UNIVERSIDADE DE SÃO PAULO
Instituto de Ciências Matemáticas e de Computação

Gamification of Collaborative Learning Scenarios: An Ontological Engineering Approach to Deal with the Demotivation Problem Caused by Computer-Supported Collaborative Learning Scripts

Geiser Chalco Challco

Tese de Doutorado do Programa de Pós-Graduação em Ciências de Computação e Matemática Computacional (PPG-CCMC)

ICMC USP
SÃO CARLOS

SERVIÇO DE PÓS-GRADUAÇÃO DO ICMC-USP

Data de Depósito:

Assinatura: ______________________

Geiser Chalco Challco

Gamification of Collaborative Learning Scenarios: An Ontological Engineering Approach to Deal with the Demotivation Problem Caused by Computer-Supported Collaborative Learning Scripts

Doctoral dissertation submitted to the Institute of Mathematics and Computer Sciences – ICMC-USP, in partial fulfillment of the requirements for the degree of the Doctorate Program in Computer Science and Computational Mathematics. *EXAMINATION BOARD PRESENTATION COPY*

Concentration Area: Computer Science and Computational Mathematics

Advisor: Prof. Dr. Seiji Isotani

USP – São Carlos
July 2018

Geiser Chalco Challco

Gamificação de Cenários de Aprendizagem Colaborativa: Uma Abordagem de Engenharia de Ontologias para Lidar com o Problema de Desmotivação Causado por Scripts de Aprendizagem Colaborativa Suportados por Computador

Tese apresentada ao Instituto de Ciências Matemáticas e de Computação – ICMC-USP, como parte dos requisitos para obtenção do título de Doutor em Ciências – Ciências de Computação e Matemática Computacional. *EXEMPLAR DE DEFESA*

Área de Concentração: Ciências de Computação e Matemática Computacional

Orientadora: Prof. Dr. Seiji Isotani

USP – São Carlos
Julho de 2018

ABSTRACT

CHALLCO, G. C. **Gamification of Collaborative Learning Scenarios: An Ontological Engineering Approach to Deal with the Demotivation Problem Caused by Computer-Supported Collaborative Learning Scripts**. 2018. **??** p. Tese (Doutorado em Ciências – Ciências de Computação e Matemática Computacional) – Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo, São Carlos – SP, 2018.

Increase both students' motivation and learning outcomes in Collaborative Learning (CL) activities is a challenge that the Computer-Supported Collaborative Learning (CSCL) community has been addressing in the past last years. The use of CSCL scripts to structure and orchestrate the CL process has been shown to be effective to support meaningful interactions and better learning, but the scripted collaboration often does not motivate students to participate in the CL process, which makes more difficult the use of scripts over time in CL activities. To deal with the motivation problems, the researchers, educators and practitioners are now looking at gamification as a solution to motivate and engage students. However, the gamification is a complex task, requiring from instructional designers and practitioners, knowledge about game elements (such as leaderboards and point systems), game design (e.g. how to combine game elements) and their impact on motivation, engagement and learning. Moreover, the gamification is too context-dependent, requiring personalization for each participant and situation. Thus, to address these issues, an ontological engineering approach to gamify CL sessions has been proposed and conducted in this dissertation. In this approach, an ontology has been formalized to enable the systematic representation of knowledge extracted from theories and best practices related to gamification. In this ontology, the concepts, extracted from practices and theories related to gamification, and identified as relevant to deal with the motivation problem caused by the scripted collaboration, have been formalized as ontological structures to be used by computer-based mechanisms and procedures in intelligent-theory aware systems. These mechanisms and procedures with ontological structures aim to provide support to give advices and recommendations that will help instructional designers and practitioners to gamify CL sessions. To validate this approach, and to demonstrate its effectiveness and efficiency into deal with the motivation problem caused by the scripted collaboration, four empirical studies were conducted in real situations at the University of São Paulo with undergraduate Computer Science and Computer Engineering students. The results of the empirical studies demonstrated that, for CL activities where the CSCL scripts are used as a method to orchestrate and structure the CL process, the ontological engineering approach to gamify CL scenarios is an effective and efficient solution to deal with the motivation problem because the CL sessions obtained by this approach affected in a proper way the participants' motivation and learning outcomes.

Keywords: Ontology, Gamification, Collaborative Learning, Scripts, Motivation .

RESUMO

CHALLCO, G. C. **Gamificação de Cenários de Aprendizagem Colaborativa: Uma Abordagem de Engenharia de Ontologias para Lidar com o Problema de Desmotivação Causado por Scripts de Aprendizagem Colaborativa Suportados por Computador**. 2018. **??** p. Tese (Doutorado em Ciências – Ciências de Computação e Matemática Computacional) – Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo, São Carlos – SP, 2018.

Aumentar a motivação e os resultados de aprendizagem dos estudantes nas atividades de aprendizagem colaborativa é um desafio que a comunidade de Aprendizagem Colaborativa com Suporte Computacional tem abordado nos últimos anos. O uso de scripts para estruturar e orquestrar o processo de aprendizagem colaborativa demonstrou ser eficaz para dar suporte as interações significativas e um melhor aprendizado, mas a colaboração com scripts muitas vezes não motiva os alunos a participar do processo de aprendizagem colaborativa, o que dificulta o uso de scripts ao longo do tempo em atividades de aprendizgem colaborativas. Para lidar com problemas de motivação, os pesquisadores, educadores e profissionais estão agora olhando a gamificação como uma solução para motivar e envolver os alunos. No entanto, a gamificação é uma tarefa complexa, exigindo de projetistas instrucionais e profissionais, conhecimento sobre elementos do jogo (e.g. leaderboards e sistemas de pontos), design de jogos (e.g. como combinar elementos do jogo) e seu impacto na motivação, engajamento e aprendizado. Além disso, a gamificação é muito dependente do contexto, exigindo personalização para cada participante e situação. Assim, para abordar esses problemas, uma abordagem de engenharia ontologias para gamificar sessões de aprendizagem colaborativa foi proposto e desenvolvida nesta dissertação. Nessa abordagem, uma ontologia foi formalizada para possibilitar a representação sistemática de conhecimentos extraídos de teorias e melhores práticas relacionadas à gamificação. Na ontologia, os conceitos, extraídos de práticas e teorias relacionadas à gamificação, e identificados como relevantes para lidar com o problema de motivação causado pela colaboração com scripts, foram formalizados como estruturas ontológicas a serem utilizadas por mecanismos e procedimentos informatizados em sistemas inteligentes cientes de teorias. Esses mecanismos e procedimentos com estruturas ontológicas visam fornecer suporte para dar conselhos e recomendações que ajudarão os projetistas instrucionais e profissionais a gamificar as sessões de aprendizagem colaborativa. Para validar a abordagem e demonstrar sua eficácia e eficiência em lidar com o problema de motivação causado pela colaboração com scripts, quatro estudos empíricos foram conduzidos em situações reais na Universidade de São Paulo com estudantes de graduação em Ciência da Computação e Engenharia da Computação. Os resultados dos estudos empíricos demonstraram que, para as atividades de aprendizagem colaborativa no que os scripts são usados como um método para orquestrar e estruturar o processo da aprendizagem colaborativa, a abordagem de engenharia ontológica para gamificar cenários de aprendizagem colaborativa é um eficaz e eficiente solução para lidar com o problema de motivação porque as sessões de aprendizagem colaborativa obtidas por essa abordagem afetaram de maneira adequada a motivação e os resultados de aprendizagem dos participantes.

Palavras-chave: Ontologia, Gamificação, Aprendizagem Colaborativa, Scripts, Motivação .

LIST OF FIGURES

LIST OF CHARTS

LIST OF ALGORITHMS

LIST OF TABLES

CONTENTS

CHAPTER

1

INTRODUCTION

This chapter starts with the context and delimitation of research problem (**??**). After that, the chapter formulates the research questions and objectives (**??**). The research methodology is presented in **??**. The thesis statement and contributions are presented in **??**. The chapter ends with the structure of this dissertation (**??**).

1.1 Context and Problem Delimitation

Over the last two decades or so, with the growing number of technologies that enable people to communicate and work in group activities using computers and Internet, researches and practitioners have developed technology and software applications that facilitate and foster the Collaborative Learning (CL) (**??**). Such technology and the research field that studies how to effectively link together the advanced in computer science with the collaborative learning is known as Computer-Supported Collaborative Learning (CSCL), and it has been proved an important to support the learning process of students by cognitive, social and technological reasons (**??**). However, CSCL is only beneficial when there is an adequate design establishing the way in which the collaboration should happened (**??????**). Students frequently fail to be engaged in productive learning interactions when they are left to interact in CL activities without any support. Hence, several researchers propose the use of scripts to guide and orchestrate the collaboration among students (**??**).

Scripted collaboration aims to engage the students in fruitful and meaningful interactions according to a design that has the purpose to attain a set of pedagogical objectives. Thereby, CSCL scripts have been proposed by the community to support the well-thought-out design of the CL scenarios by means of computer-based systems (**????**). These scripts are the technology that describes how the interactions among students will be orchestrated in a group activity to increase the possibility of achieving the pedagogical objectives (**??**). These scripts provide information that facilitates the group formation, the role distribution, and the sequencing of interaction for the participants of a CL activity. Despite of these benefits, there are situations in which the scripts may cause motivation problem. Sometimes, a learner does not want to play the role assigned by the scripts, and he may neglect his personal behavior to get the task completed without effort and, other times, the lack of choice over the sequence of interactions may produce in the students a sense of obligation in complete an unwilling activity (**????**). These issues may negatively influence the students' motivation, learning attitudes and behaviors, degrade the classroom group dynamics, and result in long-term and widespread negative learning outcomes (**????**)

The motivation problem caused by the scripted collaboration makes more difficult the use of CSCL technology over time. In fact, less motivated students prefer to spend more time in other activities rather than to learn and, as consequence, the achievement of expected learning outcomes becomes difficult (**????**). In this sense, motivating learners in the entire instructional process of CL is important. However, the traditional instructional design practice assumes that the motivation is a simple preliminary step that must happen before the instruction (**????**). This assumption is based in which the good quality of learning materials can keep the students focused during the learning process, but if this process is long, there is a good chance that the students will lose their initial attention. To solve this problem, several approaches, such as the use of affective feedbacks based on emotion-aware (**????**), peer learning companions (**??**), and so on, have been proposed to motivated students along the entire instructional process. These solutions assume that the students like the content-domain and/or have the desired to learn, so that students that do not have the desire to learn are not motivated and engage for these approaches.

In the last years, efforts of CSCL community have been directed to finding new innovative solutions that, beside to motivate and engage students during the entire CL process, are not completely tied to the domain-content and desired to learn the domain-content. In this direction, several researchers and practitioners have pointed Gamification as a promising technology to deal with motivation problem in the instructional/learning domain (**??????**). Gamification defined "*as the use of game design elements in non-game contexts*" (**??**) aims to increase the students' motivation and engagement by making the learning process more game-like. This is done through the introduction of game elements, such as points, leaderboards, competition, cooperation and so on. These elements are not part of the domain-content, neither they belong to the instructional/learning process, so that they can even motivate students who do not have the desire and/or interest in to learn the content-domain. These game elements are introduced along the entire learning process, so that the benefits of gamification strongly depend on how well these game elements are applied, and how well they are linked with the pedagogical approaches (**????**).

When CL scenarios are gamified to deal with the motivation problem caused by the scripted collaboration, the author of this thesis hypothesizes that the chances to achieve engagement and educational benefits will be increased whether there is a proper connection between the game elements and the CL process. Nevertheless, developing such well-though-out gamified

CL scenario, hereinafter referred to as gamified CL scenarios, is not trivial. The main difficulty to gamify CL scenarios as well as other non-game context is that the gamification is too context dependent (**????**). Its effects vary individual to individual, and they depend of many factors such as the individual personality traits, preferences, and current students' emotions (**????**) (e.g., a user who likes competition would be more motivated by a leaderboard rather than a user who want to obtain items to customize his/her avatar). Also, the expected effects of the game elements vary according to the non-game context and target behavior that is being gamified (**????**) (e.g., gamifying a learning scenario to promote the sign-up of participants is not the same that gamifying an interactive enviroment to maintain the students attention). As consequence of this context-dependency, when a CL scenario is not well gamified, instead to have a positive effect, they may cause a detrimental on the students' motivation (**??**), cheating (**??**), embarrassment (**??**), and lack of credibility on badges (**??**).

Another difficulty to gamify CL scenarios, as well as other non-game contexts, it is the lack of approaches to systematically represent, in an unambiguous way, the gamification knowledge acquired in the last years by researchers and practitioners. This knowledge constituted by theories and best practices related to gamification lacks of a formal and common vocabulary, definitions, and representation to apply gamification. As can be appreciated in the current literature of gamification (**????????**), each author proposes his/her own definitions, classifications and representation to describe the concepts and characteristics about how to gamify a non-game context. This fact hinders the creation of models and/or frameworks that formally represent the gamification and its application by computer-based systems in a common understandable and sharable manner, and to the best of the thesis author's knowledge, there are no one approaches has been proposed to represent the knowledge about how to gamify CL scenarios to deal with the motivation problem caused by the scripted collaboration.

Due to the variety of students who can participate in CL sessions, the diversity of subjects that can be under study in a CL activity, and the range of different CSCL scripts that can be used to orchestrate the CL process, it is necessary to personalize the gamification, providing a tailored gamified CL scenario for each situation. This task is difficult and time-consuming, so that developing a computational based-support in intelligent-theory aware systems to give assistance with the personalization of gamification is very helpful and necessary. In this direction, in the context of CSCL, one interesting solution has been proposed to gamify CL scenarios using adaptive profiles and machine learning techniques (**????**). However, this solution is not oriented to deal with the motivation problem caused by the scripted collaboration, its purpose is to increase the communication among the participants in CL scenarios. Furthermore, this solution falls into the category of computer-based mechanisms and procedures that support the gamification, it does not provide a model to share the theoretical knowledge related to gamification obtained by this computer-based mechanism. Solutions based on machine learning to personalize gamification require a lot of data to support the personalization of gamification, and they may have overfitting or underfitting problem with the data. A computer mechanism based only in machine learning techniques to personalize gamification lacks of theoretical-justification to explain why a game element is introduced, and why a certain configuration of game elements increases the motivation participants in a CL scenario.

For the reason exposed above, to deal with the motivation problem caused by the scripted collaboration through the gamification of CL scenarios, a computational support with a common and shareable structure to describe knowledge extracted from the best practices and theories related to gamification is essential to overcome the challenges and difficulties of gamification. In the direction to make explicit the knowledge contained in computer-based mechanisms and procedures, ontologies have been consolidated as the most advanced technology to support the representation of knowledge in a common computer-understandable and sharable manner (**??????**). Ontologies constitute an explicit mapping between the target world of interest and its representation with the purpose to describe concepts without ambiguities providing a common way to represent the knowledge (**??**). Taking advantages of this commonality, and using the computer interconnection technologies such as Internet, computer-based mechanisms in intelligent systems use ontologies to share understandings and interpretations of target world. In this direction, employing ontologies, some interesting and practical results have been obtained in the formalization and organization of knowledge extracted from different theories and practices related to gamification (**??????**). However, currently, there is no one ontology that allows the description of fundaments concepts extracted from the best practices and theories related to gamification, and how these concepts are applied in CL scenarios to deal with the motivation problem caused by the scripted collaboration.

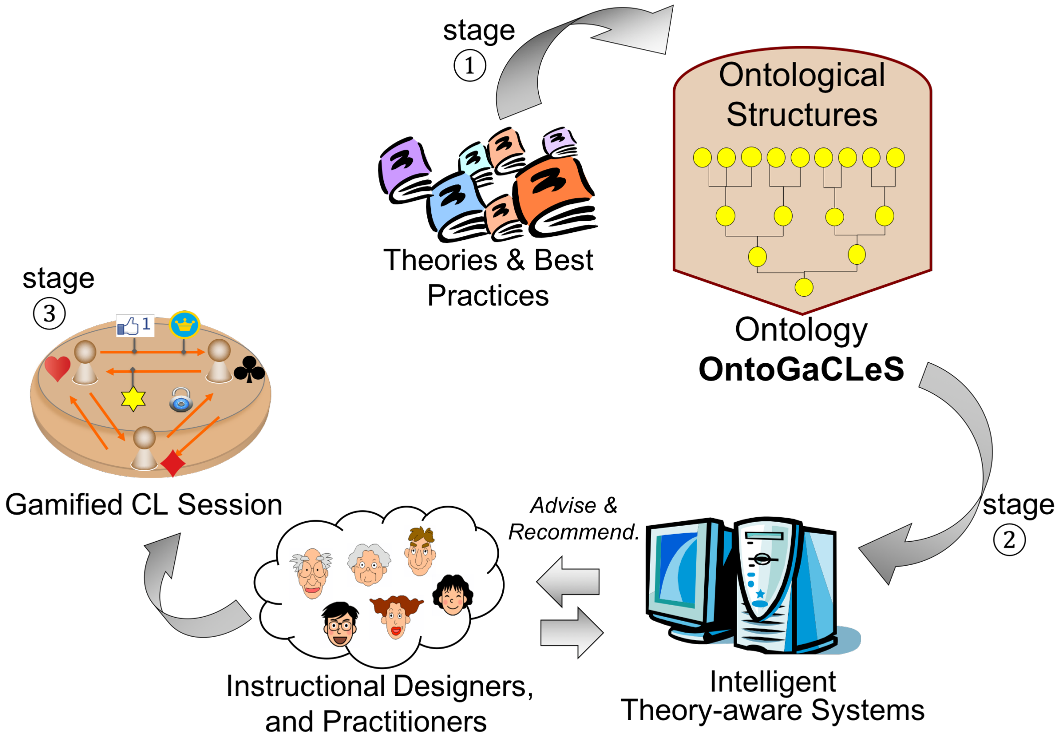
Therefore, the general research goal in this PhD thesis dissertation refers to the definition of an ontology to, from a philosophical perspective, systematically formalize the knowledge extracted from the best practices and theories related to gamification, and the definition of computer-based mechanisms that employ this ontology to deal with the motivation problem caused by the scripted collaboration in CL activities where the CSCL scripts are used as a method to orchestrate and structure the collaboration among students.

1.2 Research Questions and Research Objectives

The overarching research question (**RQ**) answered in this PhD thesis dissertation is: "*How can gamification and ontologies be used to deal with the motivation problem caused by the scripted collaboration in CL activities where CSCL scripts are used as a method to orchestrate and structure the collaboration among students?*"

To answer this research question, the author of this thesis proposes the ontological engineering approach to gamify CL scenarios shown in **??**. This approach consists into three major stages described as follows:

Figure 1 – Ontological engineering approach to gamify CL scenarios



Source: Elaborated by the author.

1. The first stage is the formalization of the necessary knowledge about how to gamify CL scenarios for dealing with the motivation problem caused by the scripted collaboration into an ontology named **OntoGaCLeS** – ***Onto**logy to **Ga**mify **C**ollaborative **Le**arning **S**cenarios*. This ontology has been developed using ontology engineering in which, by extracting concepts from the theories and practices related to gamification, the author of this thesis defines a set of ontological structures that enables the systematic formalization and representation of necessary knowledge to gamify CL scenarios.

2. The second stage is the development of computer-based mechanisms and procedures whereby intelligent theory-aware systems will provide support in the gamification of CL scenarios to deal with the motivation problem caused by the scripting collaboration. Such support is given by the knowledge formalized in the ontology OntoGaCLeS during the first stage, and the purpose of the computer-based mechanisms is to use this knowledge to facilitate the tasks of instructional designer and practitioners, especially novice users, in the gamification of CL scenarios. This knowledge provides theoretical justification for the personalization of gamification and, thus, to obtain tailored gamified CL sessions adapted for each situation. Such sessions are known as ontology-based CL sessions, and they are CL scenarios that have been gamified and instantiated at the most concrete level by detailing the participants and content-domain to be directly run in a learning environment.

3. The third stage is the validation of the ontological engineering approach to gamify CL

scenarios as a method to deal with the motivation problem caused by the scripted collaboration. This validation is carried out in ontology-based gamified CL sessions obtained by the approach, and it consists in measuring the effectiveness and efficiency of these sessions for dealing with the motivation problem caused by the scripted collaboration. The effectiveness and efficiency were measured by comparing the effects on students' motivation and learning outcomes caused by ontology-based CL sessions, non-gamified CL sessions and CL sessions gamified without using the support given by the ontology OntoGaCLeS.

Regarding to the formalization of knowledge about how to gamify CL scenarios for dealing with the motivation problem caused by the scripted collaboration (Stage 1), the research questions answered by this dissertation are:

RQ1: Which concepts from the theories and practices related to gamification should be taking into account to deal with the motivation problem caused by the scripted collaboration? and How should these concepts be applied in the gamification of CL scenarios?

RQ2: How can the concepts extracted from the theories and best practices related to gamification, and identified as relevant to deal with the motivation problem caused by the scripted collaboration, be represented as ontological structures?

Regarding to the development of computer-based mechanisms and procedures whereby intelligent theory-aware systems will provide support in the gamified CL scenarios using the knowledge described in the ontology OntoGaCLeS (Stage 2), the research questions answered by this dissertation are:

RQ3: What computer-based mechanisms and procedure are necessary in intelligent-theory aware systems to give a helpful support in the gamification of CL scenarios? and How can the knowledge encoded in the ontology OntoGaCLeS be used by these mechanisms and procedures for dealing with the motivation problem caused by the scripted collaboration?

Regarding to the validation of the ontological engineering approach to gamify CL scenarios as a method to deal with the motivation problem caused by the scripted collaboration (Stage 3), the research questions answered by this dissertation are:

RQ4: What are the effects of ontology-based gamified CL sessions on the students' motivation and learning outcomes? and What are the effectiveness and efficiency of these sessions to deal with the motivation problem caused by the scripted collaboration?

