UNIVERSIDADE DE SÃO PAULO

Instituto de Ciências Matemáticas e de Computação

Gamification design in computer-supported collaborative learning: an approach for tailoring influence principles to player roles

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

SERVIÇO DE PÓS-GRADUAÇÃO DO ICMC-USP

Data de Depósito:

Assinatura: _____

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Gamification design in computer-supported collaborative learning: an approach for tailoring influence principles to player roles

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. *FINAL VERSION*

Concentration Area: Computer Science and Computational Mathematics

Advisor: Prof. Dr. Seiji Isotani

USP – São Carlos
December 2017

Ficha catalográfica elaborada pela Biblioteca Prof. Achille Bassi
e Seção Técnica de Informática, ICMC/USP,
com os dados fornecidos pelo(a) autor(a)

B732g Borges, Simone de Sousa
 Gamification design in computer-supported
collaborative learning: an approach for tailoring
influence principles to player roles / Simone de
Sousa Borges; orientador Seiji Isotani. -- São
Carlos, 2017.
 192 p.

 Tese (Doutorado - Programa de Pós-Graduação em
Ciências de Computação e Matemática Computacional) --
Instituto de Ciências Matemáticas e de Computação,
Universidade de São Paulo, 2017.

 1. Gamificação. 2. Computação Persuasiva. 3.
Aprendizagem Colaborativa com Suporte
Computacional. 4. Formação de Grupos. 5. Sistemas de
Informação. I. Isotani, Seiji, orient. II. Título.

Simone de Sousa Borges

**Design de gamificação em aprendizagem colaborativa com
suporte computacional: uma abordagem para a adaptação
de princípios de influência a papéis de jogadores**

Tese apresentada ao Instituto de Ciências
Matemáticas e de Computação – ICMC-USP,
como parte dos requisitos para obtenção do título
de Doutora em Ciências – Ciências de Computação e
Matemática Computacional. *VERSÃO REVISADA*

Área de Concentração: Ciências de Computação e
Matemática Computacional

Orientador: Prof. Dr. Seiji Isotani

USP – São Carlos
Dezembro de 2017

In memory of my mother...gone too soon.

ACKNOWLEDGEMENTS

Foremost, I would like to express my deepest gratitude to Vinicius Durelli for your invaluable help and affection. Thank you for being by my side all these years, helping me to improve my English and programming skills, and for reminding me to endure during the dark times. Vinicius also should be thanked for beating most of the hardest bosses in all video games we played together: Zelda, Dark Souls, Far Cry 3, Fallout 4, and others, whenever we had time to spare. I had fun living by your side, traveling together and playing video games, those were amazing times. Thank you, dear. I also would like to thank my sister (Adriana), my nephew (Bruno), and my brother-in-law (Sebastião) for always being there for me, and for always welcoming me with unconditional support and love at their home.

I am thankful to my supervisor Dr. Seiji Isotani for his invaluable feedback and guidance throughout the past years. It is utterly my fault if his high standards are not reflected in this document.

My sincere thanks also goes to Dr. Riichiro Mizoguchi. During my period abroad, I learned a lot from him. Our chats helped me to figure out how I should go about doing research, writing papers, and enjoying life in Japan — And for this I am really in debt. Thank you, *sensei*.

My gratitude also goes to Dr. Mitsuru Ikeda who welcomed me at Ikeda's Lab. I am also thankful to all members of Ikeda's Lab, very special thanks to Raja Suleman, Ikue Osawa, and Pasinee Apisakmontri. I am glad we became friends. I enjoyed spending quality time with you, guys. Also, it goes without saying that all help I received during my period in Japan meant a lot to me.

Very special thanks to my friends and colleagues from Isotani's Lab and LABES, in particular, Helena, Kamila, Raquel, Cida, Fernando Hebler, Armando, Laiza, Rafaela, Diego, and Geiser.

I am also deeply thankful to Dr. Sergio Zorzo for believing in me and influencing my life positively.

For the sake of finishing my Ph.D., I took many friends for granted. Still, they have not given up on me: Bete, Virgínia, Sandro, Vinícius Fidelis, Tiago Lemos, Vinícius Freitas, I miss a lot our Dungeons and Dragons sessions. Rafael Durelli, Patrícia, Diego, and Matheus, thanks for the dinners, movie sessions and chats. Jerônimo, Fernanda, Marcos Assunes, and Antônio Gomes, who were always there with their positive thinking.

