” represents a PS as the decomposition of a macro-gameplay event into a sequence of micro-gameplay events.

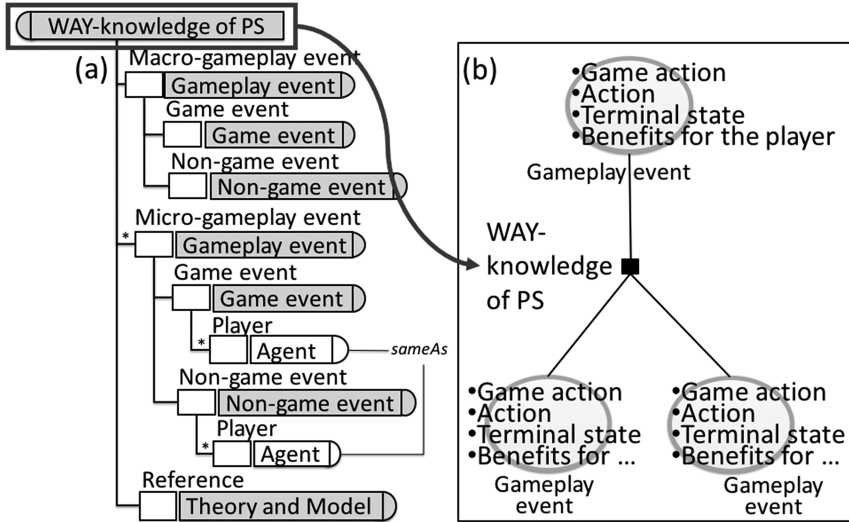


Fig. 7. (a) Ontological structure to represent a persuasive strategy; and (b) its representation as a decomposition tree.

Figure 7(b) shows the representation of PS as a decomposition tree of gameplay events, where: the macro-gameplay event represents the “*what to achieve*” as a goal; and the micro-gameplay events represent the “*how to achieve*” the goal defined in the macro-event through a sequence of sub-goals. The goals in this decomposition tree for the micro- and macro-gameplay events are the “*benefits for the player*” (*I-mot goal*) or “*terminal states*” defined in the non-game events. When there are no “*benefits for the player*” in a macro-gameplay event, the goal of a decomposition tree is the “*terminal state*.”

Based on the ontological structure “WAY-knowledge of PS,” we define a WAY-knowledge base of PSs whose part is shown in Fig. 8. In this base, the PSs are classified according to firstly the categories of PSs, and secondly according to the expected changes in the attitudinal and behavioral states. In this figure, the PS “*Oinas-Kukkonen & Harjumaa’s reward strategy to increase behavior*” is defined as a “*reward strategy*” of “*PS for dialogue*.” The goal of this strategy is to “*increase behavior (familiar behavior)*” making this behavior a “*familiar behavior*” (terminal state) by the action “*increase the behavior by reward*.” Next, this strategy decomposes the macro-gameplay event into two micro-gameplay events that have the actions: “*measure behavior*” and “*give reward*.”