The research objectives pursued to answer the research questions *RQ1* and *RQ2* are:

RO1: To review the scientific literature in order to identify the most relevant concepts from the theories and practices related to gamification that should be taking into account to deal with the motivation problem caused by the scripted collaboration, and how these concepts be applied in the gamification of CL scenarios; and

RO2: To define the necessary ontological structures to represent the concepts identified as relevant in the scientific literature of gamification to deal with the motivation problem caused by the scripted collaboration.

In order to answer the research question *RQ3*, the research objectives is:

RO3: To identify and define the computer-based mechanisms and procedures that must be implemented by intelligent-theory aware systems to give a helpful support in the gamification of CL scenarios, and how these mechanisms and procedure use the knowledge encoded in the ontology OntoGaCLeS for dealing with the motivation problem caused by the scripted collaboration.

The research objective pursued to answer the research question *RQ4* is:

RO4: to analyze the effects of ontology-based gamified CL sessions on the students' motivation and learning outcomes for the purpose of validating the ontology engineering approach to gamify CL scenarios in reference to the effectiveness and efficiency to deal with the motivation problem caused by the scripted collaboration.

It is out of scope in this dissertation to deal with the following objectives:

- To compare, validate or judge the best practices and theories related to gamification.
- To create, modify or extend the concepts described in the best practices and theories related to gamification.
- To create a generic and complete representation of all concepts described in the practices and theories related to gamification. The author of this thesis only concentrates on the formalization of the minimal necessary concepts from these practices and theories to deal with the motivation problem caused by the scripted collaboration.
- To validate the concepts and ontological structures formalized in the ontology OntoGaCLeS using semantic reasoner engines or formal methods based on logic and/or mathematics.

1.3 Research Methodology

As this PhD thesis dissertation is framed in the multidisciplinary field of CSCL with research questions and research objectives oriented to be answered and achieved by theoretical and empirical studies, a mixed research method needs to be employed to conduct this research. Following the research methodology framework proposed by **????**), the mixed research method employed in this PhD thesis research consists in four iterative phases: informational, propositional, analytical and evaluation.

Informational phase: In this phase, the research problems and potential solutions were identified based on information gathered from the scientific literature and discussions with experts in fields of CSCL, gamification and ontology engineering. The results of this phase were an outline of the knowledge involved in this dissertation, the research questions, and the research objectives. The tasks carried out in this phase correspond to tasks extracted from the scientific (observing the world) and engineering (observing existing solutions) research methods. These tasks were:

- The search, review and analysis of scientific literature regarding to: CSCL, gamification and ontology engineering. This literature review was performed with emphasis in scripted collaboration, gamification of learning and instruction, and ontology-engineering applied to Artificial Intelligence in Education (AIED).
- The participation as member of the research group in Applied Computing in Education Laboratory (CAEd-Lab, *Laboratorio de Computação Applicada a Educação e Tecnologias Sociales Avançadas*) at the University of São Paulo. Particularly, the expertise field in CSCL and Ontologies of this research group has been very important and valuable to conduct the research and the literature reviews.
- The participation in several conferences and workshops related to the context and problem domain in which this dissertation is framed. These conferences and workshop, in chronological order, were: the III Escola de Ontologias UFAL-USP, 2014 (Workshop); the 20$^{\text{th}}$ International Conference on Collaboration and Technology, CRIWG, 2014 (Conference), the Summer School on Computers in Education, 2015 (Workshop); the XXVI Brazilian Symposium on Computers in Education, 2015 (Conference); the 6$^{\text{th}}$ Latin American School for Education, Cognitive and Neural Sciences, 2016 (Workshop); and the Higher Education for All: International Workshop on Social, Semantic, Adaptive and Gamification techniques and technologies for Distance Learning, 2017 (Workshop).
- The participation as visiting research at the Research Center for Service Science at the School of Knowledge Science in the Japan Advanced Institute of Science and Technology (JAIST) has also been significant for the informational phase. This

research center is dedicated to study, design and implementation knowledge co-creation process in complex service systems. This research center focuses in the use of ontologies and ontology-engineering as the technology to develop and solve a broad variety of domains/tasks, and their research members have a long history working in the research field of Artificial Intelligence in Education. Particularly, the expertise of the Prof. Mitsuro Ikeda and Prof. Riichiro Mizoguchi were valuable and important for this phase due to their involvement in various research projects related to the modeling of knowledge for the students' learning growth, CL process, and instructional design.

Propositional phase: In this phase, solutions were proposed and formulated using the information gathered in the previous phase. As results of the propositional phase, constructors of necessary concepts to gamify CL scenarios were identified and proposed as ontological structures in the ontology OntoGaCLeS. Prototypes of computer-based mechanisms and procedures were also developed for gathering practitioner and user opinions as early feedback of these systems. The tasks carried out in this phase correspond to task extracted from the scientific (proposing theories or models) and engineering (proposing and developing solutions) research methods. These tasks were:

- The proposal of ontological structures in the ontology OntoGaCLeS to represent gamified CL scenarios and ontological models to personalize the gamification of CL scenarios based on player type models and need-based theories of motivation.
- The proposal of ontological structures in the ontology OntoGaCLeS to represent the application of persuasive game design models in gamified CL scenarios and ontological models to apply persuasive game strategies as a method for dealing with the motivation problem caused by the scripted collaboration.
- The proposal of a computer-based model to unify the modeling of the learners' growth process and the flow theory based on the principle of good balance between the perceived challenges and skills.
- The definition of a conceptual flow to gamify CL scenarios as a computer-based procedure to use the knowledge described in the ontology OntoGaCLeS, and the definition of a reference architecture based on this flow to build computer-based mechanisms that provide support in intelligent-theory aware systems for dealing with the motivation problem caused by the scripted collaboration.

Analytical phase: This phase consists into analyze and explore the solutions formulated in the propositional phase with the purpose to identify whether the proposed solutions are understandable, how them can be deployed into practice, what are the potential problems in understanding and using them, and wether there are any omissions or gaps in these solutions. The tasks carried out in this phase correspond to task extracted from the empirical (applying to case studies) and analytical (developing new solutions derived from the results obtained in the case studies) research methods. These tasks were:

- The formalization of an ontological model to personalize the gamification of CL scenarios based on the Dodecad player type model proposed by **??**), and the formalization of an ontological model to personalize the gamification of Cognitive Apprentice CL scenarios based on the Yee's player type model. These two formalizations were developed as case studies to validate in the evaluation phase the ontological structures proposed to systematically formalize ontological models to personalize the gamification of CL scenarios.
- The formalization of an ontological model to apply gamification as a persuasive technology in gamified Cognitive Apprenticeship scenarios employing the persuasive game design strategies defined in the Model-driven persuasive game proposed by **??**).
- The implementation of a computer-based mechanism (as a proof of concept) in which the knowledge encoding in the ontology OntoGaCLeS is used for setting up the proper player roles and game elements for CL sessions.
- The development of an algorithm (as a proof of concept) to apply the principle of good balance between the perceived challenges and skills from the flow theory in the gamification of CL scenarios.
- The development of a computer-based mechanisms (as a proof of concept) to apply gamification as persuasive technology in the gamification of CL scenarios.

Evaluation phase: The focus of this phase is to conduct empirical tests and evaluations for the solutions formulated in the propositional phase and for the findings found in the analytical phase. In this phase, the empirical data gathered through the tests and evaluations aim to assess the contributions from different perspectives. The task carried out in this phase correspond to task from the empirical (validating the solutions) and analytical (analyzing the results obtained from empirical observations) research methods. These tasks were:

- The analytical evaluation of the ontological structures proposed to represent gamified CL scenarios and the ontological models to personalize the gamification of CL scenarios. This evaluation was carried out by publishing these ontological structures and the ontological models obtained from them in the analytical phase (the ontological model to personalize gamification in CL scenarios based on the Dodecad player type model, and the ontological model to personalize gamification in Cognitive Apprentice CL scenarios based on the Yee's player type model) as scientific articles in conferences and journals related to the fields of CSCL, and Artificial Intelligent in Education. These articles, in chronological order, were: "*Towards an Ontology for Gamifying*

Collaborative Learning Scenarios" published in the 12th International Conference on Intelligent Tutoring Systems, ITS, 2014; "*An Ontology Engineering Approach to Gamify Collaborative Learning Scenarios*" published in the 20th International Conference on Collaboration and Technology, CRIWG, 2014; and "*Personalization of Gamification in Collaborative Learning Contexts using Ontologies*" published in the journal of IEEE Latin America Transactions, 2015. During the conferences important feedbacks to improve the ontological structures were obtained from informal discussions with the participants of the conferences who shared their expertise in the domain of CSCL and Artificial Intelligent in Education.

- The analytical evaluation of the ontological structures proposed to represent the application of persuasive game design models in gamified CL scenarios and the ontological models to apply persuasive game strategies as a method for dealing with the motivation problem caused by the scripted collaboration. This evaluation was carried out by publishing these ontological structures and the ontological models obtained from them in the analytical phase (the ontological model to apply gamification as a persuasive technology in gamified Cognitive Apprenticeship scenarios employing the persuasive game design strategies defined in the Model-driven persuasive game) as scientific articles scientific articles in conferences and journals related to the fields of CSCL, and Artificial Intelligent in Education. These articles, in chronological order, were: "*Steps Towards the Gamification of Collaborative Learning Scenarios Supported by Ontologies*" published in the 17th International Conference on Artificial Intelligence in Education, AIED, 2015; "*An Ontological Model to Apply Gamification as Persuasive Technology in Collaborative Learning Scenarios*" published in the 26th Brazilian Symposium of Informatics in Education, SBIE, 2015; "*Gamification of Collaborative Learning Scenarios: Structuring Persuasive Strategies Using Game Elements and Ontologies*" published in the 1st International Workshop of Social Computing in Digital Education, SOCIALEDU, 2015; and "*An Ontology Framework to Apply Gamification in CSCL Scenarios as Persuasive Technology*" published in the Brazilian Journal of Computers in Education, 2016. During the conferences important feedbacks to improve the ontological structures were obtained from informal discussions with the participants of the conferences who shared their expertise in the domain of CSCL and Artificial Intelligent in Education.

- The conduction of a pilot empirical study in which, prior to carry out the full-scale empirical studies, the activities, methods, instruments and activities that have been used in the full-scale studies were evaluated to adjust and improve the full-scale study design. This empirical study has been conducted to assess the effectiveness of *the ontological engineering approach to gamify CL scenarios* for dealing with the motivation problem caused by the scripted collaboration. Such effectiveness is measured by comparing the effect of the ontology-based CL sessions obtained by the approach against the effect of non-gamified CL sessions on the participants' intrinsic motivation and learning outcomes, and the percentage of participation by groups. This empirical study was conducted with undergraduate computer science students at the university of São Paulo during the second semester of 2016 in the course of Laboratory of Introduction to Computer Science, and for a CL activity related to the topic of loop structures. In such CL activity, the ontology-based gamified sessions and non-gamified CL sessions have been instantiated using a CSCL script inspired by the cognitive apprenticeship theory as the method to orchestrate and structure the collaboration among the students.

- The conduction of a full-scale empirical to evaluate the effectiveness of *the ontological engineering approach to gamify CL scenarios*. This effectiveness has been measured by comparing the effects of ontology-based gamified CL sessions against the effects of non-gamified CL sessions on the participants' intrinsic motivation and learning outcomes. This study was carried out in the course of introduction to computer science with undergraduate computer engineering students at the university of São Paulo during the first semester of 2017. The CL activity in which these CL sessions have been instantiated was related to the topic of condition structures using a CSCL script based on the cognitive apprentice theory to orchestrate and structure the collaboration among the participants.
- The conduction of a full-scale empirical study to also evaluate the effectiveness of *the ontological engineering approach to gamify CL scenarios*. However, in this empirical study, the effects of ontology-based gamified CL sessions against the effect of non-gamified CL sessions were compared on the participants' level of motivation instead to compare these effects on the participants' intrinsic motivation. This empirical study was carried out during the first semester of 2017 in the course of Introduction to Computer Science at the university of São Paulo with undergraduate computer engineering students. In this context, a CSCL script inspired by the cognitive apprentice theory was used to structure and orchestrate the collaboration among the students a CL activity related to the the topic of loop structures.
- The conduction of a full-scale empirical study to evaluate the efficiency of *the ontological engineering approach to gamify CL scenarios* for dealing with the motivation problem caused by the scripted collaboration. Such efficiency was measured by comparing the effects on the participants intrinsic motivation, level of motivation, and learning outcomes caused by ontology-based CL sessions against the effects caused by CL sessions that have been gamified without using the support given by the ontology OntoGaCLeS. This empirical study was carried out in the course of Introduction to Computer Science at the university of São Paulo during the first semester of 2017. The undergraduate computer engineering students signed up in this course participated in a CL activity related to the topic of recursion in which the

collaboration among the students was orchestrated and structured by a CSCL script inspired by the cognitive apprentice theory.

1.4 Thesis Statement and Claimed Contributions

The thesis statement of this PhD thesis dissertation is that:

"*For CL activities where the CSCL scripts are used as a method to orchestrate and structure the collaboration among the participants, the gamification of CL scenarios using the support given by the ontology OntoGaCLeS constitutes an effective and efficient solution to deal with the motivation problem caused by the scripted collaboration because this ontology encodes the necessary theoretical knowledge related to theories and best practices of gamification to perform this task*."

The claimed contributions are:

1. The identification of most relevant concepts from the theories and practices related to gamification that should be taking into account to deal with the motivation problem caused by the scripted collaboration (RO1).

2. Ontological structures that represent the concepts identified as relevant in the theories and practices related to gamification for dealing with the motivation problem caused by the scripted collaboration (RO2).

   a) A set of ontological structures to represent gamified CL scenarios and ontological models to personalize the gamification of CL scenarios based on player types models and need-based theories of motivation.

   b) A set of ontological structures to apply persuasive game design models in gamified CL scenarios and ontological models to apply persuasive game strategies as a method for dealing with the motivation problem caused by the scripted collaboration.

   c) A unify modeling of learners' growth process and flow theory as a computer-based model to apply the principle of good balance between the perceived challenges and skills for gamified CL scenarios.

3. A conceptual flow to gamify CL scenarios using the knowledge described in the ontology OntoGaCLeS, and a reference architecture based on this flow to build computer-based mechanisms that provide support in intelligent-theory aware systems for dealing with the motivation problem caused by the scripted collaboration (RO3).

4. An empirical evaluation of *the ontological engineering approach to gamify CL scenarios* in which, to validate the effectiveness and efficiency of this approach for dealing with the motivation problem caused by the scripted collaboration, the effects of ontology-based

gamified CL sessions on students' intrinsic motivation, level of motivation and learning outcomes are compared against the effects caused by the non-gamified CL sessions and CL sessions that have been gamified without using the support given by the ontology OntoGaCLeS (RO4).

1.5 Structure of the Dissertation

This PhD thesis dissertation is structured in eight chapters:

Chapter 1: *Introduction*

Chapter 2: *General Background and Fundamental Concepts* contains the background related to the context and research problem addressed in this dissertation. An overview related to the fields of CSCL and scripted collaboration, gamification and ontology engineering are presented in the chapter. The motivation problem caused by the scripted collaboration, and the current approaches to deal with this problem are also detailed in the chapter. The concepts that were identified as relevant in the theories and practices of gamification and their difficulties to apply it in CL scenarios for dealing with the motivation problem caused by the scripted collaboration are presented in the chapter.

Chapter 3: *Ontological Structure to Personalize the Gamification in CL Scenarios* describes the ontological structures, that have been proposed by the author of this thesis, and that have been formalized in the ontology OntoGaCLeS, to represent gamified CL scenarios and ontological models to personalize the gamification in CL scenarios based on player types models and need-based theories of motivation. The chapter also shows the procedure followed to build an ontological model ontological model to personalize the gamification of CL scenarios based on the Dodecad player type model.

Chapter 4: *Ontological Structures of Persuasive Game Design in CL Scenarios* describes the ontological structures proposed by the author of this thesis to apply persuasive game design models in gamified CL scenarios and to represent ontological models to apply persuasive game strategies as a method for dealing with the motivation problem caused by the scripted collaboration. The chapter also describes the procedure to formalize an ontological model in which gamification is applied as persuasive technology for gamified Cognitive Apprenticeship scenarios employing the persuasive game design strategies defined in the Model-driven persuasive game proposed by **??**).

Chapter 5: *A Unify Modeling of Learners' Growth Process and Flow Theory* presents the computer-based model proposed by the author of this thesis to unify the modeling of the learners' growth process and the flow theory based on the principle of good balance between the perceived challenges and skills. This model has been used in the gamification of CL scenarios to define the rewards to be promised and given to maintain the learner's flow state in the CL process.

Chapter 6: *Computer-based Mechanisms and Procedures to Gamify CL Scenarios* describes the flow proposed by the author of this thesis to use the knowledge described in the ontology OntoGaCLeS to gamify CL sessions. The reference architecture based on this flow by which computer-based mechanisms could be built in intelligent-theory aware systems to provide support in the gamification of CL scenarios for dealing with the motivation problem caused by the scripted collaboration is presented in the chapter. The chapter also describes the computer-based mechanisms that has been developed by the author of this thesis using the reference architecture to conduct the evaluation of the ontological engineering approach to gamify CL scenarios.

Chapter 7: *Evaluation of the Ontological Engineering Approach to Gamify CL Scenarios* presents the empirical studies that have been carried out in real situations to validate the effectiveness and efficiency of this approach to deal with the motivation problem caused by the scripted collaboration.

Chapter 8: *Conclusions and Future Work* summarizes the contributions of this PhD thesis dissertation, and the chapter also discusses possible future research directions.

CHAPTER

2

GENERAL BACKGROUND AND FUNDAMENTAL CONCEPTS

This chapter presents the general background and fundamental concepts related to the domain problem that is addressed in this thesis. At the first section (**??**), an overview of the CSCL field and scripted collaboration is presented to provide a comprehensive and clear understanding about the research context. The **??** elaborates an overview of gamification, and the best practices and theories related to this technology. Finally, the **??** presents the fundamentals of ontologies and ontology engineering.

2.1 CSCL and Scripted Collaboration

Although CL has a long history in education, it is not until the early 1990s that the research field dedicated to study how to provide support for the CL through the use of Internet and computational technology had gained attention and strength (**??**). Such research field known as Computer-Supported Collaborative Learning (CSCL) is a multidisciplinary field that combines studies from the cognitive psychology education and from the computer science to effectively enhance the CL process through the use of computational technology (**??**).

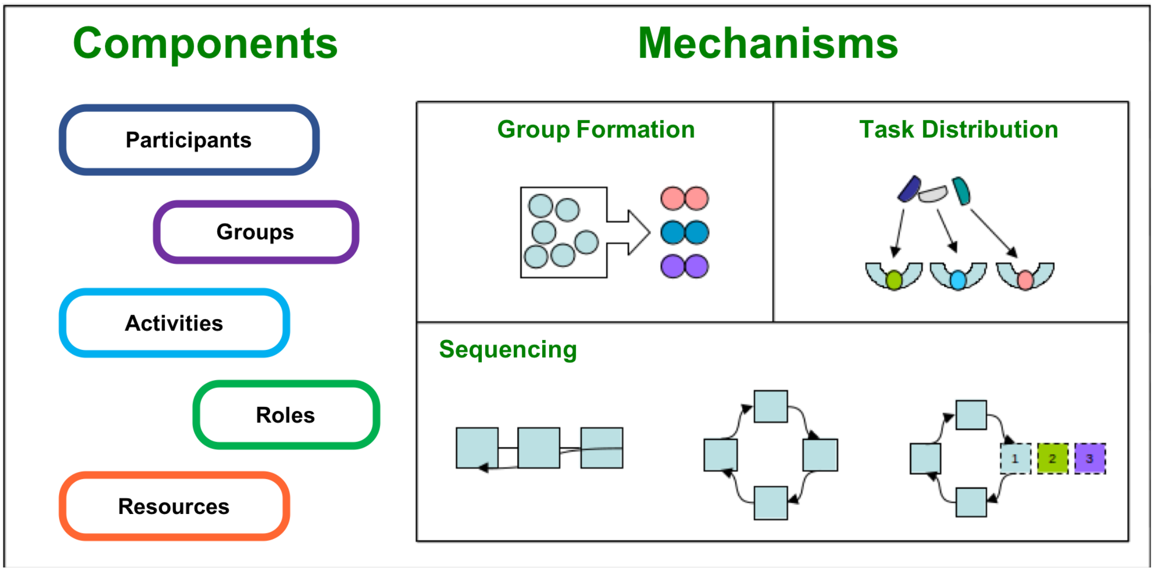
The general aim of CSCL field is to develop technologies to support or create situations in which two or more students learn together through the interaction among them (**??**). In these situations, the learning outcomes is consequence of students' interactions and how these interactions affect the individual learning for each one of the students. In consequence, to enable a well-though-out design of CL, the CSCL scripts have been proposed by the CSCL community as the technology to facilitate the social and cognitive processes of learning by describing the way in which the learners will interact with each other in a CL scenario (**??**).

2.1.1 CSCL Scripts

CSCL scripts are the technology that describes how to structure and orchestrate the CL process to attain a set of pedagogical objectives defined by an instructional design (**??**). Such description is provided in the CSCL scripts through prescribed instructions that indicates how to facilitate the social and cognitive processes in group activities (**??**). These prescribed instructions are defined by instructors, like teachers or instructional designers, as a way to attain a set of learning goals, and they indicate the way in which students should collaborate, they constrain the interactions among the participants, they specify the roles for the participants, they indicate the distribution of task, tools, and resources used in the CL process.