My appreciation also goes to all my dear ESL teachers at Virginia International University (VIU), especially to Mrs. Beata McBride for helping me with the final translations of the Br-STPS. I extend my thanks to Rodrigo Fraxino and Leonardo Marques for your help and insights.

This research was made possible by the financial support provided by CNPq (232227/2014-4-SWE), MCT/CNPq (383625/2012-2), and CAPES (DS-50308332/D).

“In the midst of winter, I found there was, within me, an invincible summer.”
(Albert Camus)

ABSTRACT

BORGES, S. DE S. **Gamification design in computer-supported collaborative learning: an approach for tailoring influence principles to player roles.** 2017. 192 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, 2017.

Gamification is a term that refers to the use of game design elements in contexts other than video games. In these contexts, the primary goal of gamification is not playful, but rather to motivate users to perform tasks or change behaviors. It is also the goal of gamification, captivate users and influence them to persist in the use of the gamified system. In recent years, we have witnessed a growing interest in gamification and its application in learning environments, especially online. In learning contexts, motivating students to follow up on teaching tasks is an important role for teachers and intelligent educational systems. However, ill-designed gamification interventions can become a distraction capable of interfering on the teaching-learning process. Despite this, most studies in the area remain focused on the potential benefits of gamification and less on investigating systematized solutions to achieve these benefits. Our contribution to the solution of the problem is based on the use of persuasion profiles that take into account the student's player roles. We conduct systematic mappings of the literature to gather information about gamification in education, and how group formation in collaborative learning environments. As a result, we created two conceptual frameworks. One framework to help understand and classify group formation in the context of computer-supported collaborative learning, and other to support the definition of player roles in collaborative learning environments. Also, in a preliminary study ($N = 481$), we adapted and validated for Brazilian Portuguese speakers a scale to measure users' susceptibility to persuasion. In another study ($N = 149$) we developed a theoretical model to map persuasive strategies and different roles of players to support the elaboration of persuasion profiles. Finally, to verify the feasibility of our model, in another study ($N = 18$) we elaborated prototypes of user interfaces and analyzed the perceived persuasiveness of the interfaces for different players roles and their susceptibility to persuasion. Results show that less motivated students were more likely to accept the suggestions of the prototypes, whereas users with above-average motivation (among observed students) reacted negatively to influence attempts by showing low agreement rates for the requirements of the prototypes. We also observed in the three studies ($N = 648$) that the number of individuals susceptible to the principle of authority were the lowest, compared to the other influence principles. Few research initiatives have been investigating the development of tailored gamified. One of the reasons for such deficiency is the difficulty of creating computational models based on learner's psychological traits (e.g., psychological needs, susceptibility to persuasion, and learner and player roles). However, more worrisome than the ineffectiveness of gamification models based on one-size-fits-all is the risk of designing counterproductive models that could backfire, since the appropriate strategy to

motivate an individual may end up discouraging others. Thus, evidence suggest that gamification design could benefit of influence principles, although tailored solutions should be designed to minimize the risks of selecting counter-tailored and ill-defined persuasive strategies.

Keywords: Gamification, Persuasion Profiling, Influence Principles, Persuasive Technology, Group Formation.

RESUMO

BORGES, S. DE S. **Design de gamificação em aprendizagem colaborativa com suporte computacional: uma abordagem para a adaptação de princípios de influência a papéis de jogadores.** 2017. 192 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, 2017.