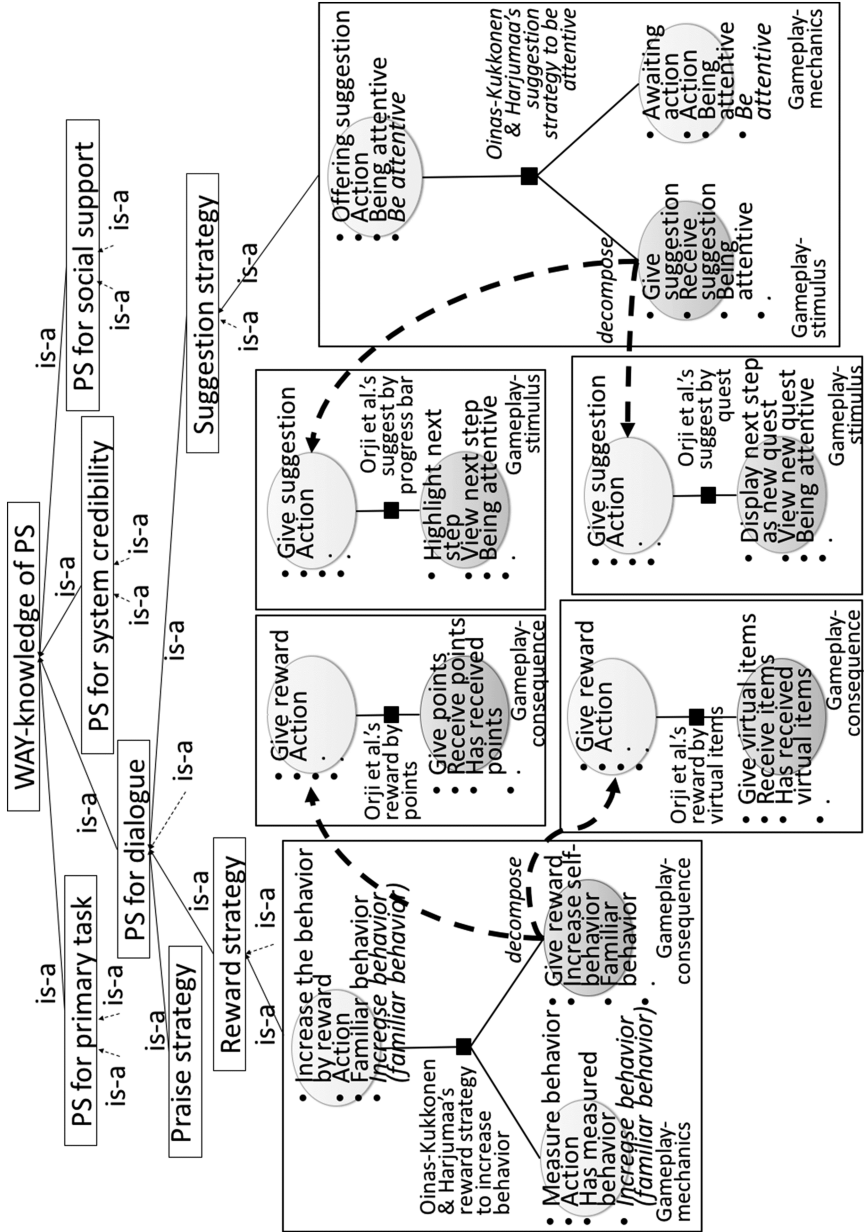


Fig. 8. A portion of the WAY-knowledge base of Persuasive Strategies.

During the action “*measure behavior*,” the player performs the “*action*” defined in the macro-gameplay event, and we call this event as *gameplay-mechanics event*. After to measure behavior, in the second micro-gameplay event, the game action “*give reward*” produces the cognitive action “*increase self-behavior*” that changes the behavioral state from “*non-familiar behavior*” to “*familiar behavior*,” and we call this event as *gameplay-consequence event*.

Figure 8 also shows two PSs for the decomposition of game activity “*give reward*.” Both strategies are similar in the internal psychological change that they produce. However, the first PS “*Orji et al.’s reward by points*” employs a point system as a game agent to do the action “*give the points*,” while the second PS “*Orji et al.’s rewards by virtual item*” employs a virtual item system as a game agent to do the action “*gives virtual items*.”

Beside the reward strategy detailed above, Fig. 8 details the PS “*Oinas-Kukkonen & Harjuma’a’s suggestion strategy to be attentive*” defined as suggestion strategy of “*PS for dialog*.” This PS decompose the macro-gameplay event with the action “*offering suggestion*” into two micro-gameplay events that have the actions: “*give suggestion*” and “*awaiting action*.” In this case, for example, we show two PSs that are defined to decompose the activity “*give suggestion*,” one of these strategy employs the progress bar system and the other strategy employs an “*quest system*” to do the actions “*highlight the next step*” and “*display the next step as new quest*,” respectively.

5 Case Study in the CSCL Script for Argumentation

To demonstrate the utility of our approach that consists of the conceptualization of PSs presented in the previous section, we are developing an advanced authoring intelligent theory-aware system based on the reference architecture shown in Fig. 4. Figure 9 illustrates the manner in which this theory-aware system uses the WAY-knowledge base of PSs to gamify a CL scenario during the CL gameplay design. In this example, as we show in Fig. 9(a), the CL scenario being gamified is a scenario based on the CSCL script for “*argumentation, counter-argumentation and integration*” proposed by Stegmann et al. in [33]. After the selection of player roles and games elements for each student of CL scenario, as shown in Fig. 9(a-1), the socializer role is assigned for the student I1 who has the role of arguer, while the achiever role is assigned for the student I2 who has the role of co-arguer.