In order to narrow the number of elements used to describe the CSCL scripts, and provide a common and sharable description of CSCL scripts, **??**) propose a framework that is currently wide accepted by the community as the common specification to describe the CSCL scripts using natural language. This framework formalizes the CSCL scripts as a set of components and mechanisms illustrate in **??**.

Figure 2 – Components and mechanisms of CSCL scripts



Source: Adapted from **??**).

The structural *components* of CSCL scripts are the participants, groups, activities, roles and resources. The component of *participants* is used to describe the participants, such as learners, monitors, and teachers. Although this description can be abstract or concrete and simple or complex, it is often presented in a simple manner with rules that indicate conditions to participate in the CL process. The component of *activities* describes what will be performed by the participants in the CL process to attain the learning goals defined by the instructional designers. The component of *roles* describes the privileges, obligations and expectations of participants in the CL process. The component of *groups* of participants defines through hierarchical structures how the students are grouped according to the participants' characteristics. The component of *resources* describes the learning objects (e.g. content, material, and tools) that can be used by the participants during the CL process.

The *mechanisms* of CSCL scripts are the group formation, component distribution and sequencing. The mechanism of *group formation* consists in the specifications of how the participants will be distributed over the groups. The mechanism of *task distribution* provides the specification about how the components of scripts are distributed over groups using the mapping of groups, activities, roles, and resources. The mechanism of *sequencing* consists in the definition of how the components and groups defined in scripts are distributed over time. In general, this sequencing describes the execution order of activities in the CL process.

Chart 1 – Components and mechanisms of social script

Structural components:	
Participants:	A number of participants that must be divisible by the number of case studies.
Groups:	Case groups
Activities:	(a) Applying theoretical concepts to the case study and constructing arguments (b) Critiquing initially scaffolder with prompts for eliciting clarification, identifying conflicting views and constructing counter-arguments
Roles:	*Analyst* and *Critic*
Resources:	Case studies (minimal number is three case studies)
Mechanisms:	
Group formation:	All participants are grouped by the number of case studies. Each participant becomes member of all case groups although with different roles in each. Each participant is the responsible analyst for one case study and critic for all other cases
Task distribution:	Each case group receives one case study, and the roles are distributed in a way that each participant assumes the role of analyst in one case group and the role of critic in all other case groups
Sequencing:	- the analyst writes an analysis of case study. (a) - wait for all case group analysts to be done, and writes a critique for the analysis of case study. (b) - wait for all case group critics to be done, and the analyst considers each critique and writes a reply to each. (a) - wait for all case group analysts to be done each critic in turn reads the reply and writes a second critique. (b) - wait for all case group critics to be done... the analyst considers all critiques and revises the analysis of case study (a)

Source: Adapted from **??**).

?? shows the description of the *social script* (**??**) using the framework proposed by **??**). In this example, the CL scenarios orchestrated by the social script foster the acquisition of knowledge through a set of case studies (*resources*) that are analyzed and reviewed by the students groups. The number of students in each group is equal to the number of case studies, and the ideal number is three. In the first step of sequencing, each learner playing the *analysis* role writes down an analysis of case study, and then, he critiques the analyses made by other learners playing the *critics* role. In the second step of sequencing, each learner revises his/her own analysis, taking into consideration the critiques received by the other learners in the case group.

Having the description of CSCL scripts only in natural language does not allow the computers programs to interpret them, and to run a CL scenario following the instructions indicated by the scripts without human intervention. Therefore, to represent the CSCL scripts in a computer readable manner, the IMS-Learning Design[1] (IMS-LD) specification has been adopted by different tools, such as (web)COLLAGE (**????**), CIAN (**??**), LeadFlow4LD (**??**), NUCLEO (**??**), CoLearn (**??**), CeLS (**??**), and LAMS (**??**), as the language to describe CSCL scripts.

Despite the benefits that brings the use of the IMS-LD specification to represent CSCL scripts, several researchers had indicated that this language is insufficient to fully support the modeling of CSCL scripts (**????**). Of course, the purpose of IMS-LD specification is not to provide a full support for describing CSCL scripts in a computer-readable manner, the IMS-LD has been developed as a neutral, generic and flexible educational modeling language to describe a wide range of pedagogies approaches - the teaching strategies, pedagogical goals and their associated activities (**??**). In this sense, to support the representation of CSCL scripts in a computer-readable manner, a wide variety of extensions on the IMS-LD elements has been proposed in by several researchers (**??????????**).

Instead, to simply provide a computer-readable representation of CSCL scripts, the work of **????**) proposes the formalization of these scripts in a computer-understandable manner through the use of ontologies. This solution consists in a set of ontological structures that makes the description of CSCL scripts more semantically-rich, allowing the explicit specification of learning goals, purposes, and other relevant information that cannot be represented using the IMS-LD specification, i.e., learning strategies, group goals, interaction patters from learning theories. Providing this formalization in the CL ontology, **??**) demonstrates that intelligent-theory aware systems can interpret these scripts and provide advice and recommendation to support for the modeling of learners' development (**??**), the formation of effective groups (**??**), and the instructional design of CL activities (**??**).

2.1.2 Levels of Abstraction and Granularity of CSCL Scripts

CSCL scripts have different levels of abstraction and granularity in the description of CL scenarios (**??????**). This classification of scripts in two dimension, abstraction and granularity, gives them an enormous flexibility to be reused in the instructional design process of CL scenarios, and it also allows the use of multiple scripts to describe different aspects of CL scenario in separated scripts. Whereas the levels of abstraction classify a script according to the completeness of elements described by them, from the most abstract to the most concrete, the levels of granularity classify the scripts according to the aggregation level of elements described by them, from the most coarser grained to the finest grained.

[1] URL: <http://www.imsglobal.org/learningdesign/>

According to **??**), a CSCL script can be classified in one of the four levels of abstraction defined as follows as:

***Script Schemata*:** are scripts use to describe the core instructional design principles whereby is expected to trigger interactions among participants in the CL process. In this sense, these scripts are defined in a content free didactic form, so that they can be used to describe patterns of CL. Examples of script schemata are the Jigsaw script (**????**), conflict script (**??**), and reciprocal script (**??**). The jigsaw script describes a CL scenario in which the principle of interaction consists in the grouping and re-grouping of participants with complementary information to share their knowledge. The conflict script describes a CL scenario to group learners with contradictory knowledges or opinions to instigate the discussion. The reciprocal script describes a CL scenario that assigns alternate roles to the students for facilitating questioning and tutoring activities.

***Script Classes*:** are specialization of scripts schemata for a specific learning context. This specialization is not absolute complete, so that script classes are independent in the content-domain and student data. The script classes cover a range of scripts that describe variations of a prototype with particular details related to a specific learning context of a script schemata to facilitate its adoption. These details are, for example, the number of participants, and the king of content (matter) that will be taught. In this sense, a script class is based in a script schemata to describe CL scenarios for a specific learning context. For instance, the Universanté Script (**??**) is a script class based on Jigsaw schema that was designed to describe CL scenarios for learning contexts with different thematic groups and participants from different nations.

***Script Instances*:** are scripts in which the content-domain are specified for a particular situation. A script instance is more concrete than a script class, and it has been instantiated from a script schema or class to be reusable more or less by teachers who only need to define participants' data. These scripts are more concrete that script classes, but they are independent in the particularities of students and learning environment.

***Script Sessions*:** are scripts in which the content-domain and participants data are specified to be directly executed in a learning environment. In this sense, these scripts detail the information of participants and content-domain in the most concrete level defining, for example, the students' names and the deadlines of activities. A CL scenario that is described by a script session is known as CL session, and when it is represented in a script session using a computer-readable formalization, it can be directly executed in a learning environment to orchestrate and conduct the CL process.

Different benefits from the use of script schemata and classes as patterns are obtained in the instructional design process of CL scenarios (**??????**). During the design/authoring phase, repositories of script schemata and classes facilitate the sharing and reuse of these scripts in distributed learning environments (**????**). The structures of script schemata and classes are used as templates to create new script schemata and classes (**????**).

During the instantiation/production phase, script schemata and classes provide advice and recommendation that help the CL practitioners to instantiate these scripts and to obtain CL sessions (**??????**). Script schemata and classes facilitate the generation of computer-interpretable scripts, they provide information to support the search of applicable learning material and tools for the CL scenario (**??????**). The script schemata and classes are also uses to obtain recommendation about how to bind individuals in groups and roles according to the knowledge described in these scripts (**????**).

Regarding to the level of granularity (**??**), the CSCL scripts can be classified in macro-scripts and micro-scripts.

***Macro-scripts*:** are scripts that basically describe the CL process in a courser-grained level without detailing the specific interactions among participants. A macro-script describes how to attain a set of pedagogical objective indicating the sequencing of individual and group activities that must be follow by participants. Thus, for example, in the Jigsaw macro-script, to promotes the individual accountability and positive interdependence, the sequencing of activities consists in three activities: an individual activity, expert group activity, and jigsaw group activity. In the individual activity, each student studies a particular part of a whole problem. In the expert group, the students of different groups that study the same part of the whole problem meet together for exchanging ideas. At last activity, students of each jigsaw group meet to contribute with their expertise to solve the whole problem.

***Micro-scripts*:** are scripts that describe the CL process in a fine-grained level (**??**), they indicate, for example, the dialogues that must happen among student to achieve the pedagogical objectives, and they are intended to describe the communication model between participants. Thus, for example, to facilitate the negotiation and elaboration of a domain concepts, **??**) describe a micro-scripts for online peer discussion using a sequence of sentence openers (e.g. my proposal for an adjustment of the analysis is....) that prompted learners to contribute with the discussion and critique one another's contributions.

As can be noticed above, the macro-scripts and micro-scripts have a hierarchical relationship to describe the CL process of CL activities. The micro-scripts describe the communication process in a CL activity (**??**), whereas the macro-scripts describe groups, roles, and flow of CL activities (**??**). Despite this explicit hierarchical relationship, there are few models and tools in which all the elements of macro-scripts and micro-scripts are combined to support the design of CL scenarios (**????**). **??**) propose a hierarchical model in which schemata and classes of macro-scripts and micro-scripts are used as templates to generate scripts. In the work of **??**), the hierarchical relationships of macro-scripts and micro-scripts is represented as hierarchical task networks to support the automatic generation of unit of learning.

In the CL ontology (**??**), and therefore in the ontology OntoGaCLeS, the hierarchical relationship between the macro-scripts and micro-scripts is not explicitly described as a direct link between macro-scripts and micro-scripts. The hierarchical relationship is implicitly described as part of the conceptualization of events and processes proposed by **??**). Based on in this conceptualization in which the representation of an event can be constituted by many distinct sub-events to describe a process, the hierarchical relationship of macro- and micro-scripts can be inferred from these events that are explicitly described in the CL ontology and the ontology OntoGaCLeS.

2.1.3 Motivation Problem Caused by the Scripted Collaboration

The motivation problem caused by the scripted collaboration should be interpreted in his dissertation as the negative effects caused by the scripts on participants' motivation, and implicitly it also includes the negative effects on the learning outcome. **??**) indicated that there may be a danger to overscript the CL process. The sequencing of interactions is rejected by some students when they had difficulties to adapt to perform structured tasks, in specially, for highly coercive scripts which dictate interaction in a very detailed and inflexible way. This kind of scripting collaboration prevent the independent, exploratory thinking, and when they are designed with high degree of coercion, it decreases student motivation.

Similar to the research works of **????**), this thesis dissertation argues that the scripted collaboration may cause motivational problems and reactance towards the script based on the self-determination theory (**??**) as a central element for motivation. Depending on the individual attribution pattern, students would suffer motivational problems to uphold learning efforts, e.g., when students do not have a optimal fit between the external scripts (guidelines provided by the system that specifies the sequencing) and the internal script (low-structure script in the mind of students), and the external script provides scaffolds that guide procedures for which internal scripts are already represented by the learner or where a learner might even hold more effective or efficient internal script, the performance of the learner will decrease (**??**).

In the same direction, negative effects on the participants' motivation have been pointed out by many researchers who have successfully applied CSCL scripts to enhance and/or to mediated the CL process. For example, **??**) proved that, for some students, overlaying scripting produces reactance, and the work of **??**) indicates that motivation loss for students occurred when there is a overlaying of scripting. When the scripted collaboration is over extended for a long period of time and over many collaborative sessions, the motivation problem occurs (**????**).

2.2 Gamification

2.2.1 Games, Game Elements, and Gameplay

Based on the similarities and differences between games and problem-solving activities shown in **??**, **??**) defines a game as "*a problem-solving activities approached with a playful attitude*."

Chart 2 – Similarities and differences between the games and the problem-solving activities

Games (read in top-down order)	**Problem-Solving Activities**
- Games are entered willfully,	
- have clear goals,	- The problem that is trying to solve defines a clear goal,
- have conflict,	- it involves conflicts, in which
- have rules,	- we determine the rules of problem,
- can be won an lost,	- we eventually defeat the problem or are defeated by it;
- are interactive, interact with it	- the problem is like a cleaner, smaller version of a real-world situation, which we can more easily consider, manipulate, or interact with it,
- have challenge,	- this is usually challenging,
- can create their own internal value,	- has its space with internal importance, if we are closed to attain the goal of solving this problem;
- engage game players, and	- we quickly become engaged if we care about the problem, and
- are closed and formal systems	- we will be establishing a closed and formal system if the problem is well understand

Source: Adapted from **??**).

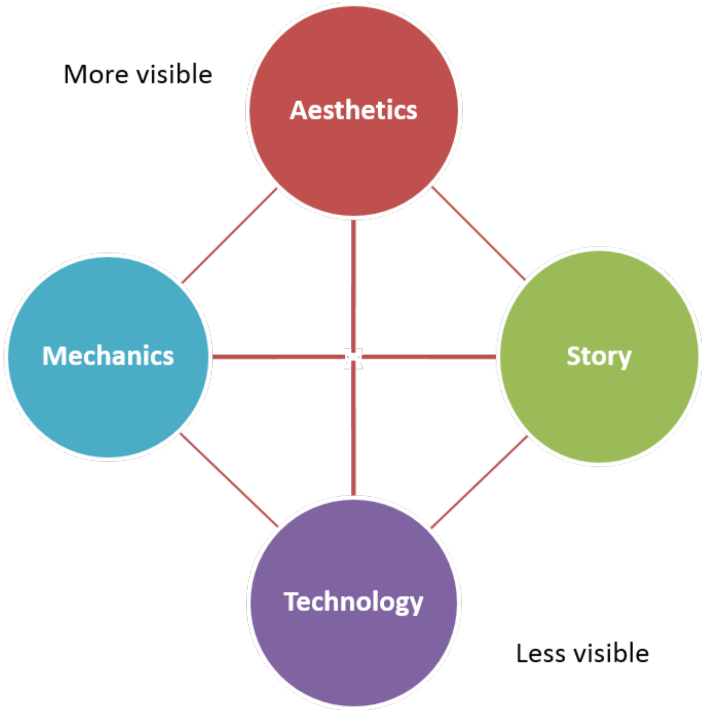
Frequently, the problems are viewed as something negative, but people really do get pleasure from solving them. As humans, our complex brains enjoy solve problems, and this is our primary advantage as a species. Frequently, people who enjoy solving problems are going to solve more problems, and get better at solving problems. Games are not simply problem-solving activities, one who plays games must have sufficient motivation to solve problem, and it means having playful attitude.

There are many ways to classify the elements that are part of a game. According to **??**), these elements as shown in **??** are classified in the following four basic elements:

Mechanics: These are rules and procedures that are used to describe the goals of games, how game players can try to achieve them, and what happen when they try.

Story: This is the sequence of events (script) that unfold in your game. It may be pre-scripted, linear, or complex with branching and emergent. In general, the mechanics that will be used must strengthen the story, and the mechanics will also help reinforce the ideas of story.

Figure 3 – Elements and components of games



Source: **??**).

Aesthetics: There are how your game looks, sounds, smells, tastes, and *feels*. They are an important aspect of game design that have most direct relationship to a player's experience during the game (gameplay experience).

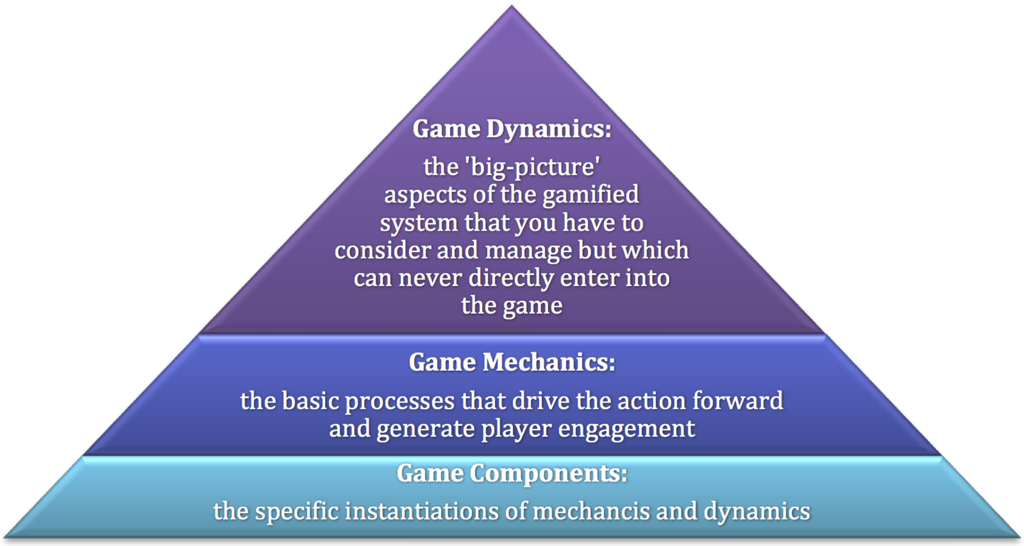
Technology: This is the materials and interactions that make your game possible. It is the medium in which the aesthetics happen, in which the mechanics will occur, and through which the story will be told.

Although the elements listed above define the components of a game, the essence of a game is rooted in the interactive nature in which the users act as players (**??**). The player puts his mind inside the game world, but the game world really only exists in the mind of the player. This magical situation is made possible by the game interface, which is where player and game come together. Thus, the goal of a good game interface is not to look nice or to be fluid, although those are nice qualities, the goal of a game interface is to make players feel in control of their experience because the purpose of a game is by itself to create an experience in the user mind.

According to **??**), the game elements are described as smaller pieces used to build blocks that, in an integrate form, constitutes gameplay experience. Thus, these game elements are separate in three categories: dynamics, mechanics and components, described in **??**.

Based on the hierarchy of game elements showed in **??**, the game elements are classified as:

Figure 4 – Hierarchical classification of game elements



Source: **??**).

Game Dynamics when the game element are the big-picture aspects of the game-like system that can be to consider and manage but which you can never directly enter into the game. e.g. constraints, emotions, narrative, progression, relationships, and personalization.

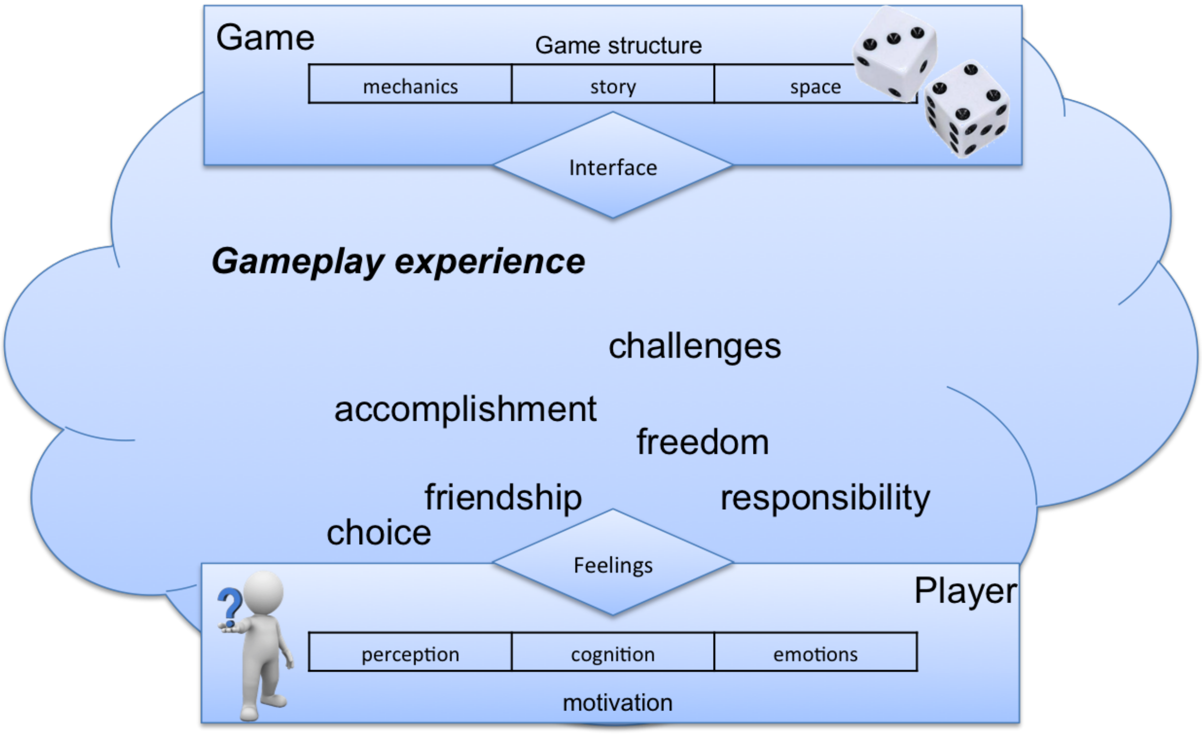
Game Mechanics when the game element is part of the basic processes that drive the action forward and generate player engagement. e.g. challenges, chance, competition, cooperation, feedback, resource acquisition, rewards, transactions, turns, win-states, and profiles.