Gamificação é um termo que se refere ao uso de elementos do projeto de jogos em contextos que não são jogos. Nestes contextos, o objetivo primário da gamificação não é lúdico, mas sim o de motivar os usuários a realizarem tarefas ou alterarem comportamentos. Também é objetivo da *gamificação*, cativar usuários e influenciá-los a persistirem na utilização do sistema *gamificado*. Nos últimos anos, testemunhamos um crescente interesse em gamificação e sua aplicação em ambientes de aprendizagem, especialmente online. No contexto da aprendizagem, motivar os estudantes a dar seguimento as tarefas pedagógicas é um papel importante dos professores e dos ambientes educacionais inteligentes. Por essa razão, as tecnologias persuasivas como a *gamificação* têm sido usadas também em ambientes de aprendizagem colaborativa para aumentar o engajamento dos estudantes e para reduzir o sentimento de obrigação na execução de tarefas pedagógicas. Contudo, quando mal utilizada, a gamificação pode se tornar uma distração capaz de interferir no processo de ensino-aprendizagem. Entretanto, a maioria dos estudos na área continuam focados nos potenciais benefícios da gamificação e menos em investigar soluções sistematizadas para se atingir os benefícios. Nossa contribuição para a solução do problema é baseada no uso de perfis de persuasão que levam em consideração o papel de jogador do estudante. Nós conduzimos mapeamentos sistemáticos da literatura para obter informação sobre *gamificação* em educação e como são formados grupos de estudantes em ambientes de aprendizagem colaborativa. Como resultado nós criamos dois arcabouços conceituais. Um arcabouço para ajudar a compreender e classificar a formação de grupos no contexto da aprendizagem colaborativa com suporte computacional, e outro para apoiar a definição de papéis de jogadores em ambientes colaborativos. Em um estudo preliminar (N=481), adaptamos e validamos para o português brasileiro uma escala para medir a susceptibilidade à persuasão dos usuários. Em outro estudo (N=149) desenvolvemos um modelo teórico para mapear estratégias persuasivas e diferentes papéis de jogadores para apoiar a elaboração de perfis de persuasão. Para verificar a viabilidade de nosso modelo, em outro estudo (N=18) elaboramos protótipos de interfaces do usuário. Analisamos a capacidade de influenciar das interfaces comparando papéis de jogadores e susceptibilidade a princípios de influência. Os resultados mostram que os estudantes menos motivados eram mais susceptíveis a aceitar as sugestões do protótipo, enquanto usuários com índices de motivação acima da média (dentre estudantes observados), tendiam a reagir negativamente às tentativas de influenciá-los, apresentando índices menores de concordância para com as solicitações do protótipo gamificado. Observamos ainda nos três estudos conduzidos (N=648), comparado aos outros princípios de influência, o número

de indivíduos suscetíveis ao princípio de autoridade eram os menores. Poucas iniciativas de pesquisa vêm investigando como desenvolver sistemas de gamificados que se adaptam aos papéis de jogadores. Parte desta deficiência pode ser explicada devido à complexidade no projeto e desenvolvimento destes sistemas. Entretanto como evidenciado, além da ineficácia dos modelos de gamificação baseados em uma solução para todos, o maior risco observado está no uso de modelos contraproducentes, uma vez que a estratégia apropriada para motivar um indivíduo, pode acabar desmotivando outros (*backfire effect*).

Palavras-chave: Gamificação, Perfil Persuasivo, Princípios de Influência, Tecnologia Persuasiva, Formação de Grupos.

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LIST OF ABBREVIATIONS AND ACRONYMS

CFI	Comparative Fit Index
CI	Confidence Interval
CL	Collaborative learning
CSCL	Computer-Supported Collaborative Learning
DGD1	Demographic Game Design model 1
DGD2	Demographic Game Design model 2
ES	Effect Size
ESL	English as a Second Language
FA	Factor Analysis
GDE	Game design elements
GUI	Graphical User Interface
HCI	Human-Computer Interaction
IPO	Input-Process-Output
KMO	Kaiser-Meyer-Olkin
LMS	Learning management system
MMORPG	Massively Multiplayer Online Role-Playing Games
MOOC	Massive Open Online Course
MUD	Multi-User Dungeon
PA	Parallel Analysis
PCA	Principal Component Analysis
PLS	Partial Least Square
PT	Persuasive technology
RMSEA	Root Mean Square Error of Approximation
SDT	Self-Determination Theory
SEM	Structural Equation Modeling
SRMS	Standardized Root Mean Square Residual
StP-II	Individual Susceptibility to Persuasion II
STPS	Susceptibility to Persuasion Scale
TLI	Tucker-Lewis fit index

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INTRODUCTION

1.1 Context

Collaborative learning (CL) has been around for quite some time, but in the last decade it gained prominence because of advances in computer technology (e.g., popularization of laptops, tablets, and smartphones) and the widespread use of Internet-based educational tools (e.g., Learning management system (LMS) and Massive Open Online Course (MOOC)) (SOLLER *et al.*, 2005). These advances have set the stage for Computer-Supported Collaborative Learning (CSCL), which is a pedagogical strategy where individuals study in groups, and knowledge is constructed through discussions, argumentation, exchange of ideas, conflict resolution, and so on (STAHL; KOSCHMANN; SUTHERS, 2006).