Figure 9(a-1) also shows that the motivational strategies for socializers and achievers are the “*Gamifying by persuasive strategy COOP*,” in both cases. Figure 9(a-2) shows that the selected game elements in gameplay strategy (*I-gameplay strategy*) for socializer and achiever are the communal discovery. Finally, the individual motivation goals (*I-mot goal*) for students I2 are “*satisfy mastery*,” “*be attentive*” and “*increase behavior (familiar behavior)*” as shown in Fig. 9(a-3).

The default “*CL gameplay*” for the scenario shown in Fig. 9(a-4) is obtained by employing an ontological model that extends the ontological structures shown in Fig. 3. This model employs the information defined by Orji et al. in [29], and its detail of construction can be found in [3]. As result of the application of this model, each gamified

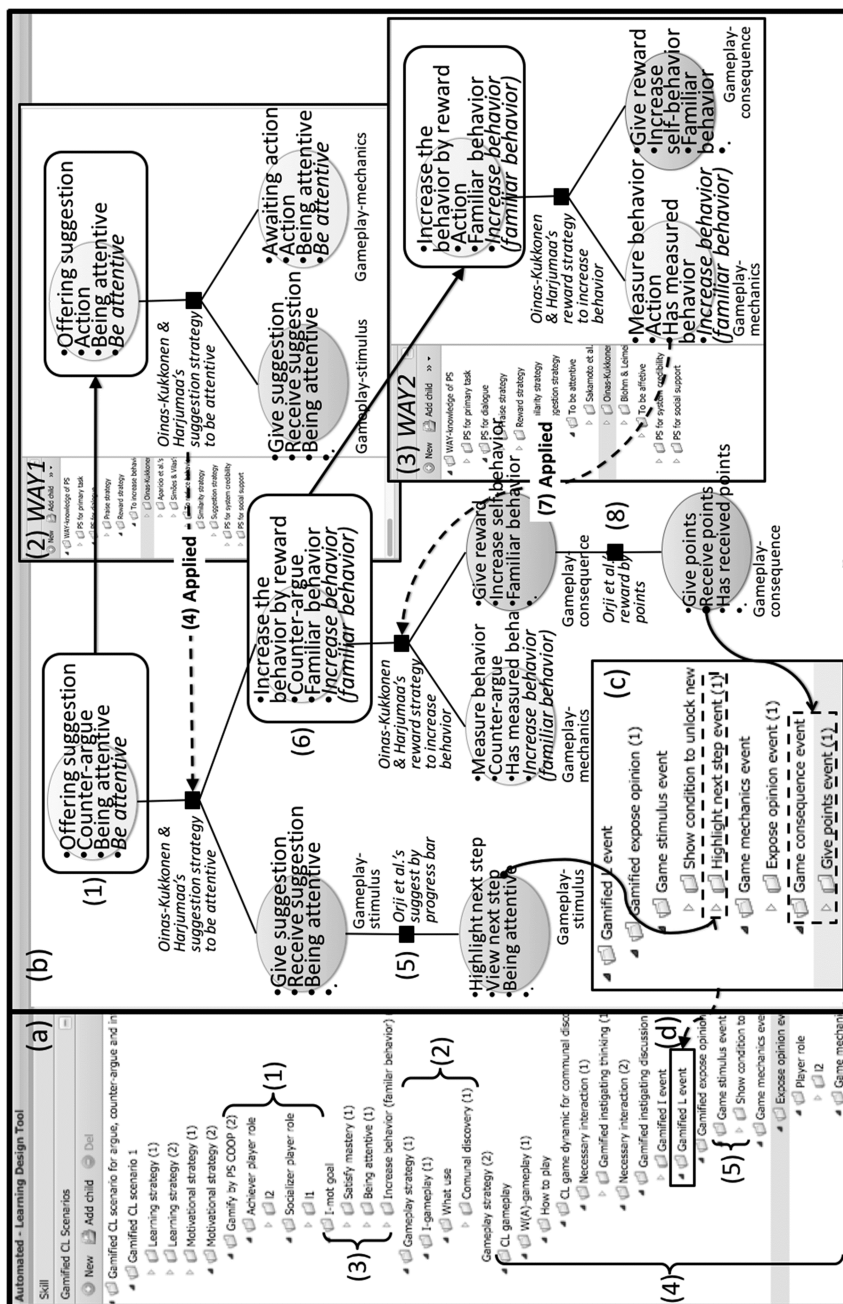


Fig. 9. Illustration of how to employ the WAY-knowledge base of Persuasive Strategies.