Game Component when the game element is the more-specific forms that mechanics or dynamics can take. e.g. achievements, badges, collections, leaderboards, levels, notifications, points, progress bars, quests/missions, status, teams, and virtual goods.

The *gameplay experience*, or simply called *gameplay*, is the player's interpretation of manner in which a player or players interacted in a game world (**??????**). Figure **??** shows the relation among the fundamental components which are part in the formation of gameplay experience. The model showed here is not intended to constitute a comprehensive analysis of all possible elements between a game and a player, the game is represented as a structure (of mechanics, story, and space) that engenders the gameplay experience in the mind of the player through a game interface. Thus, the gameplay experience happens by linking perception, cognition, and emotions when a person does actions that are motivated by the game (motivation).

There are certain feelings, feelings of choice, feelings of freedom, feelings of responsibility, feelings of accomplishment, feelings of friendship, and many others, which only gameplay experience seems to offer (**??**). The gameplay experience is not identical in people, each person has completely different and unique experience playing a game, but the experience is imaginary. Thus, the game designers must have careful selection the proper game elements, such as game

Figure 5 – Fundamental components in the gameplay experience



Source: Adapted from **??**).

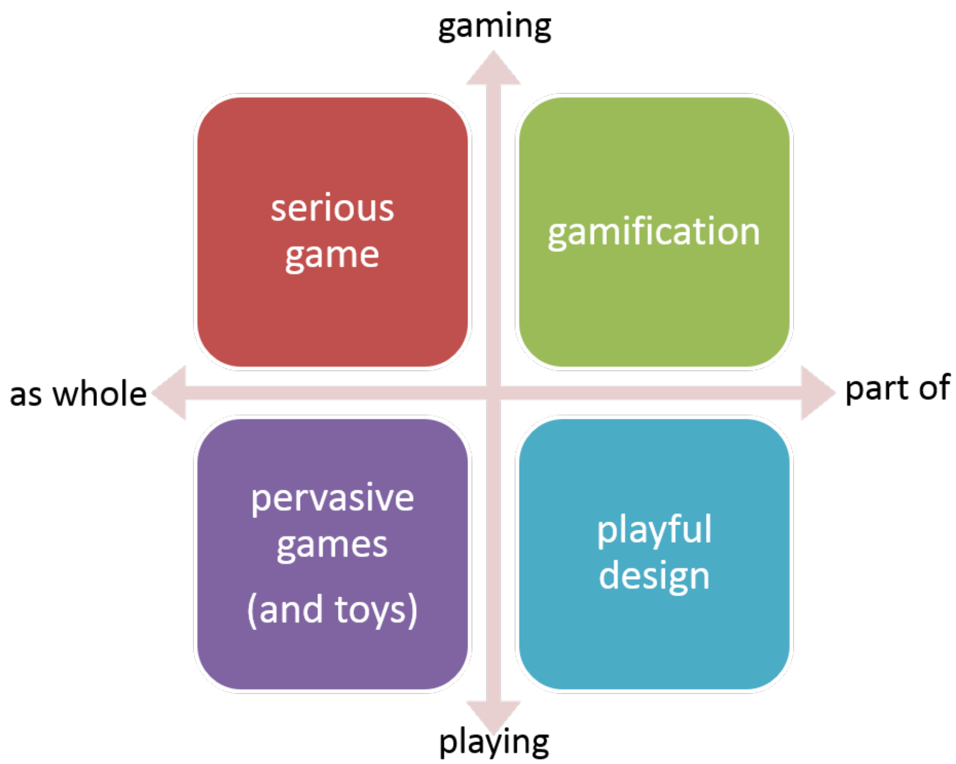
mechanics, game interfaces, among others, that are used to create certain kinds of experiences when a player interacts with them. This task is known as *game design*, and it is basic when some situation, scenario or application is being gamified.

2.2.2 What Is Gamification? and What Is It Not?

While no standard conceptualization of gamification exists, most studies agree that gamification generally refers to the use of game-based elements, such as game mechanics, aesthetics, and game thinking in non-game contexts aimed at engaging people, motivating action, enhancing learning, and solving problems (**????**). However, it is important a deeper and scientific conceptualization to identify theoretical foundations, purposes, and knowledge about how to apply gamification in practice. In this sense, based on the work of academics and industry practitioners, **??**) establish the conceptualization of gamification as the use of game design elements in non-game contexts, and **??**) defines gamification as the process of making activities more game-like. In other words, it covers coordinated practices that objectively manifest the intent to produce more of the kinds of experiences that typify games.

?? shows where gamification and others game design technology are situated based on the degree of design (as whole or parts) and purpose (for playing or gaming). As we can see in the figure, gamification and serious game are similar in terms of purpose, but they differ in the degree of design, both are made for non-entertainment purposes, serious game describes the

Figure 6 – Situating gamification in the scope of game design technology



Source: Adapted from **??**).

design of application as a whole game, while gamification describes the design of application as part of whole. Gamification and playful design have the same degree of design, both implements parts of application as game, while the purpose of playful design is entertainment as a desirable user experience or mode of interaction, and gamification is made for non-entertainment.

According to **??**), gamification is related to gaming, not playing or playfulness, where playing denotes a free-form of expression, improvisational, even tumultuous recombination of behaviors and meanings. Gaming consists in the capture of playing that is structured by rules-base systems. Gamification does not describe the design of full-fledged games, gamified applications merely incorporate elements of games (also called game atoms (**??**)). However, these elements do not refer game-based technologies or other game related practices (e.g. as authoring tools, graphic engines), gamification is only reserved for the use of game design. The use of game design elements in gamification is for purposes other than the normal expected use as part of an entertainment game (for non-entertainment purpose).

2.2.3 Outcomes of Gamification

When gamification is properly applied, a wide range of desired outcomes can be achieved, such as enjoyment, engagement, fun, satisfaction, motivation, loyalty, participation, efficiency, and behavior change (**??**). In this sense, the outcomes of gamification as shown in **??** can be seen as: (1) the psychological outcomes (i.e. motivation, engagement, enjoyment, and fun) that are results of implemented motivational affordance (i.e. badges, points, leaderboards, and feedbacks); and (2) the behavioral outcomes (i.e. response pattern, duration of interactions, participation, and learning) that are result of psychological outcomes.

Figure 7 – Expected outcomes of gamification

Source: Adapted from ??).

In educational contexts, most studies, as shown in **??**, propose the engagement of learners as psychological outcomes, and the improving of learning as behavioral outcomes (**??**). For example, **??**) investigated how story/theme, clear goals, feedbacks, challenge and rewards (motivational affordance) could be used to increase the engagement and enjoyment (psychological outcomes) of students, and the results showed an increase in the speed of completion of tasks (behavioral outcomes).

2.2.4 Theories and Models of Motivation

As defined by **??**), motivation is an internal set of processes what is referred as hypothetical construct associated with three general psychological processes (arousal, direction, and intensity). The arousal is the first component caused by the need or desire to some object or state that is at least partially unfulfilled or below expectation. This discrepancy initiates the action to satisfy the need, to obtain the desired object or to achieve the unfulfilled state. Moreover, this discrepancy is personal, and differs in each individual, different people have different needs and different things that they think are important. Thus, the second is a directional component defined by personal goals and goal discrepancies that are seen as major goads to attention and action. The third component is the intensity dimension defined by the goal difficulty and importance of arousal because some needs are more important than others, and some goals are more difficult to attain than others.

Having knowledge about how to motivate people, it is possible to build and formalize the proper understanding of what pushes people to interact in a gamified application, what make it fun, and why it is enjoyable. In this direction, there are different theories and models of motivation related to gamification, that are briefly summarized as follows.

Chart 3 – Outcomes of gamification in educational contexts

Source	Motivational Affordances	Psychological Outcomes	Behavioral Outcomes
(??)	points, feedback, leaderboards, time constraints (challenge)	enjoyment, engagement	impact on learning (usefulness)
(??)	badges	enjoyment, attitude towards badges	level and quality of participation
(??)	leaderboards, badges	attitude towards gamification	learning outcomes
(??)	clear goals, challenge, feedback, levels, story/theme	engagement, fun	effectiveness of learning
(??)	achievements, clear goals	perceived added value of gamification, fun	exploration of the campus while interacting with the application
(??)	badges		impact on time management, carefulness and achieving learning goals
(??)	leaderboards, narrative (story/theme), deadline (challenge)	difference in users' approach to virtual patient interaction	Number and duration of interactions with virtual patients, likelihood of voluntary participation to a virtual patient interaction
(??)	story/theme, clear goals, feedback, challenge, rewards	engagement, enjoyment	task performance
(??)	story/theme, rewards		increasing knowledge about the library, its services and resources, teaching library skills

Source: Adapted from **??**).

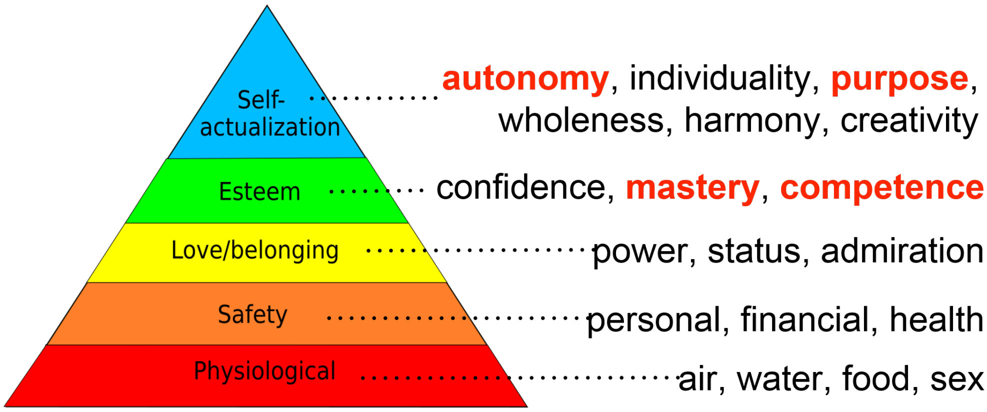
2.2.4.1 Need-based Theories

There are many theories that revolve around the fulfillment of humans' needs, defined as the arousal component of motivation. These theories describe what make certain outcomes appear attractive, and they constitute the basic foundations of motivation. With relation to gamification, there are three main need theories that are detailed in the paragraphs below.

Maslow's hierarchy of needs theory states that a person has a pyramid hierarchy of needs that a person must satisfy from bottom to top (**????**). As shown in **??**, the Maslow's need pyramid classifies the needs from basic to complex in five categories: physiological, safety, love/belonging, esteem, and self-actualization.

According to **??**), only unsatisfied human needs influence behavior, if there is a deficit in a lower level, all behaviors of an individual will be oriented to satisfy this deficit. In the Maslow's need pyramid, needs are arranged in order of importance to human life, as said before from the basic to the complex.

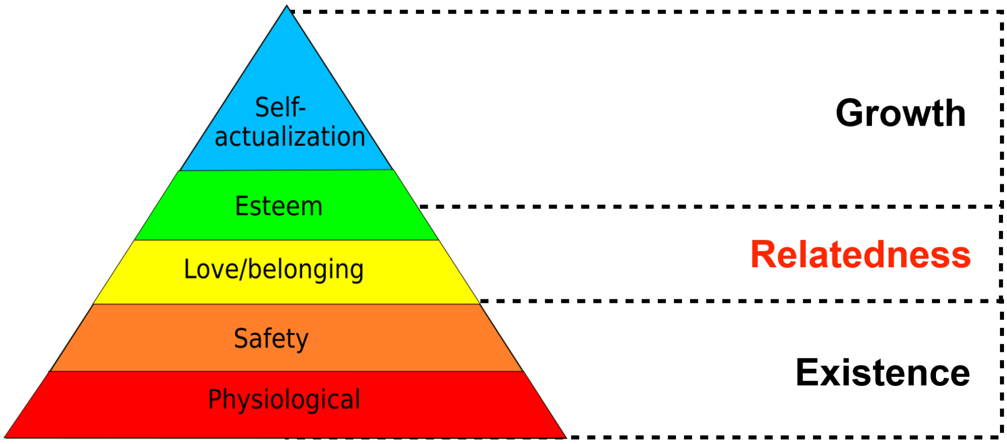
Figure 8 – Maslow's pyramid of need



Source: Adapted from **??**).

Alderfer's ERG Theory, as shown **??**, condenses Maslow's pyramid hierarchy of needs in three categories: Existence (material and physiological), Relatedness (social and external esteem) and Growth (internal esteem and self-actualization) (**????**).

Figure 9 – Relation between Maslow's hierarchy of needs theory and Aldefer's ERG theory



Source: Elaborated by the author.

Different to Maslow's hierarchy of needs theory, a person can regress to a basic level from a complex level if a relatively more significant need (of complex level) is not satisfied (**??**). Thus, a person may satisfy a need at hand, whether or not a previous need has been satisfied. Finally, the theory states that the order of needs to differ for different people.

Self-Determination Theory (SDT) is one of the most well-known theory related to motivation. Through the understanding of needs and motivation, this theory explains the human beings' innate psychological needs for personal development and well-being, and the impact of the environment on individual's motivation (????). SDT defines three innate needs (competence, relatedness, and autonomy) that cause individual motivation, and when these needs are fulfilled they invoke great personal growth (??).

According to SDT theory, the three needs are not learned, and they are seen as universal necessities in humanity across time, gender and culture. They are summarized as follows:

- *Autonomy* is the need to have independence and to be able make own choices (??). ??) states that autonomy does not mean to be independent of other persons. In a game, an example is to give a player freedom to make his own choices among various paths to choose.
- *Relatedness* is the need to be connected with others, iterate with them, and experience caring for them (??). In a game, there are many elements that allow a player socializer with other players.
- *Competence* is the need to control the outcomes and experience a sense of ability (mastery) (??). In a game, when a player sees a leaderboard or progress state, he or she increases their proficiency and skills.

In the SDT, there are two categories of motivation: intrinsic motivation, and extrinsic motivation (??). Extrinsic motivation occurs when an external stimulus evokes a target behavior. Some of these stimulus can be rewards, threats, punishment, pressure, external regulations, and rules. The intrinsic motivation comes from individuals, and pushes them to act for the sake of the activity itself (??). The intrinsic motivation occurs when the behavior is itself rewarding or engaging for the individual. The intrinsic motivators act on the human predisposition to strive for novelty and challenges, to extend and exercise one's capacities, to explore and to learn (??). These intrinsic motivators include altruism, competition, cooperation, sense of belonging, love or aggression (??).

On the one hand, the use of extrinsic motivators is a highly reliable technique for behavioral change, but the behavior disappears instantly when these external motivators are halted (??). On the other hand, intrinsic motivation is intense, and lasting engagement in the behavior, but it cannot be predicted every each person as it is internalized (??). Internalization of motivation refers to the active attempt to transform an extrinsic motive into personally endorsed values. It means the assimilation of behavioral regulations that were originally external.

2.2.4.2 Skinner's reinforcement theory

The reinforcement theory or operant conditioning theory proposed by ??) states that reinforced behaviors will tend to be repeated, while punished behavior tend to be decrease and will eventually end. Thus, the operant conditioning is a process that attempts to modify behavior by positive and negative reinforcement. Therefore, through operant condition, an individual makes an association between consequences and behaviors. For example, telling a child to go to his room is a punishment frequently used to avoid the cursing.

Chart 4 – Forms of operand conditioning to human behavior

<table>
<tr><th></th><th>Positive</th><th>Negative</th></tr>
<tr><td rowspan="2">Reinforcement</td><td rowspan="2">add appetitive stimulus</td><td>Escape
remove noxious stimuli</td></tr>
<tr><td>Active Avoidance
avoid noxious stimulus</td></tr>
<tr><td>Punishment</td><td>add noxious stimuli</td><td>remove appetitive stimulus</td></tr>
</table>

Source: Elaborated by the author.

In this sense, the reinforcement and punishment as shown in **??** are operant conditioning that come in two forms: positive and negative. As we can see in this table, the negative reinforcement has two forms, one related to remove the noxious stimuli (escape) and other related to avoid the stimuli (active avoidance).

2.2.4.3 Csikszentmihalyi's Flow Theory

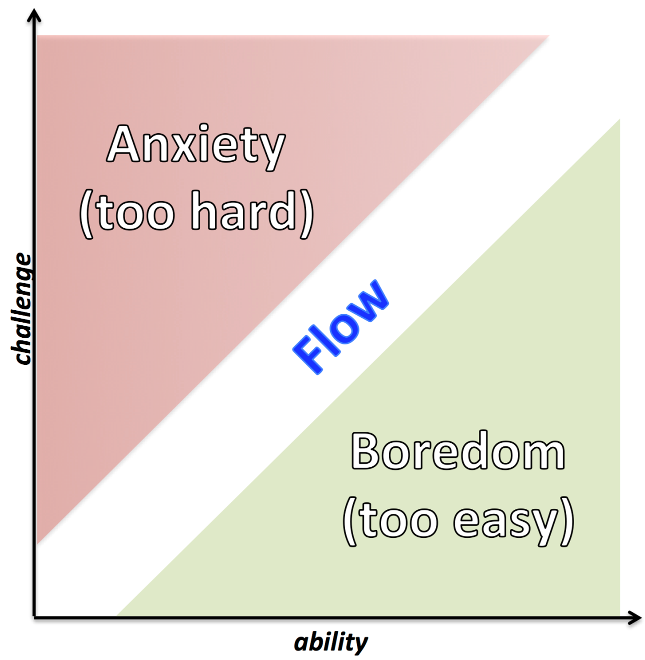
Csikszentmihalyi's flow theory constitutes an important theory regarding the study of affective states during active activities for intrinsic purposes, such as discussions, exercises, and learning activities (**????**). Passive activities like listening music or watching TV usually do not need individuals to actively do something. The flow theory describes the experiences of intrinsically motivated persons in tasks chose for its own sake. Thus, this theory states that in order for a task to be fully engaging it must reach an optimal mind state named flow, which is a state of optimal intrinsic motivation, full concentration, absorption and intense immersion (**????**). In other words, if a user is in flow state during the performance of a task, he or she feels naturally in control and neither overwhelmed by difficulty nor uninterested. The users in flow state experience a loss of self-awareness, forgetting about time, worry, ego and physical symptoms.

It is not a simple task to reach a flow state, and according to the flow theory, the following conditions must be satisfied to achieve the flow state:

- Clear goals, in which the expectations and rules are clearly discernable.
- Direct and immediate feedback, in which the successes and failures of task are apparent, so that behavior can be adjusted as needed.
- Good balance between ability level and challenge.

In the flow theory, the most important condition is accomplishing and maintaining the right balance between difficulty and ability to do some task. There must be enough challenge

Figure 10 – Graph of the three-flow channel model



Source: Adapted from **??**).

so that the user will not become bored but not so much that the user will feel frustrated by the complexity (**??**). This delicate equilibrium is denominated as flow channel and is depicted on **??**.

The ability to create the flow state in games and game-like systems as gamification is essential to engagement users in these applications (**??**). However, it is typically challenging to create activities that induce the right balance between ability and difficulty that matches all users of an application.

2.2.5 Persuasion and Persuasive Design Models

Persuasion as a practice is as old as human existence, and it is defined as the process of influencing changes of peoples' beliefs, attitudes, intentions, and motivations toward target behaviors (**??**). Human-to-human persuasion was broadly researched since early 400 BC when Aristotle defined rhetoric as "*… the faculty of observing in any given case the available means of persuasion*" (**??**). Thus, there are many persuasive models that are concentrated on addressing aim to change the mental state of the persuades through communication (**??**). In the last decade, many researches pointed out that similar to a human persuader, computing technologies can be used to produce changes in human behaviors, beliefs, attitudes, intentions, and motivation in various ways of designing technology to influence these changes in different contexts, such as sports (**??**), health (**??**), and education (**????**).

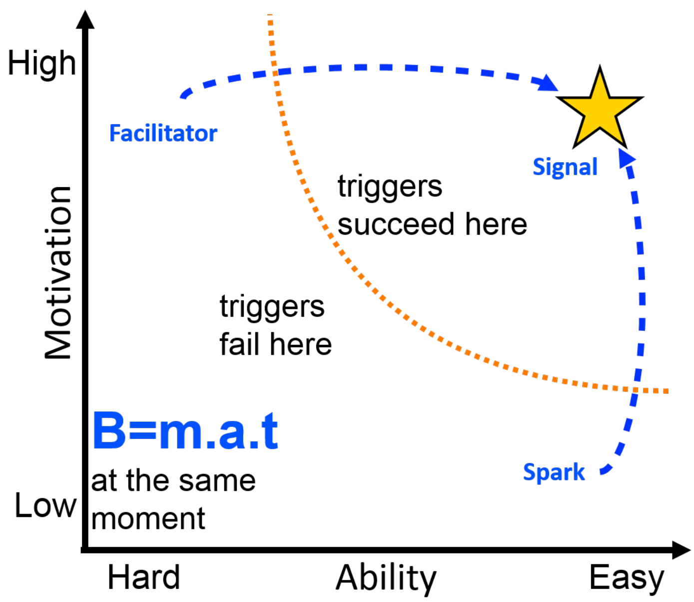
In this section, an overview of most relevant persuasive design models to develop computer as persuasive technologies, defined as Captology (**??**), is summarized below.