The feasibility of CSCL demands a deep understanding of many concepts (ISOTANI *et al.*, 2009a) and the orchestration of several stages (KOBBE *et al.*, 2007), among them we can highlight *group formation*. Group formation is an umbrella term that covers several strategies, algorithms, techniques, and methods to cluster individuals according to several constraint (i.e., criteria) (CRUZ; ISOTANI, 2014a). Constraint-based group formation aims the creation of optimal learning groups (i.e., effectiveness), the idea is that when groups are created randomly or without careful considerations, CL may provoke inefficient interactions that might compromise the learning process (KOBBE *et al.*, 2007; ISOTANI *et al.*, 2009a).

However, as pointed out by Dillenbourg (2002), there are situations in which such level of control may interfere, at least to some degree, with students' motivation. Despite this, the interplay of motivation and cognition when students undertake collaborative group work is a research area that has not been fully investigated (MURPHY, 2005; ROBERTS; MCINNERNEY, 2007; SHIMAZOE; ALDRICH, 2010; SMITH *et al.*, 2011; SEIDEL; TANNER, 2013; BOVILL; FELTEN; COOK-SATHER, 2014; CHAMBLISS; TAKACS, 2014; YUSOP; BASAR, 2016). To solve this problem, among other solutions, researchers and practitioners have been investigating

how gamification-based approaches can be used as persuasive tools to motivate and engage students in learning scenarios (KAPP, 2012; HAMARI; KOIVISTO; SARSA, 2014a; KNUTAS *et al.*, 2014; CHALLCO *et al.*, 2016a; BORGES *et al.*, 2016a).

Persuasive technology (PT) is a broad term used to refer to software and devices intentionally designed to influence people by shaping or reinforcing some desirable behaviors or attitudes towards an action or issue, without using coercion or deception (FOGG, 2002). Persuasive technology has been around for twenty years (FOGG; NASS, 1997) and over this time, several prominent persuasive-based approaches were proposed (HAMARI; KOIVISTO; PAKKANEN, 2014). Currently, there is a growing interest on gamification-based persuasive technology or, gamification¹, as well as its applications and implications (HAMARI; KOIVISTO; SARSA, 2014b). The term *Gamification* refers to the use of game design elements in non-game contexts in order to motivate, persuade, and engage people towards adopting or changing attitudes e/or behaviors (DETERDING *et al.*, 2011; HAMARI; KOIVISTO; PAKKANEN, 2014).

Inspired mainly by successful uses of gamification in other domains (DOMÍNGUEZ *et al.*, 2013), there has been a growing interest in applying gamification to education (BORGES *et al.*, 2014). For instance, Khan Academy (2017) have been helping students to learn math and other subjects. Meu Tutor (2017) is an adaptive platform that helps students to prepare for college entrance exams. Duolingo is a well known free language platform (SETTLES; MEEDER, 2016). Codecademy (2017), Ruby Warrior (2017) and Code.org (2017) are few examples of gamification-based platforms that teach how to program software.

Research has shown that motivation plays a fundamental role in education (RYAN, 2012). Still, in *group formation* approaches, few efforts have tried to combine knowledge of design, technology and social science to improve learner's motivation and, eventually, learning outcomes. One of the reasons for such deficiency is the difficulty of creating computational models of learner's psychological aspects (i.e., motivation, sensibility to persuasion, learner-player roles) to support the creation of more efficient gamification-based persuasive strategies and personalize them to different player types.