instructional and learning event defines the game action “*show condition to unlock new content*” as game stimulus event that persuades the student I2 to do the actions of learning event as shown in Fig. 9(a-5).

Employing the WAY-knowledge base of PSs, we can personalize the gamified instructional and learning event for each student of a gamified CL scenario by adding new game stimulus and game consequences events, so that the Fig. 9(b) shows how this personalization is done for the student I2 over the learning event “*expose opinion*.” First, after the selection of the event that will be personalized, the macro-gameplay event is automatically filled by the information of selected event as shown in Fig. 9(b-1). Based in the individual motivational goals “*be attentive*” and “*increase behavior (familiar behavior)*” of student I2, the system proposes the ways of decomposition WAY1 and WAY2, respectively shown in Fig. 9(b-2) and (b-3). The first way (WAY1) emerges from the PS “*Oinas-Kukkonen & Harjuma’s suggestion strategy to be attentive*” because it allows to “*be attentive*” (I-mot goal). The second way (WAY2) emerges from the PS “*Oinas-Kukkonen & Harjuma’s reward strategy to increase behavior*” because it allows to “*increase behavior (familiar behavior)*.” In this example, the designer selects the first way (WAY1) decomposing the macro-gameplay (Fig. 9(b-1)) into two micro-gameplay events with the game actions “*give suggestion*” and “*awaiting action*” as shown in Fig. 9(b-4). The designer can decompose the game action “*give suggestion*” by employing different PSs. For this example, the designer selects the PS “*Orji et al.’s suggest by progress bar*” as shown in Fig. 9(b-5). Next, the designer decomposes the gameplay mechanics event shown in Fig. 9(b-6) into two micro-gameplay events with the game actions “*awaiting action*” and “*give reward*” as shown in Fig. 9(b-7). This decomposition emerges from the PS “*Oinas-Kukkonen & Harjuma’s reward strategy to increase behavior*” (WAY2) shown in Fig. 9(b-3). Finally, the game action “*give reward*” is decomposed into the game action “*give points*” by the application of PS “*Orji et al.’s reward by points*” shown in Fig. 9(b-8).

The process to personalize the gamified instructional and learning event shown in Fig. 9(b) can be repeated for each student and over each instructional and learning event to define a better gamified CL scenario. At the end of this process, as shown in Fig. 9(c), the system integrates the game events in a set of game stimulus and game consequence events. For this example, the game action “*highlight next step*” done by the “*progress bar system*” is integrated into a game stimulus event, and the game action “*give points*” done by the “*point system*” is integrated in a game consequence event. Finally, the last step is the addition of game stimulus and game consequence events into its respective gamified event as shown in Fig. 9(d).

6 Conclusion and Future Steps for Our Research

In this study, we propose to structure the knowledge of PSs into the ontology *Onto-GaCLeS*. This structuration contributes to a better understanding of how to apply Gamification as PT in CL scenarios. Our approach is similar to the structuration of learning/instructional theories proposed by Hayashi *et al.* in [12]. In both cases, the theories and models are conceptualized from two viewpoints: the theory/model as a

whole, and the theory/model as an aggregation of strategies. As a result of this structuration, we obtain a theory's independent and common WAY-knowledge base of PSs. Thus, we also propose a reference architecture for semantic-web intelligent theory-aware systems that employ this WAY-knowledge. Finally, to demonstrate the applicability of our approach, we illustrated the manner in which an intelligent theory-aware system based on this reference architecture allows to build better personalized gamified CL scenarios.

Our future work includes the formalization of more PSs from different theories and models to design PT, including models to design persuasive messages. We will develop a complete intelligent theory-aware system to help instructional designers in the gamification of CL scenarios. Finally, we will also evaluate the effectiveness of persuasion proposed by this system in CL scenarios.

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