2.2.5.1 Fogg's Behavior Model

According to **??**), for a behavior to occur, the motivation, ability, and trigger must converge at the same moment reaching the activation threshold. **??** depicts the Fogg's behavior model, in which the components of model (motivation, ability, and trigger) show that, to pass the activation threshold and trigger the behavior, an event or task must be motivating and not too difficult. In this sense, the three components of Fogg's behavior model are defined as follows:

- *Motivation* is the process used to allocate energy in actions to maximize the satisfaction of needs (**??**). In this process, energy is the time and effort available to meet those needs, and needs are the magnet that drives motivation. Thus, motivation can be measured by the degree in which someone is willing or engaged in performing the behavior (**??**).
- *Ability* is the degree to which someone has the skills or tools to carry out the behavior (**??**). There are six factors that work together in the context of a trigger to define the ability, these factors are: time, money, physical effort, brain cycles, social deviance, and non-routine.
- *Trigger* is what prompts people to take a behavior. The trigger is also known with different names such as cue, prompt, call to action, request, and so on. The trigger is related to the degree to which someone is provoked to perform the behavior (**??**). Sometimes a trigger can from our daily routine (e.g. walking through the kitchen may trigger us to open the fridge), other times the triggers can be external, such as alarms, messages, and so on.

Figure 11 – Visual depiction of Foog's Behavior Model



Source: Adapted from **??**).

When a target behavior does not occur, at least one of those three factors is missing, or one is not enough sufficient to attain the activation threshold. The fact, if the individual has a high motivation to accomplish the task, but if he/she does not have the ability to perform it, the behavior will not occur. On other hand, if the individual lacks motivation to perform a target behavior, this behavior does not occur. Having the ability and motivation alone are not enough to cause a behavior, people need triggers that them "*to complete the action in a certain moment*" (**??**). This trigger is not simply something that prompts or tells something to the users, independent of level of motivation and ability, a trigger at the proper time leads to the target behavior in a predictable way using this trigger as facilitator, spark, or signal.

- *Facilitators* is a proper type of trigger for users that have high motivation but lack ability to perform certain behavior. The goal is these triggers is to make the behavior easier to do, and these facilitators can be embodied in text, video, graphics, and others medias used in games.
- *Sparks* are one type of trigger used when a person lacks motivation to perform a target behavior. Thus, triggers of this type should be designed in tandem with a motivational element. Some examples of sparks can be text or videos that inspire to hope or highlights fear.
- *Signals* is a trigger type that works best when people have both the ability and the motivation to perform the target behavior. The signals do not seek to simplify the task or to motivate people, they are only reminder because the individuals have both motivation and ability.

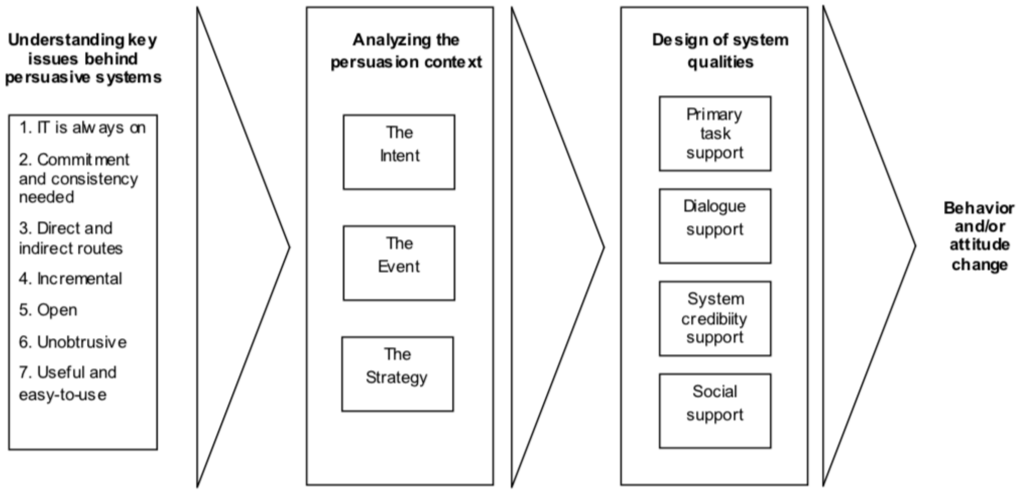
The game elements, more specifically game mechanics in the game design and gamification, acts as influencers that push users over the activation threshold and trigger them to perform a targeted behavior (**??**). In essence, a successful gamified system must cause all three elements of the behavior model to occur all at once.

2.2.5.2 Persuasive System Design Model

Following the research work of Captology (**??**), several models have been proposed to guide the design and evaluation of persuasive technology. The most popular of these models is the Persuasive System Design (PSD) model proposed by **??**). **??** shows the phases for the context analysis of PSD in which, from the first step of understanding the key issues behind persuasive system, the second step of analyzing the persuasion context identifies: the intent (of the persuader), the event (that triggers the persuasion) and the strategy (by which the subject is persuaded).

The third step is the design of system qualities based on design principles classified in 4 categories: primary task, dialogue, credibility, and social support.

Figure 12 – Phases for the context analysis of Persuasive Systems Development



Source: **??**).

Primary Task Support: techniques that help the users to achieve their goals by the principles of:

- *Reduction*: to make the complex behavior into simple tasks by helping the users to perform the target behavior, and thus, to increase the benefit/cost ratio of a behavior. Example: Listing a few options to be chosen, so that the user does not have to select one him/herself.
- *Tunneling*: to guide the users through a process or experience providing opportunities to persuade along the way. Example: An interactive guide in which the step by step indicates how the user should perform a process.
- *Tailoring*: to adapt the information for the potential needs, interests, personality, usage context or other factors relevant to a user group. Example: Giving different interface to a beginner, intermediate and advanced users.
- *Personalization*: to offer personalized content or services with a greater capability of persuasion. Example: Adjusting personalized information in a search engine.
- *Simulation*: to provide simulations that can persuade the users to observe immediately the link between cause and effect. Example: Before-and-after pictures of people that a people has lost weight.
- *Rehearsal*: to provide means with which to rehearse a behavior can enable people to change their attitudes or behavior in the real world. Example: A fight simulator to help pilots in their practices.

Dialogue Support: techniques used in dialogue with the user in a similar way in which human-to-human interaction occur. Their principles are:

- *Praise*: by offering this type of message, a system can make users more open to persuasion Example: Compliments given by an application when the users perform target behaviors.
- *Rewards*: by given rewards to the users when they perform target behaviors. Example: The users earn a virtual trophy when they complete a task.
- *Reminders*: by reminding the users of their target behavior, the users will more likely achieve their goals. Example: A program that reminds the users to perform a target behavior.
- *Suggestion*: by offering fitting suggestions, an application has greater persuasive powers. Example: An application that suggests the users change their habits
- *Similarity*: by imitating the users' behaviors, people are more readily persuaded through systems that remind them of themselves in meaningful way. Example: Using slang in the communication, an application is targeted at young people.
- *Self-monitoring*: to keep the track of the user progress/performance. Example: Presenting a daily step count of fitness trainer.
- *Liking*: by being visually attractive for the users, a system is likely to be more persuasive. Example: Pet-related symbols are adequate for a website targeted at pet owners.
- *Social-role*: by adopting a social role, a system is more likely to be used by the users. Example: A virtual specialist in an application provides better support to communicate users and specialists.

Credibility Support: focuses in maintaining credibility on the importance of a system in which the principles are:

- *Trustworthiness*: in a system is viewed as trustworthy increasing the powers of persuasion. Example: A well-known 3rd party using to verify the strengths of products instead of just relying on advertising.
- *Expertise*: A system that is viewed as incorporating expertise will have increased powers of persuasion. Example: Incorporating expertise opinions in a system.
- *Surface credibility*: People make initial assessments of the system credibility based on a firsthand inspection. Example: A fast, clean and highly polished website without advertising feels more credible.
- *Real-world feel*: A system that highlights people or organization behind its content or services will have more credibility. Example: A contact form in a system to support questions and/or feedback from its users.

- *Authority*: A system that leverages roles of authority will have enhanced powers of persuasion. Example: Quotes given by an authority, such as the government in a web-site.
- *Third-party endorsements*: Third-party endorsements, especially from well-known and respected sources, boost perceptions on system credibility. Example: Guarantee certificates provide certain quality.
- *Verifiability*: Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources. Example: Claims on a website are supported by links to relevant sources.

Social Support: Social factors have ability to influence humans because they are social creatures. Thus, the following principles determine the system's persuasiveness.

- *Social learning*: A person will be more motivated to perform a target behavior when he/she can be used to observe others performing the behavior. Example: An application sharing the journal of others to motivate him/she to perform the behavior indicated in the journal.
- *Social comparison*: System users will have a greater motivation to perform the target behavior if they can compare their performance with the performance of others. Example: Leaderboards in a learn-to-type application shows how well someone is doing compared to others.
- *Normative influence*: A system can leverage normative influence or peer pressure to increase the likelihood that a person will adopt a target behavior. Example: A smoking cessation application shows pictures of newborn babies with serious health problems.
- *Social facilitation*: System users are more likely to perform target behavior if they discern via the system that others are performing the behavior along with them. Example: A homework application shows how many children in the user's class are doing homework at the same time.
- *Cooperation*: A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to co-operate. Example: A homework application giving multiple users parts of an equation.
- *Competition*: A system can motivate users to adopt a target attitude or behavior by leveraging human beings' natural drive to compete. Example: An online competition, such as Quit and Win (stop smoking for a month and win a prize).
- *Recognition*: Public recognition for an individual or group increases the likelihood that a person/group will adopt a target behavior. Example: Names of top contributors, and published on a website as user of the month.

2.2.6 Game Design Models

In gamification, several models concerning to the game design are used to describe the manners in how to combine and apply game elements in the non-game context. These models are based on theories and models of motivation and human behavior, as well as persuasion and persuasive design model. In the following subsections, an overview of most relevant game design models are presented.

2.2.6.1 Player Types: Bartle's Player Types, Yee's Motivational Components, and Marczewski's Player Types

2.2.6.2 MDA model

2.3 Ontologies and Ontology Engineering

2.3.1 What is an ontologies? and Why is an ontology important?

For philosophers, the definition of ontology came from the Greek "*being, that which is*," present participle of the verb "*be*," and "science, study, and theory", is the philosophical study of the nature of being, becoming, existence, or reality, as well as the basic categories of being and their relations (**??**). In computer science, for **??**), an ontology is defined as an explicit specification of a conceptualization in which the conceptualization refers to the meaningfulness of concepts and their relationship given the context of the target world. **??**) defines an ontology as the basic structure or armature around a knowledge base that can be built. As the knowledge bases are composed by facts of a given domain (**??**), an ontology is an framework in which these facts are represented. For (**??**), an ontology is not a simple representation of concepts and their relations. An ontology contains restrictions defined through axioms in which these axioms are formal logical expressions that validate and check the consistency of domain. Finally, an ontology constitute agreements to achieve the mutual understanding of the target domain in a human and computer understandable manner (**??**).

The definitions of ontology presented above also indicate the reasons "*why*" many researches and practitioners have been attracted to develop and use ontologies as knowledge source in powerful and intelligent computational systems and applications. In these applications, an ontology first provide a common conceptual structure that enables the development of sharable and reusable knowledge-based by computer-based mechanisms and procedures, and second an ontology facilitates the interoperability of information enabling them to merge and integrate data from different sources.

????) define the fundamental components of an ontology as: individuals, classes, attributes, and relations. Individuals are instances or objects that constitute the basic or ground level of ontologies. The classes are sets, collections, concepts, types of objects, or kinds of things. Attributes are aspects, properties, features, characteristics, or parameters that classes can have.

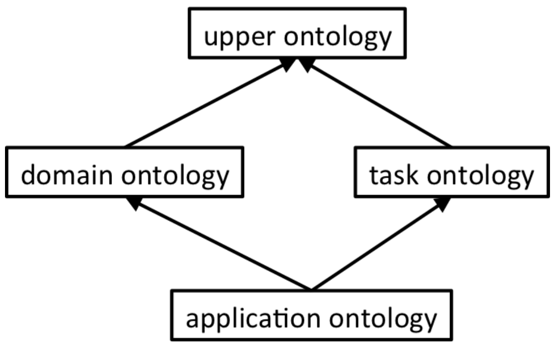
Relations are ways in which classes and individuals can be related to one another. In addition to these fundamental components, an ontology as a theory of concept (**??**) is also constituted by the following two elements: (1) a *set of essential concepts* that result from the articulation of basic knowledge present in a given domain, in which the concepts can be represent using a specialized vocabulary; and (2) a *body of knowledge* that describes the given domain using the essential concepts. In this sense, the body of knowledge is composed by:

- The hierarchy (*class/sub-class*) resulting from "*is-a*" relations between concepts;
- The definition of *important relations* (e.g. "*part-of*," and "*same-as*") between concepts apart from the "*is-a*" relation;
- The *axiomatization* of semantic constraints between those concepts and relations.

2.3.2 Types of Ontologies

2.3.2.1 Classification by Level of Dependence

Figure 13 – Types of ontologies according to level of dependence



Source: **??**).

2.3.2.2 Lightweight Ontologies and Heavyweight Ontologies

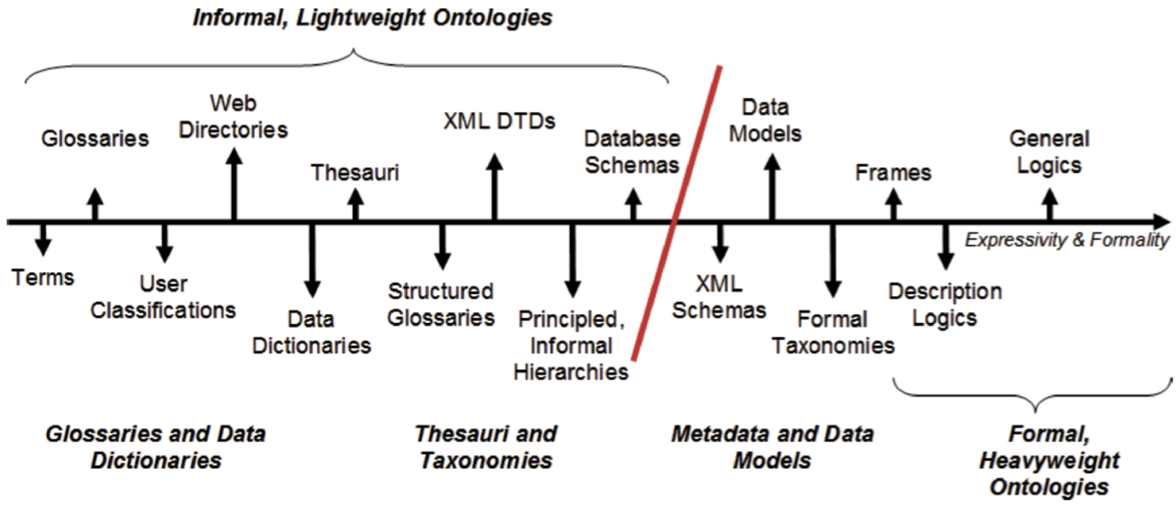
2.3.3 Ontology Representation

Nowadays, the ontologies can be represented in two ways, one representation is the formal representation that is used for computer consumption, and another representation is the graphical representation for human comprehension.

2.3.3.1 Formal Representation

To allow the formal representation for a direct computer consumption, there are many languages that have been proposed using the predicate logics, description logics or frame based languages. The most popular language and framework to describe ontologies is the Web

Figure 14 – The spectrum of lightweight and heavyweight ontologies



Source: **??**).

Ontology Language (OWL) language that is based on the Resource Description Framework (RDF)/RDF-Schema.

The RDF specification was developed by the World Wide Web Consortium (W3C) for metadata description. It is formally represented in the eXtensible Markup Language (XML) employing triplets that contain a subject node, predicate, and object node (<subject, predicate, object>). Each node in the triplet can be a web resource (URI reference), a value (literal) or a document identifier (to represent a blank node). A set of triples also can become a node itself, and a property is a semantic relation between nodes (subject and object).

To represent triplets, the RDF/RDF-Schema specifications define classes, properties, and relationships that can be used to describe these triples as statements about resources. It also includes definition of tags and hierarchical structures (taxonomy) providing the basic elements for the description of ontologies. However, the RDF-Schema has some limitation, especially to support computational reasoning on data available through the internet (**??**). Thus, the OWL specification provides an expressive language to develop ontologies.

OWL is a language developed and endorsed by the W3C to satisfy the formalism for the Semantic Web (SW). It allows the SW applications to understand and answer queries of agents (people or other programs) by reasoning on Web content by ontological descriptions. OWL was developed based on DAML+OIL (**??**) with a formal specification influenced by description logics, the frames paradigms and the OWL exchange syntax (namely RDF/XML) (**??**).

There are three variants of OWL referred as OWL Lite, OWL DL and OWL Full. These three variants allow to achieve a good balance between scalability and expressive power. According to the OWL specification, each variant is an extension of its simpler predecessor. Thus, OWL Lite is used manly for classification hierarchy and simple constraints; OWL DL gives maximum expressiveness retaining computational completeness and decidability; and OWL Full gives maximum expressiveness, however with no computational guarantees, the reasoning process using OWL Full may not be completed in a finite time. **??** shows as example part of an ontology to represent the formalization of bicycle in OWL language.

Figure 15 – Part of bicycle ontology in the OWL

```
<owl:Class rdf:ID="Vehicle">
    <rdfs:label> Veiculo</rdfs:label>
    <rdfs:subClassOf rdf:resource="#Any" />
</owl:Class>
<owl:Class rdf:ID="sport_cycle">
    <rdfs:label>Bicicleta_Esportiva </rdfs:label>
    <rdfs:subClassOf rdf:resource="#bicycle" />
</owl:Class>
<owl:Class rdf:ID="city_cycle">
    <rdfs:label>Bicicleta_Urbana</rdfs:label>
    <rdfs:subClassOf rdf:resource="#bicycle" />
</owl:Class>
<owl:Class rdf:ID="bicycle">
    <rdfs:label>bicicleta </rdfs:label>
    <rdfs:subClassOf rdf:resource="#Vehicle" />
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:cardinality rdf:datatype="http://www.w3.org/
            <owl:onProperty rdf:resource="#has_body_color" />
        </owl:Restriction>
    </rdfs:subClassOf>
    <rdfs:subClassOf>
        <owl:Restriction>
            <owl:onProperty rdf:resource="#has_body_color" />
            <owl:allValuesFrom rdf:resource="#Color" />
```

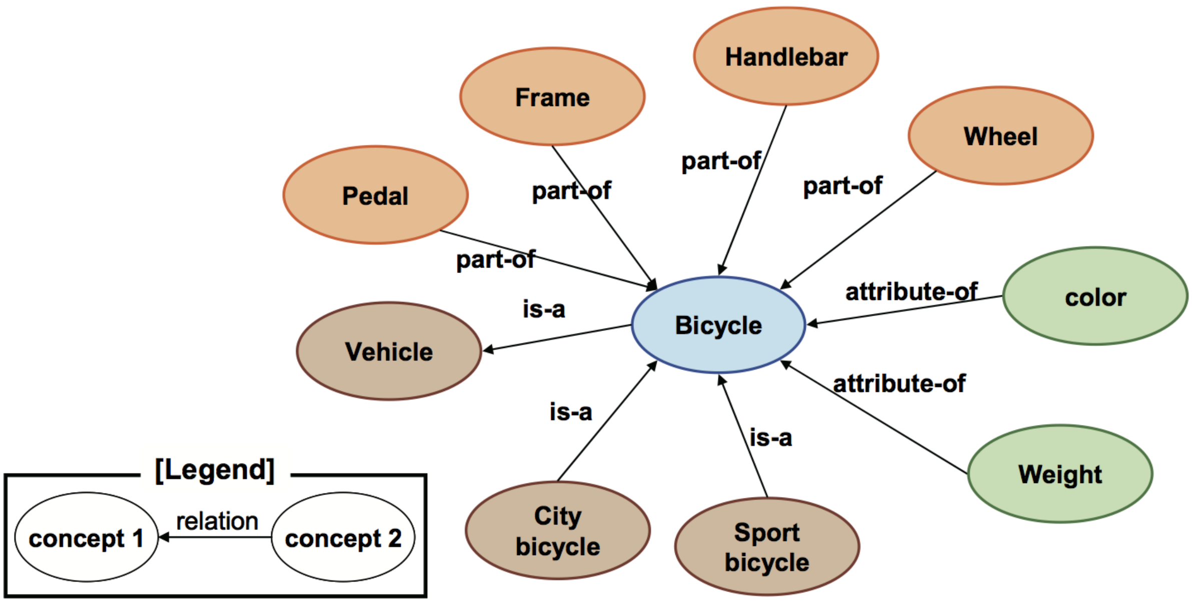
Source: **??**).

As the author of this dissertation used the graphical representation to describe the ontological structures, details of the RDF/RDF-Schema and OWL languages are not detailed in this section. The RDF/RDF-Schema and OWL are automatically generated by graphical ontology editors, such as Protégé (**??**), OntoEdit (**??**) and Hozo (**??**).

2.3.3.2 Graphical representation

As an ontology is mainly composed by concepts and their relations, the graph is a common representation of ontologies, where the nodes represent concepts and the arrows represent relations between concepts (**??**). **??** shows the graphical representation of an ontology referred to bicycle. In this ontology, the concept of a bicycle is a specialization of vehicle represented using *is-a* relation (<bicycle *is-a* vehicle>). In this ontology, the class "*City bicycle*" and "*Sport bicycle*" are related to the class "*Bicycle*" by the arrows "*is-a*" to indicate that the bicycle is specialized into sport bicycle and city bicycle, and the class "*Bicycle*" is associated to the class "*Vehicle*" by the arrows "*is-a*" to indicate that vehicle is a super-class of the class bicycle. The attributes "*Color*" and "*Weight*" are indicated by the arrows "*attribute-of*." Finally, the arrows "*part-of*" indicate the elements that compose a bicycle, and these elements are: *Wheel*, *Handlebar*, *Frame*, and *Pedal*. The scheme of colors in this figure helps the reader identify the relationship between concepts.

Figure 16 – A graph representation of a bicycle ontology



Source: **??**).

Although the representation of ontologies using graphs is the most common, it suffers deficiencies that do not help to capture important elements in an ontology (**??**), especially when trying to represent the model of roles proposed by **??**).