1.2 Problem Delimitation

There is a large amount of research on motivation and learning coming from different background; all demonstrating that motivation plays a vital role for individual learning (BORGES *et al.*, 2016a). However, in the case of CSCL, learning is a more complex process (SCHOOR; BANNERT, 2011). As pointed out by Barkley, Major and Cross (2014), the engagement of the students is a product of their *motivation* and active learning; and if either element is not present, engagement will not occur. In addition, the type and the level of motivation the learners experience in a learning session is highly affected by the social environment in which one they

¹ In this thesis we adopt the term *gamification*.

are embedded (RYAN, 2012). Thus, in a social learning situation, the motivation of the learners will be optimal if the environment supports their basic psychological needs for competence, autonomy and relatedness (RYAN; DECI, 2000b).

For instance, Järvelä, Hurme and Järvenoja (2010) investigated how personal incompatibilities and not fulfilled expectations can lead to negative social experiences and demotivation when the need for relatedness is not satisfied. Also in Schoor and Bannert (2011), they raised some concerns regards trying to manipulate students' motivation. In this study, students' competence was evaluated (if appropriate) after completing specific collaborative tasks. The exploratory analyses presented evidence that the act of given an appraisal to the partner who performed best might have played an unexpected role. Learners who appraised their more successful partner have an increase in their rates of free-ride behavior. The authors assumed that the free-ride effect indicates that part of the participants lost their motivation (i.e., need for competence was not satisfied) after comparing their performance with the more successful partner. In Patall, Cooper and Robinson (2008), a meta-analysis of 41 studies investigated the effects of having choice (related to need for autonomy) and possible intrinsic motivation outcomes. These studies investigated both children and adults samples in different environments. The meta-analysis shows evidence that backs up the idea that enabling learners to choose from different learning alternatives enhanced their intrinsic motivation.

Despite the importance, the role of motivation in group formation is a research area that has not been fully investigated (MURPHY, 2005; ROBERTS; MCINNERNEY, 2007; SHIMAZOE; ALDRICH, 2010; SMITH *et al.*, 2011; SEIDEL; TANNER, 2013; BOVILL; FELTEN; COOK-SATHER, 2014; CHAMBLISS; TAKACS, 2014; YUSOP; BASAR, 2016). Currently, most group formation strategies found in the literature are focused on learner's cognitive dimension (i.e., performing collaborative learning tasks) and social interactions (i.e., only in service of scaffolding the cognitive process); while the psychological dimension (i.e., motivational aspects) have been overlooked (DILLENBOURG; JÄRVELÄ; FISCHER, 2009; SCHOOR; BANNERT, 2011; KIRSCHNER *et al.*, 2015).

In CSCL, the use of constraint-base group formation approaches is justified mostly by the evidence that free collaboration might not produces *systematic* learning outcomes (STAHL; KOSCHMANN; SUTHERS, 2006; BARKLEY; MAJOR; CROSS, 2014; ISOTANI *et al.*, 2009a). However, in some situations, the lack of choice when forming groups can negatively influence the basic psychological needs of the learners (i.e., autonomy, relatedness, and competence) (PATALL; COOPER; ROBINSON, 2008; RYAN; DECI, 2000b) therefore impacting their motivation, and as a consequence it might hinder their willingness to join groups (MURPHY, 2005; ROBERTS; MCINNERNEY, 2007; SHIMAZOE; ALDRICH, 2010; SMITH *et al.*, 2011; SEIDEL; TANNER, 2013; BOVILL; FELTEN; COOK-SATHER, 2014; CHAMBLISS; TAKACS, 2014; YUSOP; BASAR, 2016).

Overall, although constraint-based GF strategies are not perfect, the learning gains shown by decades of research on the field (BLUMENFELD; KEMPLER; KRAJCIK, 2006) are strong enough to justify its use. However, there are situations in which optimal learning outcomes might not be achieved without fulfilling learners' need satisfaction (GAGNÉ, 2003; BLUMENFELD; KEMPLER; KRAJCIK, 2006; GIESBERS *et al.*, 2013; NOPONEN, 2016).