To deal with the modeling of ontologies based on the model of role, the Hozo ontology editor (**??**) has been proposed as an authoring environment in which the differentiating of basic concepts (e.g. human, and artifact) from role concepts (e.g. learner, and reward) is described as frames diagrams. In this graphical representation based on frames, to deal with the concept of role, the following three classes are defined:

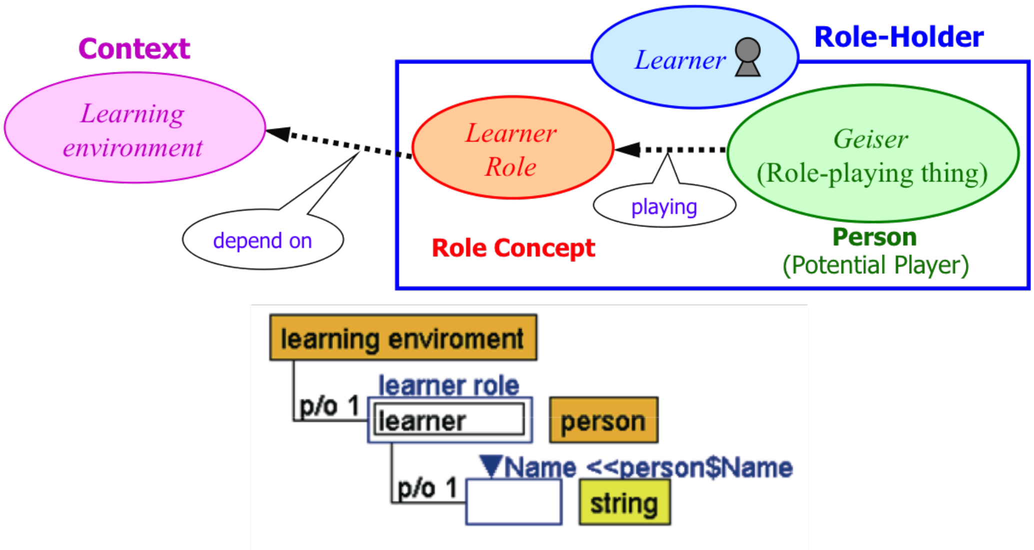
Role concept - A concept representing a role that depends on a context (e.g. learner role that depends on the school);

Basic concept - A concept that does not need other concepts to be defined (e.g. human); and

Role holder - An instance of a base concept that is holding the role (e.g. learner).

The basic concepts are used as class constraints, and the instances that satisfy the class constraints play the role, becoming role holders. For example as shown in the **??**, "In a learning environment there is a vacancy for a learner, and a person, whose name is Geiser, fills the position, becoming a learner in the particular environment." The person who plays a role is referred as a role holder. Thus, *Geiser* becomes a *learner* in the *learning environment* by playing the *learner role*. The top of the figure shows how the concepts around a role are related to each other and in the bottom is shown the representation in Hozo.

Figure 17 – The learner role holder in Hozo representation



Source: Elaborated by the author.

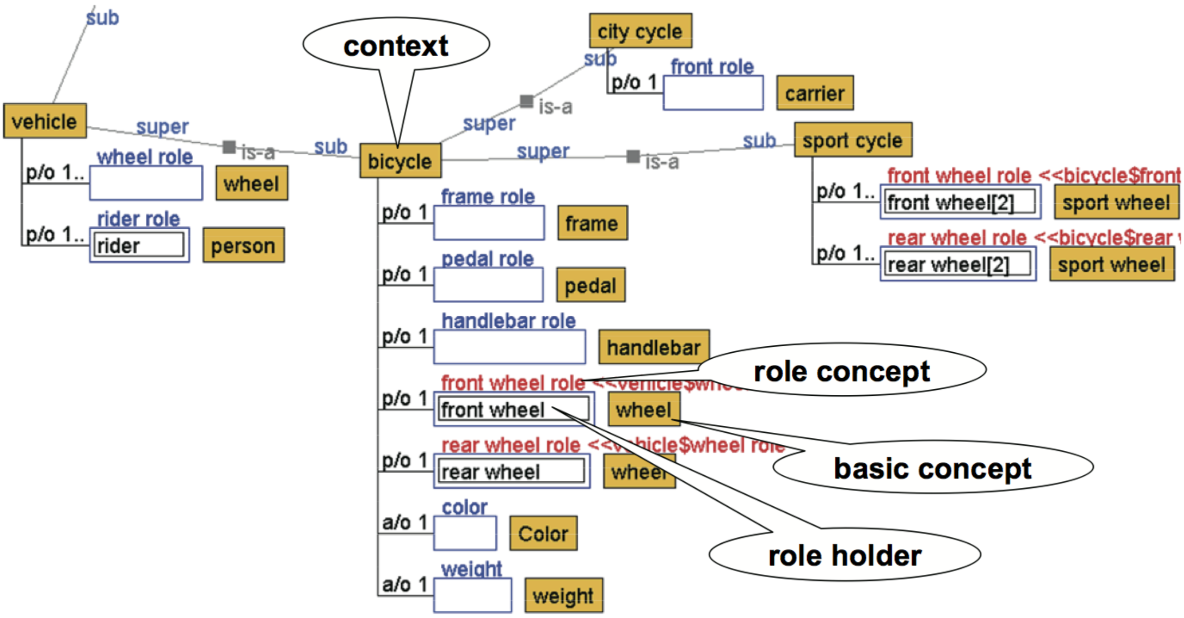
?? shows the representation of bicycle ontology using Hozo representation. In this figure, the relations part-of and attribute-of is respectively represented by labels "*p/o*" and "*a/o*" that appear in front of each slot. Thus, the frame, pedal, handlebar, and wheels are part of the bicycle. Observe that in the context of bicycle, a wheel (basic concept) can play the role of front wheel or rear wheel (role concepts). Thus, a particular instance of a wheel that plays one of these roles (front wheel role or rear wheel role) is referred to as role holder. In summary, a front wheel is an instance of wheel playing the front wheel role.

2.3.4 Ontology Engineering

Ontology engineering encompasses a set of activities conducted during the conceptualization, design, implementation and deployment of ontologies (**????**). It covers topics including philosophy, metaphysics, knowledge representation formalisms, development methodology, knowledge sharing and reuse, knowledge management, business process modeling, common sense knowledge, systematization of domain knowledge, information retrieval from the Internet, standardization, and evaluation.

Developing ontologies is a time-consuming and difficult task that requires knowledge about the target domain, theoretical background on ontology formalization, and the skills to

Figure 18 – Example of bicycle ontology using Hozo representation



Source: ??).

properly define the concepts and elements as body of knowledge in ontologies. Thus, to facilitate the development of ontologies, there are several formal methodologies and methods that have been proposed. The guidelines of these methodologies and methods are categorized into three layers shown in **??** (**??**), in which:

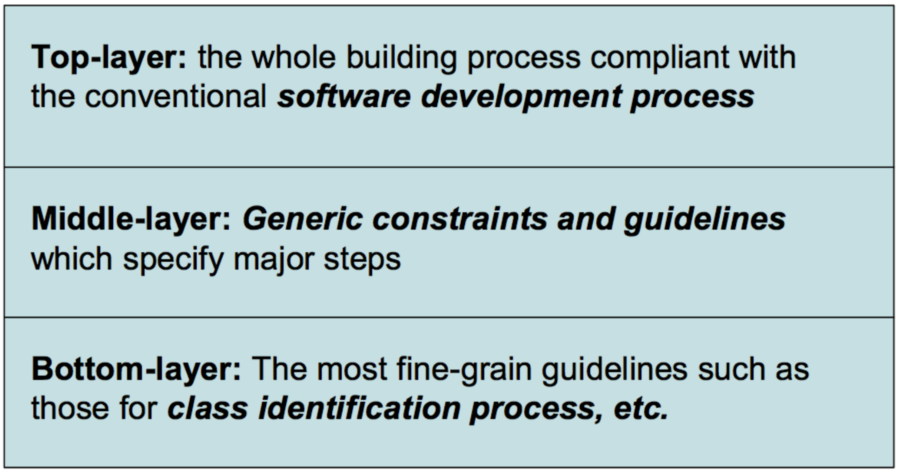
1. **Top-layer** contains the coarsest level of guidelines that specifies the whole building process with standard software development life cycles. The guidelines described in this layer correspond to ontological methods and methodologies associated with conventional software development processes and practices.

2. **Middle-layer** describes the generic constraints and guidelines that specify a set of major steps and their order of execution. In each step of middle layer, the detailed information about the activities to be completed, and the way for each activity should be carried out.

3. **Bottom-layer** corresponds to the most fine-grain guidelines that enable the construction of concepts hierarchy. It describes guidelines to create explicit semantic structures from identified concepts in the target world.

Most of the currently existing methods and methodologies describe guidelines concerned mainly with the top-layer. Some examples are METHONTOLOGY (**??**), On-To-Knowledge (**??**), and Ushold and King's methodology (**??**). Unfortunately, only a few of them deal with the middle and bottom layers. The main problem of having few methodologies for the development

Figure 19 – Three-layer classification model of guidelines proposed in methodologies and methods to develop ontologies



Source: **??**).

of the middle and bottom layers is that the chances of creating a good ontology at the end of some process decreases.

In this sense, **??**) proposed a set of guidelines to support the development of ontologies at the middle and bottom layers based the Activity-First Method (**??**), and in this dissertation, the author of this dissertation utilized these guidelines to create the ontology OntoGaCLeS. Therefore, the rest of this section presents an overview of guidelines (**??????**) that were summarized by **??**) as described as follows:

Middle Layer Guidelines

1. Identify concepts rather than terms. As ontology is totally independent of terminological problems, one cannot stress the importance of this distinction too much. Since people will be easily trapped by the endless terminological discussion departing from the underlying conceptual structure of the target domain.

2. Use mixed and flexible strategies of top-down, bottom-up and middle-out. Never stick to only one of the strategies.

3. Whenever possible, identify and use top-level ontology in the early phase of the development process to govern the rest of the steps.

4. When you deal with a concept, identify its main components, using "*part-of*" relation as well as its main attributes. You can thus find and extend candidates of concepts to be included in the ontology.

5. Definition of axioms should be done after finishing is-a hierarchy building and informal term definition.

6. Note that you cannot define any concept completely in theory. Therefore, do not stick to the definition of each term too much. At the best, you only can give necessary conditions of them. Term definition in the early phase can be rough. Detailed definition of a term should be done after you grasp the whole structure of the ontology, that is, after building is-a hierarchy.

7. Never try to seriously define a term one by one. Definition of a concept needs sufficient contextual information, which is usually not available in the early phase. Terms are related to each other and could have several meanings, which should be clarified by the context given.

8. Arrange and resolve the terminological issues (how to name a concept) at the last step.

9. When you find the necessity to define more than one meaning for one term, then you are facing the terminological problem. Each term should correspond to exactly one concept in ontology, since you are not building a dictionary, but a well-organized conceptual structure. Each term is only a label of the concept. You of course can build a dictionary after building ontology.

10. Put a higher priority on is-a hierarchy construction than term definition. Carefully designed is-a hierarchy gives you a correct context to define a term.

11. When you get stuck with a term definition, follow either one of the following :

    - Multiple meanings? Then concentrate on meaning one by one.
    - Multiple Viewpoints? Make the viewpoint explicit and then try it again
    - Check if you are discussing terminology.
    - Use is-a hierarchy to give enough context.

Bottom Layer Guidelines

1. *Identify essential properties* for each concept considered essential in the scope of a given problem. These essential properties facilitate to create more stable concepts and hierarchies during the ontology development process.

2. *Make correct use of the role-concept* that can be defined as the association of a concept to a particular role within a given context. When developing an ontology, one should carefully distinguish the difference between role-concept, role-holder, and basic concepts. Such differentiation helps to treat multiple meanings as introduced previously in the guidelines for the Middle layer.

3. *Be careful when using is-a relation* in ontologies is different from the one utilized by object- oriented programming. The is-a relation applies only for classes. Furthermore, for

given classes A and B the relation <class A is-a class B> is true if and only if the instance set of A is a subset of the instance set of B. Therefore building a relation such as <teacher is-a human> is ontologically incorrect, since *teacher* is not an ontologically-valid class because there is no person (no instance of class person) whose intrinsic property is being a teacher. Thus, in ontology, it is inappropriate to model <Mizoguchi instance-of Teacher> and <Teacher is-a Human>.

4. *Be careful when using part-of relation* such as functional, qualification, spatial and etc. Thus, it needs to be used carefully, especially avoid part-of relation to create class hierarchies such as <man part-of human>. Such an expression is valid only when you want to deal with man as a subspecies of human.

5. *Pay attention to the difference between is-a and part-of relations*. Usually, the meaning of is-a and part-of relations is easy to distinguish. The former indicates generic vs. specific relations between classes. The latter is often utilized to specify the composition of a thing (although, part-of can be used in other situations). However, sometimes when developing an ontology, one can encounter difficulties to distinguish their difference. For example, which of the following relation is correct: <Dog part-of mammal living in Japan> or <Dog is-a mammal living in Japan>? People agree that <Dog is-a mammal> is correct. However, by adding the *living in Japan* phrase to mammal the distinction is not quite that easy because *mammal living in Japan* seems to represent species, and therefore, *<dog-species* part-of *mammal-species* living in Japan> could be considered. Thus, the distinction between is-a and part-of relation is not always easy.

6. *Avoid the use of multiple inheritances* Creating multiple inheritances is the source of many problems to keep the consistency of the representation. In particular, propagating the essential properties is a problem since each concept should be recognized and represented by their own essential properties.

7. *Some boundary between similar concepts can be vague* When developing an ontology some boundaries between similar concepts do not need to be strongly conceptualized. An example is the distinction between the concepts black and white. Since the distinction between them is based on the ambiguous color gray, we cannot give a clear and unique boundary between black and white (although we recognize their existence).

8. *Create terms if there is no label to represent a concept*. If you cannot find an appropriate term to represent a concept, then you can temporarily label them with some sentences or marks (e.g., concept 1 and concept 2) until you can come up with a good label. When the body of the ontology is good enough to represent the target domain, you can revise the labels of each concept.

BIBLIOGRAPHY

Alario-Hoyos, C.; Bote-Lorenzo, M. L.; Gómez-Sánchez, E.; Asensio-Pérez, J. I.; Vega-Gorgojo, G.; Ruiz-Calleja, A. GLUE!: An architecture for the integration of external tools in Virtual Learning Environments. **Computers & Education**, v. 60, n. 1, p. 122–137, Jan. 2013. ISSN 0360-1315. Citation on page 40.

ALDERFER, C. **Existence, Relatedness, and Growth: Human Needs in Organizational Settings**. [S.l.]: Free Press, 1972. Citation on page 50.

ALDERFER, C. P. An empirical test of a new theory of human needs. **Organizational Behavior and Human Performance**, v. 4, n. 2, p. 142–175, May 1969. ISSN 0030-5073. Citation on page 50.

ALHARBI, N. M.; ATHAUDA, R. I.; CHIONG, R. A survey of CSCL script tools that support designing collaborative scenarios. In: **2014 International Conference on Web and Open Access to Learning (ICWOAL)**. [S.l.: s.n.], 2014. p. 1–8. Citations on pages 19, 38, 40, and 41.

ANDRADE, F. R. H.; MIZOGUCHI, R.; ISOTANI, S. The Bright and Dark Sides of Gamification. In: MICARELLI, A.; STAMPER, J.; PANOURGIA, K. (Ed.). **Intelligent Tutoring Systems**. Cham: Springer International Publishing, 2016. v. 9684, p. 176–186. ISBN 978-3-319-39582-1 978-3-319-39583-8. Citation on page 21.

Andreas Harrer; Ulrch Hoppe. Visual Modeling of Collaborative Learning Processes. In: **Handbook of Visual Languages for Instructional Design: Theories and Practices: Theories and Practices**. [S.l.]: Information Science Reference, 2007, (Gale virtual reference library). p. 281–298. ISBN 978-1-59904-731-7. LCCB: 2007023444. Citation on page 40.

ARAZY, O.; GELLATLY, I. R. Corporate Wikis: The Effects of Owners' Motivation and Behavior on Group Members' Engagement. **Journal of Management Information Systems**, v. 29, n. 3, p. 87–116, Dec. 2012. ISSN 0742-1222. Citation on page 50.

ARONSON, E. **The Jigsaw Classroom**. [S.l.]: SAGE Publications, 1978. (A SageView edition). LCCB: 78000583. ISBN 978-0-8039-0997-7. Citation on page 39.

ASIKRI, M. E.; LAASSIRI, J.; KRIT, S. d; CHAIB, H. Contribution to ontologies building using the semantic web and web mining. In: **2016 International Conference on Engineering MIS (ICEMIS)**. [S.l.: s.n.], 2016. p. 1–5. Citation on page 22.

BAUMEISTER, R. F.; LEARY, M. R. The need to belong: Desire for interpersonal attachments as a fundamental human motivation. **Psychological Bulletin**, v. 117, n. 3, p. 497–529, 1995. ISSN 1939-1455(Electronic);0033-2909(Print). Citation on page 51.

BORGES, S. S.; DURELLI, V. H. S.; REIS, H. M.; ISOTANI, S. A Systematic Mapping on Gamification Applied to Education. In: **Proceedings of the 29th Annual ACM Symposium on Applied Computing**. [S.l.]: ACM, 2014. (SAC '14), p. 216–222. ISBN 978-1-4503-2469-4. Citations on pages 20, 46, and 48.

Bote-Lorenzo, M. L.; Vaquero-González, L. M.; Vega-Gorgojo, G.; DIMITRIADIS, Y. A.; Asensio-Pérez, J. I.; Gómez-Sánchez, E.; Hernández-Leo, D. A Tailorable Collaborative Learning System That Combines OGSA Grid Services and IMS-LD Scripting. In: VREEDE, G.-J. de; GUERRERO, L. A.; RAVENTÓS, G. M. (Ed.). **Groupware: Design, Implementation, and Use**. [S.l.]: Springer Berlin Heidelberg, 2004, (Lecture Notes in Computer Science, 3198). p. 305–321. ISBN 978-3-540-23016-8 978-3-540-30112-7. Citations on pages 38 and 40.

BRATHWAITE, B.; SCHREIBER, I. **Challenges for Game Designers**. [S.l.]: Course Technology, 2009. ISBN 978-1-58450-580-8. Citation on page 47.

BREHM, J. W. **A Theory of Psychological Reactance**. Oxford, England: Academic Press, 1966. (A theory of psychological reactance). Citation on page 42.

CAEIRO, M.; ANIDO, L.; LLAMAS, M. A Critical Analysis of IMS Learning Design. In: WASSON, B.; LUDVIGSEN, S.; HOPPE, U. (Ed.). **Designing for Change in Networked Learning Environments: Proceedings of the International Conference on Computer Support for Collaborative Learning 2003**. Dordrecht: Springer Netherlands, 2003. p. 363–367. ISBN 978-94-017-0195-2. Citation on page 38.

CHALLCO, G. C.; BITTENCOURT, I. I.; ISOTANI, S. Computer-based systems for automating instructional design of collaborative learning scenarios: A systematic literature review. **IJKL**, v. 11, n. 4, p. 273–297, 2016. Citations on pages 40 and 41.

CHALLCO, G. C.; GEROSA, M. A.; BITTENCOURT, I. I.; ISOTANI, S. Automated instructional design for CSCL: A hierarchical task network planning approach. **Expert Systems with Applications**, v. 41, n. 8, p. 3777–3798, 2014. ISSN 0957-4174. Citation on page 41.

CHALLCO, G. C.; MOREIRA, D. A.; MIZOGUCHI, R.; ISOTANI, S. An Ontology Engineering Approach to Gamify Collaborative Learning Scenarios. In: BALOIAN, N.; BURSTEIN, F.; OGATA, H.; SANTORO, F.; ZURITA, G. (Ed.). **20th International Conference on Collaboration and Technology**. [S.l.]: Springer, 2014, (Lecture Notes in Computer Science, 8658). p. 185–198. ISBN 978-3-319-10165-1 978-3-319-10166-8. Citation on page 20.

CHAN, T. S.; AHERN, T. C. Targeting motivation-adapting flow theory to instructional design. **Journal of Educational computing research**, v. 21, n. 2, p. 151–164, 1999. Citation on page 20.

CHEONG, C.; CHEONG, F.; FILIPPOU, J. Quick Quiz: A Gamified Approach for Enhancing Learning. **PACIS 2013 Proceedings**, Jun. 2013. Citation on page 48.

CROOK, C. Motivation and the ecology of collaborative learning. **Rethinking collaborative learning**, p. 161–178, 2000. Citation on page 20.

CSIKSZENTMIHALYI, M. **Flow: The Psychology of Optimal Experience**. 1st edition. ed. New York: Harper Perennial Modern Classics, 2008. ISBN 978-0-06-133920-2. Citations on pages 52 and 53.

____. Learning, "Flow," and Happiness. In: **Applications of Flow in Human Development and Education**. [S.l.]: Springer, 2014. p. 153–172. ISBN 978-94-017-9093-2 978-94-017-9094-9. Citation on page 52.

DAVIS, K.; SINGH, S. Digital badges in afterschool learning: Documenting the perspectives and experiences of students and educators. **Computers Education**, v. 88, p. 72 – 83, 2015. ISSN 0360-1315. Citation on page 21.

DECI, E. L.; RYAN, R. M. **Self-Determination**. [S.l.]: John Wiley & Sons, Inc., 2010. (The Corsini Encyclopedia of Psychology). ISBN 978-0-470-47921-6. Citations on pages 42, 50, and 51.

DECI, E. L.; VANSTEENKISTE, M. Self-determination theory and basic need satisfaction: Understanding human development in positive psychology. **Ricerche di Psicologia**, v. 27, n. 1, p. 23–40, 2004. ISSN 0391-6081. Citations on pages 50 and 51.

DENNY, P. The Effect of Virtual Achievements on Student Engagement. In: **Proceedings of the SIGCHI Conference on Human Factors in Computing Systems**. New York, NY, USA: ACM, 2013. (CHI '13), p. 763–772. ISBN 978-1-4503-1899-0. Citation on page 48.

DERMEVAL, D.; VILELA, J.; BITTENCOURT, I. I.; CASTRO, J.; ISOTANI, S.; BRITO, P.; SILVA, A. Applications of ontologies in requirements engineering: A systematic review of the literature. **Requirements Engineering**, v. 21, n. 4, p. 405–437, Nov. 2016. ISSN 1432-010X. Citation on page 22.

DETERDING, S.; BJÖRK, S. L.; NACKE, L. E.; DIXON, D.; LAWLEY, E. Designing Gamification: Creating Gameful and Playful Experiences. In: **CHI '13 Extended Abstracts on Human Factors in Computing Systems**. Paris, France: ACM, 2013. (CHI EA '13), p. 3263–3266. ISBN 978-1-4503-1952-2. Citation on page 21.

DETERDING, S.; DIXON, D.; KHALED, R.; NACKE, L. From game design elements to gamefulness: Defining gamification. In: **Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments**. [S.l.]: ACM, 2011. p. 9–15. Citations on pages 20, 46, and 47.

DEVEDZIĆ, V. Understanding Ontological Engineering. **Commun. ACM**, v. 45, n. 4, p. 136–144, Apr. 2002. ISSN 0001-0782. Citation on page 63.

DEVEDŽIC, V. **Semantic Web and Education**. [S.l.]: Springer, 2006. ISBN 978-0-387-35417-0. Citations on pages 22, 62, and 63.

DICHEVA, D.; DICHEV, C.; AGRE, G.; ANGELOVA, G. Gamification in Education: A Systematic Mapping Study. **Journal of Educational Technology Society**, v. 18, n. 3, p. 75–88, 2015. ISSN 11763647, 14364522. Citation on page 21.

DIENG, R.; HUG, S. Comparison of Personal Ontologies Represented through Conceptual Graphs. In: **ECAI**. [S.l.: s.n.], 1998. v. 98, p. 341–345. Citation on page 61.

DILLENBOURG, P. What do you mean by collaborative learning? In: DILLENBOURG, P. (Ed.). **Collaborative-Learning: Cognitive and Computational Approaches**. Oxford: Elsevier, 1999. p. 1–19. Citation on page 35.

____. Over-scripting CSCL: The risks of blending collaborative learning with instructional design. In: KIRSCHNER, P. A. (Ed.). **Three Worlds of CSCL. Can We Support CSCL?** Nederland: Open Universiteit Nederland, 2002. p. 61–91. ISBN 978-90-358-2047-0. Citations on pages 36, 38, 39, and 41.

____. Design for classroom orchestration. **Computers Education**, v. 69, p. 485 – 492, 2013. ISSN 0360-1315. Citation on page 19.

DILLENBOURG, P.; HONG, F. The mechanics of CSCL macro scripts. **International Journal of Computer-Supported Collaborative Learning**, v. 3, n. 1, p. 5–23, Mar. 2008. ISSN 1556-1615. Citation on page 41.

DILLENBOURG, P.; JERMANN, P. Designing Integrative Scripts. In: FISCHER, F.; KOLLAR, I.; MANDL, H.; HAAKE, J. (Ed.). **Scripting Computer-Supported Collaborative Learning**. New York, NY, USA: Springer, 2007, (Computer-Supported Collaborative Learning, v. 6). p. 275–301. ISBN 978-0-387-36947-1. Citations on pages 36, 38, and 39.

DOMÍNGUEZ, A.; Saenz-de-Navarrete, J.; de-Marcos, L.; Fernández-Sanz, L.; PAGÉS, C.; Martínez-Herráiz, J.-J. Gamifying learning experiences: Practical implications and outcomes. **Computers & Education**, v. 63, p. 380–392, Apr. 2013. ISSN 0360-1315. Citation on page 48.

DONG, T.; DONTCHEVA, M.; JOSEPH, D.; KARAHALIOS, K.; NEWMAN, M.; ACKERMAN, M. Discovery-based Games for Learning Software. In: **Proceedings of the SIGCHI Conference on Human Factors in Computing Systems**. New York, NY, USA: ACM, 2012. (CHI '12), p. 2083–2086. ISBN 978-1-4503-1015-4. Citation on page 48.

FALOUT, J.; ELWOOD, J.; HOOD, M. Demotivation: Affective states and learning outcomes. **System**, v. 37, n. 3, p. 403–417, 2009. ISSN 0346-251X. Citation on page 20.

FEIDAKIS, M.; CABALLÉ, S.; DARADOUMIS, T.; JIMÉNEZ, D. G. n.; CONESA, J. Providing emotion awareness and affective feedback to virtualised collaborative learning scenarios. **International Journal of Continuing Engineering Education and Life Long Learning**, v. 24, n. 2, p. 141–167, 2014. Citation on page 20.

FEIDAKIS, M.; DARADOUMIS, T.; CABALLÉ, S.; CONESA, J. Embedding emotion awareness into e-learning environments. **International Journal of Emerging Technologies in Learning (iJET)**, v. 9, n. 7, p. 39–46, Apr. 2014. ISSN 1863-0383. Citation on page 20.

Fernandez-Lopez, M.; Gomez-Perez, A.; JURISTO, N. METHONTOLOGY: From Ontological Art towards Ontological Engineering. In: **Proceedings of the AAAI97 Spring Symposium**. Stanford, USA: [s.n.], 1997. p. 33–40. Citation on page 64.

FISCHER, F. **Keynote Talk**. Lausanne, Switzerland: [s.n.], 2007. Citation on page 36.

FISCHER, F.; KOLLAR, I.; STEGMANN, K.; WECKER, C.; ZOTTMANN, J. Collaboration scripts in computer-supported collaborative learning. **The international handbook of collaborative learning**, p. 403–419, 2013. Citations on pages 19 and 40.

Fitz-Walter, Z.; TJONDRONEGORO, D.; WYETH, P. Orientation Passport: Using Gamification to Engage University Students. In: **Proceedings of the 23rd Australian Computer-Human Interaction Conference**. New York, NY, USA: ACM, 2011. (OzCHI '11), p. 122–125. ISBN 978-1-4503-1090-1. Citation on page 48.

FOGG, B. A Behavior Model for Persuasive Design. In: **Proceedings of the 4th International Conference on Persuasive Technology**. Claremont, California, USA: ACM, 2009. (Persuasive '09), p. 40:1–40:7. ISBN 978-1-60558-376-1. Citations on pages 53, 54, and 55.

FOGG, B. J. **Persuasive Technology: Using Computers to Change What We Think and Do**. 1. ed. [S.l.]: Morgan Kaufmann, 2002. (Interactive Technologies). ISBN 1-55860-643-2 978-1-55860-643-2. Citations on pages 53 and 55.

GALTON, A.; MIZOGUCHI, R. The Water Falls but the Waterfall Does Not Fall: New Perspectives on Objects, Processes and Events. **Appl. Ontol.**, v. 4, n. 2, p. 71–107, Apr. 2009. ISSN 1570-5838. Citation on page 41.

GLASS, R.; VESSEY, I.; RAMESH, V. Research in software engineering: An analysis of the literature. **Information and Software Technology**, v. 44, n. 8, p. 491–506, 2002. ISSN 0950-5849. Citation on page 26.

GLASS, R. L. A structure-based critique of contemporary computing research. **Journal of Systems and Software**, v. 28, n. 1, p. 3–7, Jan. 1995. ISSN 0164-1212. Citation on page 26.

GOBLE, F. **The Third Force: The Psychology of Abraham Maslow**. [S.l.]: Grossman, 1970. Citation on page 49.

GOH, T.-T.; SEET, B.-C.; CHEN, N.-S. The impact of persuasive SMS on students' self-regulated learning. **British Journal of Educational Technology**, v. 43, n. 4, p. 624–640, 2011. ISSN 1467-8535. Citation on page 53.

GRUBER, T. R. A translation approach to portable ontology specifications. **Knowledge Acquisition**, v. 5, n. 2, p. 199–220, Jun. 1993. ISSN 1042-8143. Citation on page 58.

GUARINO, N. Semantic matching: Formal ontological distinctions for information organization, extraction, and integration. In: PAZIENZA, M. T. (Ed.). **Information Extraction A Multidisciplinary Approach to an Emerging Information Technology: International Summer School, SCIE-97 Frascati, Italy, July 14–18, 1997**. Berlin, Heidelberg: Springer Berlin Heidelberg, 1997. p. 139–170. ISBN 978-3-540-69548-6. Citation on page 59.

GUARINO, N.; OBERLE, D.; STAAB, S. What Is an Ontology? In: STAAB, S.; STUDER, R. (Ed.). **Handbook on Ontologies**. [S.l.]: Springer, 2009, (International Handbooks on Information Systems). p. 1–17. ISBN 978-3-540-70999-2. Citations on pages 22 and 58.

GUERINI, M.; STOCK, O.; ZANCANARO, M. A Taxonomy of Strategies for Multimodal Persuasive Message Generation. **Applied Artificial Intelligence**, v. 21, n. 2, p. 99–136, Feb. 2007. ISSN 0883-9514. Citation on page 53.

HAGGER, M. S.; CHATZISARANTIS, N. L. D. (Ed.). **Intrinsic Motivation and Self-Determination in Exercise and Sport**. 1 edition. ed. Champaign, IL: Human Kinetics, 2007. ISBN 978-0-7360-6250-3. Citation on page 51.

HAKULINEN, L.; AUVINEN, T.; KORHONEN, A. Empirical Study on the Effect of Achievement Badges in TRAKLA2 Online Learning Environment. In: **2013 Learning and Teaching in Computing and Engineering**. [S.l.: s.n.], 2013. p. 47–54. Citation on page 48.

HALAN, S.; ROSSEN, B.; CENDAN, J.; LOK, B. High Score! - Motivation Strategies for User Participation in Virtual Human Development. In: **Intelligent Virtual Agents**. [S.l.]: Springer, Berlin, Heidelberg, 2010. (Lecture Notes in Computer Science), p. 482–488. ISBN 978-3-642-15891-9 978-3-642-15892-6. Citation on page 48.

HAMARI, J.; KOIVISTO, J.; SARSA, H. Does Gamification Work?–A Literature Review of Empirical Studies on Gamification. In: **47th International Conference on System Sciences**. Hawaii, USA: IEEE Computer Society, 2014. (HICSS '14), p. 3025–3034. ISBN 978-1-4799-2504-9. Citations on pages 21, 47, and 48.

HARJUMAA, M.; Segersta ahl, K.; Oinas-Kukkonen, H. Understanding Persuasive Software Functionality in Practice: A Field Trial of Polar FT60. In: **Proceedings of the 4th International Conference on Persuasive Technology**. New York, NY, USA: ACM, 2009. (Persuasive '09), p. 2:1–2:9. ISBN 978-1-60558-376-1. Citation on page 53.

HARRER, A.; KOBBE, L.; MALZAHN, N. Conceptual and computational issues in the formalization of collaboration scripts. In: **Proceedings of the 8th Iternational Conference on Computer Supported Collaborative Learning**. [S.l.]: International Society of the Learning Sciences, 2007. p. 280–282. Citation on page 35.

Hayes-Roth, F.; WATERMAN, D. A.; LENAT, D. B. **Building Expert Systems**. Boston, MA, USA: Addison-Wesley Longman Publishing Co., Inc., 1983. ISBN 978-0-201-10686-2. Citation on page 58.

HEETER, C.; LEE, Y.-H.; MEDLER, B.; MAGERKO, B. Beyond Player Types: Gaming Achievement Goal. In: **Proceedings of the 2011 ACM SIGGRAPH Symposium on Video Games**. Vancouver, British Columbia, Canada: ACM, 2011. (Sandbox '11), p. 43–48. ISBN 978-1-4503-0775-8. Citation on page 21.

Hernández-Leo, D.; Villasclaras-Fernández, E. D.; Asensio-Pérez, J. I.; DIMITRIADIS, Y.; Jorrín-Abellán, I. M.; Ruiz-Requies, I.; Rubia-Avi, B. COLLAGE: A collaborative Learning Design editor based on patterns. **Journal of Educational Technology and Society**, v. 9, n. 1, p. 58, 2006. Citation on page 38.

Hernandez-Leo, D.; Villasclaras-Fernandez, E. D.; Asensio-Perez, J. I.; DIMITRIADIS, Y. A.; RETALIS, S. CSCL Scripting Patterns: Hierarchical Relationships and Applicability. In: **Sixth IEEE International Conference on Advanced Learning Technologies (ICALT'06)**. [S.l.: s.n.], 2006. p. 388–392. Citation on page 41.

HEWITT, J. Toward an Understanding of How Threads Die in Asynchronous Computer Conferences. **Journal of the Learning Sciences**, v. 14, n. 4, p. 567–589, 2005. Citation on page 19.

HOPPE, H. U.; OGATA, H.; SOLLER, A. **The Role of Technology in CSCL**. 1. ed. [S.l.]: Springer US, 2007. (Computer-Supported Collaborative Learning Series, v. 9). ISBN 978-0-387-71135-5. Citation on page 35.

HORROCKS, I.; others. DAML+OIL: A Description Logic for the Semantic Web. **IEEE Data Eng. Bull.**, v. 25, n. 1, p. 4–9, 2002. Citation on page 60.

HORROCKS, I.; Patel-Schneider, P. F.; van Harmelen, F. From SHIQ and RDF to OWL: The making of a Web Ontology Language. **Web Semantics: Science, Services and Agents on the World Wide Web**, v. 1, n. 1, p. 7–26, 2003. ISSN 1570-8268. Citation on page 60.

HRON, A.; HESSE, F. W.; REINHARD, P.; PICARD, E. Strukturierte Kooperation beim computerunterstützten kollaborativen Lernen. **Unterrichtswissenschaft**, v. 25, p. 56–69, 1997. Citation on page 42.

HUITT, W. Maslow's hierarchy of needs. **Educational psychology interactive**, 2004. Citation on page 49.

INABA, A.; IKEDA, M.; MIZOGUCHI, R. What learning patterns are effective for a learner's growth. In: **Proc. of the International Conference on Artificial Intelligence in Education, Sydney**. [S.l.: s.n.], 2003. p. 219–226. Citation on page 38.

ISOTANI, S. **An Ontological Engineering Approach to Computer-Supported Collaborative Learning**. Phd Thesis (PhD Thesis) — Osaka University, Japan, 2009. Citations on pages 20, 38, 61, 62, 64, and 65.

ISOTANI, S.; INABA, A.; IKEDA, M.; MIZOGUCHI, R. An Ontology Engineering Approach to the Realization of Theory-Driven Group Formation. **International Journal of Computer-Supported Collaborative Learning**, v. 4, n. 4, p. 445–478, 2009. ISSN 1556-1615 1556-1607. Citations on pages 19 and 41.

ISOTANI, S.; MIZOGUCHI, R. Theory-Driven Group Formation through Ontologies. In: WOOLF, B. P.; AÏMEUR, E.; NKAMBOU, R.; LAJOIE, S. (Ed.). **Intelligent Tutoring Systems: 9th International Conference**. Montreal, Canada: Springer Berlin Heidelberg, 2008. p. 646–655. ISBN 978-3-540-69132-7. Citations on pages 38 and 40.

ISOTANI, S.; MIZOGUCHI, R.; ISOTANI, S.; CAPELI, O. M.; ISOTANI, N.; de Albuquerque, A. R. P. L.; BITTENCOURT, I. I.; JAQUES, P. A Semantic Web-based authoring tool to facilitate the planning of collaborative learning scenarios compliant with learning theories. **Computers & Education**, v. 63, p. 267–284, 2013. ISSN 0360-1315. Citations on pages 38 and 40.

KAPP, K. M. **The Gamification of Learning and Instruction: Game-Based Methods and Strategies for Training and Education**. San Francisco, CA: Pfeiffer, 2012. Citations on pages 21 and 46.

KARKAR, A.; JA'AM, J. M. A.; FOUFOU, S. A Survey on Educational Ontologies and Their Development Cycle. In: BOURAS, A.; EYNARD, B.; FOUFOU, S.; THOBEN, K.-D. (Ed.). **Product Lifecycle Management in the Era of Internet of Things: 12th IFIP WG 5.1 International Conference, PLM 2015, Doha, Qatar, October 19-21, 2015, Revised Selected Papers**. Cham: Springer International Publishing, 2016. p. 649–658. ISBN 978-3-319-33111-9. Citation on page 22.

KELLER, J. M. Development and use of the ARCS model of instructional design. **Journal of instructional development**, v. 10, n. 3, p. 2–10, 1987. Citation on page 20.

KING, A. Scripting Collaborative Learning Processes: A Cognitive Perspective. In: FISCHER, F.; KOLLAR, I.; MANDL, H.; HAAKE, J. M. (Ed.). **Scripting Computer-Supported Collaborative Learning: Cognitive, Computational and Educational Perspectives**. Boston, MA: Springer US, 2007. p. 13–37. ISBN 978-0-387-36949-5. Citation on page 39.

KNUTAS, A.; IKONEN, J.; MAGGIORINI, D.; RIPAMONTI, L.; PORRAS, J. Creating Software Engineering Student Interaction Profiles for Discovering Gamification Approaches to Improve Collaboration. In: **Proceedings of the 15th International Conference on Computer Systems and Technologies**. New York, NY, USA: ACM, 2014. (CompSysTech '14), p. 378–385. ISBN 978-1-4503-2753-4. Citation on page 22.

KNUTAS, A.; IKONEN, J.; NIKULA, U.; PORRAS, J. Increasing Collaborative Communications in a Programming Course with Gamification: A Case Study. In: **Proceedings of the 15th International Conference on Computer Systems and Technologies**. New York, NY, USA: ACM, 2014. (CompSysTech '14), p. 370–377. ISBN 978-1-4503-2753-4. Citations on pages 21 and 22.

KOBBE, L.; WEINBERGER, A.; DILLENBOURG, P.; HARRER, A.; HÄMÄLÄINEN, R.; HÄKKINEN, P.; FISCHER, F. Specifying computer-supported collaboration scripts. **International Journal of Computer-Supported Collaborative Learning**, v. 2, n. 2-3, p. 211–224, 2007. ISSN 1556-1607. Citations on pages 19, 36, and 37.

KOLLAR, I.; FISCHER, F.; SLOTTA, J. D. Internal and External Collaboration Scripts in Web-based Science Learning at Schools. In: **Proceedings of Th 2005 Conference on Computer Support for Collaborative Learning: Learning 2005: The Next 10 Years!** Taipei, Taiwan: International Society of the Learning Sciences, 2005. (CSCL '05), p. 331–340. ISBN 978-0-8058-5782-5. Citation on page 42.

KOPER, R. An Introduction to Learning Design. In: KOPER, R.; TATTERSALL, C. (Ed.). **Learning Design: A Handbook on Modelling and Delivering Networked Education and Training**. Berlin, Heidelberg: Springer Berlin Heidelberg, 2005. p. 3–20. ISBN 978-3-540-27360-8. Citation on page 38.

KORDAKI, M.; SIEMPOS, H. The Jigsaw Collaborative Method within the Online Computer Science Classroom. In: **CSEDU (2)**. [S.l.: s.n.], 2010. p. 65–72. Citation on page 39.

KOZAKI, K.; KITAMURA, Y.; IKEDA, M.; MIZOGUCHI, R. Hozo: An Environment for Building/Using Ontologies Based on a Fundamental Consideration of "Role" and "Relationship". In: Gómez-Pérez, A.; BENJAMINS, V. R. (Ed.). **13th International Conference on Knowledge Engineering and Knowledge Management, EKAW 2002**. [S.l.]: Springer, 2002, (Lecture Notes in Computer Science, 2473). p. 213–218. ISBN 978-3-540-45810-4 978-3-540-44268-4. Citations on pages 61 and 62.

LEHTINEN, E.; HAKKARAINEN, K.; LIPPONEN, L.; RAHIKAINEN, M.; MUUKKONEN, H. Computer supported collaborative learning: A review. **The JHGI Giesbers reports on education**, v. 10, 1999. Citation on page 19.

LEO, D. H.; PEREZ, J. I. A.; DIMITRIADIS, Y. A. IMS learning design support for the formalization of collaborative learning patterns. In: **IEEE International Conference on Advanced Learning Technologies, 2004. Proceedings.** [S.l.: s.n.], 2004. p. 350–354. Citation on page 38.

LI, W.; GROSSMAN, T.; FITZMAURICE, G. GamiCAD: A Gamified Tutorial System for First Time Autocad Users. In: **Proceedings of the 25th Annual ACM Symposium on User Interface Software and Technology**. New York, NY, USA: ACM, 2012. (UIST '12), p. 103–112. ISBN 978-1-4503-1580-7. Citation on page 48.

LINDLEY, C. A. Narrative, Game Play, and Alternative Time Structures for Virtual Environments. In: GÖBEL, S.; SPIERLING, U.; HOFFMANN, A.; IURGEL, I.; SCHNEIDER, O.; DECHAU, J.; FEIX, A. (Ed.). **Technologies for Interactive Digital Storytelling and Entertainment**. [S.l.]: Springer, 2004, (Lecture Notes in Computer Science, 3105). p. 183–194. ISBN 978-3-540-22283-5 978-3-540-27797-2. Citation on page 45.

LUCERO, A.; ZULOAGA, R.; MOTA, S.; NOZ, F. M. Persuasive Technologies in Education: Improving Motivation to Read and Write for Children. In: **Persuasive Technology**. [S.l.]: Springer, Berlin, Heidelberg, 2006. (Lecture Notes in Computer Science), p. 142–153. ISBN 978-3-540-34291-5 978-3-540-34293-9. Citation on page 53.