This research suggests that gamification is one kind of persuasive technology that can capitalize on constraint-based group formation to positively influence learner's need satisfaction, thus influencing their willingness to join online CL groups. We followed the threefold formula proposed by Booth, Colomb and Williams (2008) to flesh out the scope of this research:

- **Research Problem:** Group formation when imposed might negatively influence need satisfaction of the learners, therefore impacting their willingness to join groups.
- **Research Questions (RQs):**
 - **RQ1:** How can gamification be harnessed to increase its efficacy at motivating individuals to join constraint-based groups in CSCL?
 - **RQ2:** Is there value in tailoring gamification to harness willingness to join groups?
- **Potential Contributions:** We are interested in understanding how gamification can be harnessed by influence principles to improve group formation. We conjecture that gamification initiatives that are currently designed by heavily relying on *one-size-fits-all* approach should rather be personalized. In other words, this research can be seen as an initial foray into understanding how the interplay between the appeal of game elements and the persuasive power of Cialdini's six influence principles (CIALDINI, 1993) can be explored for educational software design purposes. Therefore, the conceptual consequences (BOOTH; COLOMB; WILLIAMS, 2008) of this investigation will help researchers and practitioners to gain a more deep understanding of which influence principles can be combined with which game elements for the purpose of harnessing gamification techniques. For many researchers and practitioners, these expertise are not always effortlessly or undoubtedly accessible. Given that, we set out to investigate data gathered about the relationships between influence principles and video game player types (described in the following sections), the resulting model can be seen as a practical consequence (BOOTH; COLOMB; WILLIAMS, 2008) of this research.

1.3 Motivation, Objective and Rationale

Gamification can be an effective persuasive tool for motivating learners, and lately we have witnessed a growing interest in gamification-based persuasive technology. However,

the design and implementation of persuasive (learning) technology are complex tasks since it is hard to estimate the effectiveness of those strategies regarding each learner (GRAM-HANSEN; SCHÄRFE; DINESEN, 2012; ZULKIFLI *et al.*, 2013). For instance, many efforts of the research community have shown the weakness of *one-size-fits-all* approach to tackle motivation in persuasive technology. Moreover, they also have observed that choosing the wrong persuasive strategy could be worse than adopting one-size-fits-all solutions since the appropriate motivator for one individual might dissuade another one (ORJI; VASSILEVA; MANDRYK, 2014; KAPTEIN *et al.*, 2015) (HAMARI; KOIVISTO; SARSA, 2014b; ORJI; VASSILEVA; MANDRYK, 2014). Thus, there is room for improvement.

As commented by (KAPTEIN *et al.*, 2012), many social psychologists have pointed out that one sound way to improve the effectiveness of persuasive initiatives relies on the design of personalized persuasive strategies, tailored to fit users' personality traits (i.e., susceptibility to influence principles, player types). Nevertheless, most research in the field still focus on the *target benefits* that can be achieved by the use of persuasive technology, and less research have been found on how to tailor persuasive interventions to different users in order to reach such benefits (HAMARI; KOIVISTO; PAKKANEN, 2014; ORJI; VASSILEVA; MANDRYK, 2014; HAMARI; KOIVISTO; SARSA, 2014b; KAPTEIN *et al.*, 2015). The objective of this research is to investigate whether influence principles can support the use of game elements for harnessing learner's susceptibility to persuasion. Towards to this end, this research proposes an approach for tailoring influence principles to game design elements.

Often, the set of resources, methods and techniques employed by designers of persuasive technologies are called *influence principles* or *influence principles*². However, the available array of influence principles, their overlaps, and relationships can be be overwhelming for many designers and practitioners. In this thesis, we are interested in investigating Cialdini's six influence principles. The rationale behind arguing that influence principles provide a sound basis for tailoring gamification is that they can cover a wide range of users' susceptibility to persuasion, and also there is a large body of literature backing up their usefulness (CIALDINI, 1993). Moreover, we can explain the rationale in terms of:

- First, by capitalizing on six influence principles it is possible to simplify the overwhelming number of persuasive strategies available without diminishing the system persuasion strength (KAPTEIN, 2011).
- Second, due to the lack of guidance, many researchers and practitioners rely on one-size-fits-all and design-by-intuition solutions. So, a systematic approach might be desirable (HE; GREENBERG; HUANG, 2010).

² In this thesis we will use these terms in a interchangeable fashion, and when necessary we will make the appropriate distinction.