MAGNISALIS, I.; DEMETRIADIS, S. Extending IMS-LD Capabilities: A Review, a Proposed Framework and Implementation Cases. In: DARADOUMIS, T.; DEMETRIADIS, S. N.; XHAFA, F. (Ed.). **Intelligent Adaptation and Personalization Techniques in Computer-Supported Collaborative Learning**. Berlin, Heidelberg: Springer Berlin Heidelberg, 2012. p. 85–108. ISBN 978-3-642-28586-8. Citation on page 38.

MAGNISALIS, I. D.; DEMETRIADIS, S. N. Orchestrating Adaptive and Complex CSCL Scenarios through a Choreography among IMS-LD and External Services. In: **Proceedings of the 2012 Fourth International Conference on Intelligent Networking and Collaborative Systems**. Bucharest, Romania: IEEE, 2012. p. 89–96. ISBN 978-1-4673-2281-2 978-1-4673-2279-9 978-0-7695-4808-1. Citation on page 40.

MARCZEWSKI, A. **Gamification User Types Dodecad – The HEXAD Expansion Pack!** 2015. Https://www.gamified.uk/2015/12/16/gamification-user-types-dodecad-christmas/. Citation on page 28.

MASLOW, A. H. **Motivation and Personality**. New York: Harper, 1954. Citation on page 49.

MÄYRÄ, F.; ERMI, L. Fundamental Components of the Gameplay Experience: Analysing Immersion. In: **Proceedings of DiGRA 2005 Conference: Changing Views–Worlds in Play**. [S.l.: s.n.], 2005. Citation on page 45.

MIAO, Y.; HOEKSEMA, K.; HOPPE, H. U.; HARRER, A. CSCL Scripts: Modelling Features and Potential Use. In: **Proceedings of Th 2005 Conference on Computer Support for Collaborative Learning: Learning 2005: The Next 10 Years!** Taipei, Taiwan: International Society of the Learning Sciences, 2005. (CSCL '05), p. 423–432. ISBN 0-8058-5782-6. Citations on pages 38 and 40.

MITCHELL, T. R.; DANIELS, D. Motivation. In: **Handbook of Psychology**. [S.l.]: John Wiley & Sons, Inc., 2003. ISBN 978-0-471-26438-5. Citation on page 48.

MIZOGUCHI, R. Ontology for Modeling the World from Problem Solving Perspectives. **Proc. IJCAI-95 Workshop on Basic Ontological Issues in Knowledge Sharing, Montreal**, 1995. Citation on page 65.

____. Part 1: Introduction to ontological engineering. **New Generation Computing**, v. 21, n. 4, p. 365–384, Dec. 2003. ISSN 0288-3635, 1882-7055. Citation on page 65.

____. Part 3: Advanced course of ontological engineering. **New Generation Computing**, v. 22, n. 2, p. 193–220, Jun. 2004. ISSN 0288-3635, 1882-7055. Citations on pages 59, 64, and 65.

____. Tutorial on ontological engineering Part 2: Ontology development, tools and languages. **New Generation Computing**, v. 22, n. 1, p. 61–96, Mar. 2004. ISSN 0288-3635, 1882-7055. Citations on pages 58 and 65.

MIZOGUCHI, R.; BOURDEAU, J. Using Ontological Engineering to Overcome AI-ED Problems: Contribution, Impact and Perspectives. **International Journal of Artificial Intelligence in Education**, v. 26, n. 1, p. 91–106, Mar. 2016. ISSN 1560-4306. Citation on page 22.

MIZOGUCHI, R.; SUNAGAWA, E.; KOZAKI, K.; KITAMURA, Y. The Model of Roles Within an Ontology Development Tool: Hozo. **Applied Ontology - Roles, an interdisciplinary perspective**, v. 2, n. 2, p. 159–179, Apr. 2007. ISSN 1570-5838. Citation on page 62.

MOLINA, A. I.; REDONDO, M. A.; ORTEGA, M. Assessing CIAN as modeling language of collaborative learning activities. In: **International Symposium on Computers in Education**. Andorra la Vella, Andorra: IEEE, 2012. p. 1–6. Citation on page 38.

MORA, A.; RIERA, D.; GONZALEZ, C.; Arnedo-Moreno, J. A Literature Review of Gamification Design Frameworks. In: **2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games)**. [S.l.: s.n.], 2015. p. 1–8. Citation on page 21.

MUNTEAN, C. I. Raising engagement in e-learning through gamification. In: **Proc. 6th International Conference on Virtual Learning ICVL**. [S.l.: s.n.], 2011. p. 323–329. Citation on page 51.

NATANSON, M. The limits of rhetoric. **Quarterly Journal of Speech**, v. 41, n. 2, p. 133–139, Apr. 1955. ISSN 0033-5630. Citation on page 53.

NICHOLSON, S. A RECIPE for Meaningful Gamification. In: REINERS, T.; WOOD, L. C. (Ed.). **Gamification in Education and Business**. Cham: Springer International Publishing, 2015. p. 1–20. ISBN 978-3-319-10208-5. Citation on page 21.

NOY, N. F.; SINTEK, M.; DECKER, S.; CRUBEZY, M.; FERGERSON, R. W.; MUSEN, M. A. Creating Semantic Web contents with Protege-2000. **IEEE Intelligent Systems**, v. 16, n. 2, p. 60–71, Mar. 2001. ISSN 1541-1672. Citation on page 61.

NUNES, T. M.; BITTENCOURT, I. I.; ISOTANI, S.; JAQUES, P. A. Discouraging Gaming the System Through Interventions of an Animated Pedagogical Agent. In: VERBERT, K.; SHARPLES, M.; KLOBŬCAR, T. (Ed.). **Adaptive and Adaptable Learning: 11th European Conference on Technology Enhanced Learning, EC-TEL 2016, Lyon, France, September 13-16, 2016, Proceedings**. Cham: Springer International Publishing, 2016. p. 139–151. ISBN 978-3-319-45153-4. Citation on page 21.

OHNO, A.; YAMASAKI, T.; TOKIWA, K. I. A discussion on introducing half-anonymity and gamification to improve students' motivation and engagement in classroom lectures. In: **2013 IEEE Region 10 Humanitarian Technology Conference**. [S.l.: s.n.], 2013. p. 215–220. Citation on page 21.

Oinas-Kukkonen, H.; HARJUMAA, M. Persuasive systems design: Key issues, process model, and system features. **Communications of the Association for Information Systems**, v. 24, n. 1, p. 28, 2009. Citations on pages 55 and 56.

ORJI, R. **Design for Behaviour Change: A Model-Driven Approach for Tailoring Persuasive Technologies**. Phd Thesis (PhD Thesis), 2014. Citations on pages 28 and 33.

ORJI, R.; VASSILEVA, J.; MANDRYK, R. L. Modeling the efficacy of persuasive strategies for different gamer types in serious games for health. **User Modeling and User-Adapted Interaction**, v. 24, n. 5, p. 453–498, Jul. 2014. ISSN 0924-1868, 1573-1391. Citation on page 53.

Palomino-Ramírez, L.; Bote-Lorenzo, M. L.; Asensio-Pérez, J. I.; DIMITRIADIS, Y. A. LeadFlow4LD: Learning and Data Flow Composition-Based Solution for Learning Design in CSCL. In: BRIGGS, R. O.; ANTUNES, P.; VREEDE, G.-J. de; READ, A. S. (Ed.). **Groupware: Design, Implementation, and Use**. Omaha, NE, USA: Springer, 2008, (LNCS, 5411). p. 266–280. ISBN 978-3-540-92830-0 978-3-540-92831-7. Citation on page 38.

Patel-Schneider, P. F. Building the semantic web tower from rdf straw. In: **IJCAI**. [S.l.: s.n.], 2005. p. 546–551. Citation on page 60.

PEDRO, L. Z.; LOPES, A. M. Z.; PRATES, B. G.; VASSILEVA, J.; ISOTANI, S. Does Gamification Work for Boys and Girls?: An Exploratory Study with a Virtual Learning Environment. In: **Proceedings of the 30th Annual ACM Symposium on Applied Computing**. Salamanca, Spain: ACM, 2015. (SAC '15), p. 214–219. ISBN 978-1-4503-3196-8. Citation on page 21.

PRIETO, L. P.; Asensio-Pérez, J. I.; DIMITRIADIS, Y.; Gómez-Sánchez, E.; Muñoz-Cristóbal, J. A. GLUE!-PS: A Multi-language Architecture and Data Model to Deploy TEL Designs to Multiple Learning Environments. In: KLOOS, C. D.; GILLET, D.; GARĆIA, R. M. C.; WILD, F.; WOLPERS, M. (Ed.). **Towards Ubiquitous Learning: 6th European Conference of Technology Enhanced Learning, EC-TEL 2011, Palermo, Italy, September 20-23, 2011. Proceedings**. Berlin, Heidelberg: Springer Berlin Heidelberg, 2011. p. 285–298. ISBN 978-3-642-23985-4. Citation on page 40.

PRIETO, L. P.; Asensio-Perez, J. I.; Munoz-Cristobal, J. A.; DIMITRIADIS, Y. A.; Jorrin-Abellan, I. M.; Gomez-Sanchez, E. Enabling Teachers to Deploy CSCL Designs across Distributed Learning Environments. **IEEE Transactions on Learning Technologies**, v. 6, n. 4, p. 324–336, Oct. 2013. ISSN 1939-1382. Citation on page 40.

PRIETO, L. P.; TCHOUNIKINE, P.; Asensio-Pérez, J. I.; SOBREIRA, P.; DIMITRIADIS, Y. Exploring teachers' perceptions on different CSCL script editing tools. **Computers Education**, v. 78, n. Supplement C, p. 383 – 396, 2014. ISSN 0360-1315. Citation on page 40.

PRITCHARD, R.; ASHWOOD, E. **Managing Motivation: A Manager's Guide to Diagnosing and Improving Motivation**. 1 edition. ed. [S.l.]: Routledge, 2008. ISBN 978-1-84169-789-5. Citation on page 54.

RICHARDS, C.; THOMPSON, C. W.; GRAHAM, N. Beyond Designing for Motivation: The Importance of Context in Gamification. In: **Proceedings of the First ACM SIGCHI Annual Symposium on Computer-Human Interaction in Play**. Toronto, Ontario, Canada: ACM, 2014. (CHI PLAY '14), p. 217–226. ISBN 978-1-4503-3014-5. Citation on page 21.

Romero-Moreno, L. M.; ORTEGA, F. J.; TROYANO, J. A. Obtaining Adaptation of Virtual Courses by Using a Collaborative Tool and Learning Design. In: **Proceedings of the 2007 Euro American Conference on Telematics and Information Systems**. New York, NY, USA: ACM, 2007. (EATIS '07), p. 42:1–42:7. ISBN 978-1-59593-598-4. Citation on page 38.

RONEN, M.; Kohen-Vacs, D. Designing and Applying Adaptation Patterns Embedded in the Script. In: **The International Conference on Intelligent Networking and Collaborative Systems**. Barcelona, Spain: IEEE, 2009. p. 306–310. ISBN 978-1-4244-5165-4. Citations on pages 38 and 40.

RUMMEL, N.; SPADA, H. Can People Learn Computer-Mediated Collaboration by Following A Script? In: **Scripting Computer-Supported Collaborative Learning**. [S.l.]: Springer, Boston, MA, 2007, (Computer-Supported Collaborative Learning). p. 39–55. ISBN 978-0-387-36947-1 978-0-387-36949-5. Citation on page 41.

RYAN, R. M.; DECI, E. L. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. **American Psychologist**, v. 55, n. 1, p. 68–78, 2000. ISSN 1935-990X(Electronic);0003-066X(Print). Citations on pages 50 and 51.

SALEN, K.; ZIMMERMAN, E. **Rules of Play: Game Design Fundamentals**. [S.l.]: MIT Press, 2004. ISBN 978-0-262-24045-1. Citation on page 45.

SANCHO, P.; Fuentes-Fernández, R.; Fernández-Manjón, B. NUCLEO: Adaptive Computer Supported Collaborative Learning in a Role Game Based Scenario. In: **The 8th IEEE International Conference on Advanced Learning Technologies**. Santander, Spain: IEEE, 2008. p. 671–675. ISBN 978-0-7695-3167-0. Citation on page 38.

SCHELL, J. **The Art of Game Design: A Book of Lenses**. 1 edition. ed. Amsterdam ; Boston: CRC Press, 2008. ISBN 978-0-12-369496-6. Citations on pages 42, 43, 44, and 45.

SCHMITT, L. J.; WEINBERGER, A. Computer-Supported Collaborative Learning: Mediated and Co-Present Forms of Learning Together. In: **Second Handbook of Information Technology in Primary and Secondary Education**. [S.l.]: Springer, Cham, 2018, (Springer International Handbooks of Education). p. 1–15. ISBN 978-3-319-53803-7. Citation on page 42.

SCHOOR, C.; BANNERT, M. Motivation in a computer-supported collaborative learning scenario and its impact on learning activities and knowledge acquisition. **Learning and Instruction**, v. 21, n. 4, p. 560–573, 2011. ISSN 0959-4752. Citation on page 20.

SEABORN, K.; FELS, D. I. Gamification in theory and action: A survey. **International Journal of Human-Computer Studies**, v. 74, p. 14–31, 2015. Citations on pages 20 and 21.

SEITER, J.; GASS, R. **Perspectives on Persuasion, Social Influence, and Compliance Gaining**. [S.l.]: Pearson/Allyn and Bacon, 2004. ISBN 978-0-205-33523-7. Citation on page 53.

SKINNER, B. F. **About Behaviorism**. 1 edition. ed. New York: Vintage, 1976. ISBN 978-0-394-71618-3. Citation on page 51.

SMITH, A.; BAKER, L. **Getting a Clue: Creating Student Detectives and Dragon Slayers in Your Library**. [S.l.: s.n.], 2011. Citation on page 48.

SNYDER, C. R. R.; LOPEZ, S. J.; PEDROTTI, J. T. **Positive Psychology: The Scientific and Practical Explorations of Human Strengths**. Second edition edition. Thousand Oaks: SAGE Publications, Inc, 2010. ISBN 978-1-4129-9062-2. Citation on page 52.

STAHL, G.; KOSCHMANN, T.; SUTHERS, D. Computer-supported collaborative learning: An historical perspective. **Cambridge handbook of the learning sciences**, v. 2006, 2006. Citations on pages 19 and 35.

STEGMANN, K.; MU, J.; Gehlen-Baum, V.; FISCHER, F. The myth of over-scripting: Can novices be supported too much. In: **Connecting Computer-Supported Collaborative Learning to Policy and Practice: CSCL2011 Conference Proceedings**. [S.l.: s.n.], 2011. v. 1, p. 406–413. Citation on page 42.

STYLIANAKIS, G.; ARAPI, P.; MOUMOUTZIS, N.; CHRISTODOULAKIS, S. CoLearn: Real time collaborative learning environment. In: **Second International Conference on E-Learning and E-Technologies in Education**. Lodz, Poland: IEEE, 2013. p. 13–18. ISBN 978-1-4673-5094-5 978-1-4673-5093-8. Citation on page 38.

SUGUMARAN, V.; STOREY, V. C. Ontologies for Conceptual Modeling: Their Creation, Use, and Management. **Data Knowl. Eng.**, v. 42, n. 3, p. 251–271, Sep. 2002. ISSN 0169-023X. Citation on page 58.

SURE, Y.; ERDMANN, M.; ANGELE, J.; STAAB, S.; STUDER, R.; WENKE, D. OntoEdit: Collaborative Ontology Development for the Semantic Web. In: **The Semantic Web — ISWC 2002**. [S.l.]: Springer, Berlin, Heidelberg, 2002. (Lecture Notes in Computer Science), p. 221–235. ISBN 978-3-540-43760-4 978-3-540-48005-1. Citation on page 61.

SURE, Y.; STAAB, S.; STUDER, R. On-To-Knowledge Methodology (OTKM). In: **Handbook on Ontologies**. [S.l.]: Springer, Berlin, Heidelberg, 2004, (International Handbooks on Information Systems). p. 117–132. ISBN 978-3-662-11957-0 978-3-540-24750-0. Citation on page 64.

SWARTOUT, W.; TATE, A. Guest Editors' Introduction: Ontologies. **IEEE Intelligent Systems**, v. 14, n. 1, p. 18–19, Jan. 1999. ISSN 1541-1672. Citation on page 58.

USCHOLD, M.; KING, M. Towards a Methodology for Building Ontologies. In: **Workshop on Basic Ontological Issues in Knowledge Sharing, Held in Conduction with IJCAI-95**. Montreal, Canada: [s.n.], 1995. Citation on page 65.

Vega-Gorgojo, G.; Bote-Lorenzo, M. L.; Gómez-Sánchez, E.; DIMITRIADIS, Y. A.; Asensio-Pérez, J. I. Semantic Description of Collaboration Scripts for Service Oriented CSCL Systems. **Artificial Intelligence in Education**, v. 125, p. 935–937, 2005. Citations on pages 38 and 40.

Villasclaras-Fernández, E.; Hernández-Leo, D.; Asensio-Pérez, J. I.; DIMITRIADIS, Y. Web Collage: An implementation of support for assessment design in CSCL macro-scripts. **Computers & Education**, v. 67, p. 79–97, Sep. 2013. ISSN 0360-1315. Citation on page 38.

Villasclaras-Fernández, E. D.; Hernández-Gonzalo, J. A.; LEO, D. H.; Asensio-Pérez, J. I.; DIMITRIADIS, Y. A.; Martínez-Monés, A. InstanceCollage: A Tool for the Particularization of Collaborative IMS-LD Scripts. **Educational Technology & Society**, v. 12, n. 4, p. 56–70, 2009. ISSN 1436-4522. Citation on page 40.

Villasclaras-Fernández, E. D.; ISOTANI, S.; HAYASHI, Y.; MIZOGUCHI, R. Looking Into Collaborative Learning: Design from Macro-and Micro-Script Perspectives. In: **Proceedings of the 2009 Conference on Artificial Intelligence in Education: Building Learning Systems That Care: From Knowledge Representation to Affective Modelling**. Amsterdam, The Netherlands, The Netherlands: IOS Press, 2009. p. 231–238. ISBN 978-1-60750-028-5. Citations on pages 38 and 39.

WEINBERGER, A.; ERTL, B.; FISCHER, F.; MANDL, H. Epistemic and social scripts in computer-supported collaborative learning. **Instructional Science**, v. 33, n. 1, p. 1–30, Jan. 2005. ISSN 1573-1952. Citations on pages 20, 37, 39, and 41.

WEINBERGER, A.; FISCHER, F.; STEGMANN, K. Computer-supported Collaborative Learning in Higher Education: Scripts for Argumentative Knowledge Construction in Distributed Groups. In: **Proceedings of Th 2005 Conference on Computer Support for Collaborative Learning: Learning 2005: The Next 10 Years!** Taipei, Taiwan: International Society of the Learning Sciences, 2005. (CSCL '05), p. 717–726. ISBN 0-8058-5782-6. Citations on pages 40 and 41.

WEINBERGER, A.; STEGMANN, K.; FISCHER, F. Learning to argue online: Scripted groups surpass individuals (unscripted groups do not). **Computers in Human Behavior**, v. 26, n. 4, p. 506–515, Jul. 2010. ISSN 0747-5632. Citation on page 41.

WERBACH, K. (Re)Defining Gamification: A Process Approach. In: SPAGNOLLI, A.; CHITTARO, L.; GAMBERINI, L. (Ed.). **Persuasive Technology: 9th International Conference, PERSUASIVE 2014, Padua, Italy, May 21-23, 2014. Proceedings**. Cham: Springer International Publishing, 2014. p. 266–272. ISBN 978-3-319-07127-5. Citation on page 46.

WERBACH, K.; HUNTER, D. **For the Win: How Game Thinking Can Revolutionize Your Business**. [S.l.]: Wharton Digital Press, 2012. Citation on page 44.

WHITE, R. W. Motivation reconsidered: The concept of competence. **Psychological Review**, v. 66, n. 5, p. 297–333, 1959. ISSN 1939-1471(Electronic);0033-295X(Print). Citation on page 51.

Wikipedia. Ontology. **Wikipedia, the free encyclopedia**, Dec. 2014. Page Version ID: 638318477. Citation on page 58.

WONG, W.; LIU, W.; BENNAMOUN, M. Ontology Learning from Text: A Look Back and into the Future. **ACM Comput. Surv.**, v. 44, n. 4, p. 20:1–20:36, Sep. 2012. ISSN 0360-0300. Citations on pages 58 and 60.

WOOLF, B.; BURLESON, W.; ARROYO, I.; DRAGON, T.; COOPER, D.; PICARD, R. Affect-aware tutors: Recognising and responding to student affect. **International Journal of Learning Technology**, v. 4, n. 3-4, p. 129–164, Jan. 2009. ISSN 1477-8386. Citation on page 20.

WU, M. **Gamification 101: The Psychology of Motivation**. 2011. Http://community.lithium.com/t5/Science-of-Social-blog/Gamification-101-The-Psychology-of-Motivation/ba-p/21864. Citations on pages 52 and 55.

XU, Y. Literature Review on Web Application Gamification and Analytics. **Honolulu, HI**, p. 11–05, 2011. Citations on pages 52, 53, and 54.

ZOUAQ, A.; NKAMBOU, R. A Survey of Domain Ontology Engineering: Methods and Tools. In: NKAMBOU, R.; BOURDEAU, J.; MIZOGUCHI, R. (Ed.). **Advances in Intelligent Tutoring Systems**. Berlin, Heidelberg: Springer Berlin Heidelberg, 2010. p. 103–119. ISBN 978-3-642-14363-2. Citation on page 22.

ICMC USP
SÃO CARLOS