- Third, a systematic approach can help in understanding *what* and *why* a persuasive approach might worked for one user but not for another (KAPTEIN *et al.*, 2015).
- Fourth, we can minimize the risks of using counter-tailored strategies that might dissuade users instead of motivating them (ORJI; VASSILEVA; MANDRYK, 2014).
- Fifth, it can help avoiding the design of overly complex persuasive interventions (i.e., due to use of several persuasive strategies), thus avoiding to overwhelm users and leading to the negative effects of cognitive overload (KHALED *et al.*, 2007; ORJI; VASSILEVA; MANDRYK, 2014; BORGES *et al.*, 2016b).

As stated, the lack of systematization when designing gamification-based persuasive strategies makes not only the development of persuasive systems a more challenging task, but also can jeopardize the success of the persuasive interventions. Therefore, a key element to aid the design of such systems is the ability to systematically choose the appropriate influence principles that match users' player types, therefore backing up the persuasive strategies and the rationale of the selection of game design elements that will be part of the system.

1.3.1 *Non Objectives*

There are several sensitive issues when investigating persuasive technology and motivation, however it is out of the scope of this thesis to deal with all of them. Specifically, the objectives of this thesis *do not* include the following:

- It is not our intention to judge, validate, compare or create motivational theories;
- To argue that all possible aspects that influence motivation are presented in our model;
- To argue that our interpretation of motivational theories from the persuasive technology perspective are the best or the only one;
- To assure that our persuasive technology strategy and models have the power to affect positively (or negatively) the learning gains. The results obtained by the author of this thesis show not only positive, but also negative effects on perceived persuasiveness (see Chapter 5); however we cannot guarantee that in any environment a persuasive-based strategy to join a group will lead to effective learning.
- In this thesis, we do not aim to propose another list of game design elements. Instead, our goal is to investigate whether tailoring influence principles to player types might harness gamification interventions.

1.4 Conventions Used Throughout this PhD Dissertation

Throughout this PhD dissertation, *Italic* is used for emphasis, introducing new terms, subscripts, and superscripts. Images and tables created by the author does not present source, however the material that were not created by the author are followed by the source of origin.

1.5 Structure of this PhD Dissertation

This document is organized as follows.

Chapter 1: in this chapter, we briefly present the problems being addressed in this thesis, also the objectives and motivation.

Chapter 2: this chapter introduces the necessary background on Persuasive Technology (PT) origins, application domains, Self-Determination Theory, gamification, gamification in education, and Computer-Supported Collaborative Learning. This chapter also presents the results of the literature reviews we performed, and the theoretical frameworks that resulted from these reviews.

Chapter 3: in this chapter we explain the rationale behind our research efforts in translating, adapting, and validating an scale to measure user's susceptibility to persuasive strategies. The design of tailored persuasive profiles relies primarily on measuring user's sensibility to persuasive strategies, thus addressing the challenge of enabling the personalization of persuasive attempts. Secondly, delivering personalized content based on user's profile. Since the design of effective persuasive profiles demands the capacity to measure user's susceptibility to persuasive strategies (i.e. influence principles), as a first step towards tailoring Influence Principles to design gamification-based persuasive systems, we carried out to adapt and validity a Brazilian Portuguese version of the Susceptibility to Persuasion Scale.

Chapter 4: this chapter presents the results of the study towards an approach for tailor influence principles to gamification. It details the modeling process and the results. This study is designed based on the constructs found in the Brazilian Portuguese versions of the (a) susceptibility to persuasion scale, (b) questionnaire for identification of player profiles, (c) basic psychological need satisfaction and frustration scale, and (d) demographic information. We designed a preliminary model capitalizing on player roles and their perceived susceptibility to persuasion.

Chapter 5: this chapter presents the results of the study to test the applicability of our approach to adapt influence principles and game elements to various player roles. We designed several mock-ups prototypes and asked a group of students for feedback on the perceived persuasiveness of each prototype. It also contains the analysis of the results.

Chapter 6: this chapter presents the conclusions and future Work. It summarizes the re-

search, the contributions, discuss the limitations, presents implications of the results, publications and partnerships, and present future directions for this research.

RESEARCH BACKGROUND

This chapter presents the background related to this thesis in two parts. In the first part, I present an overview of Persuasive Technology origins and application domains, Self-Determination Theory (SDT) (RYAN; DECI, 2000b), Gamification and Gamification in Education. In the second part, I comment about Computer-Supported Collaborative Learning with emphasis in the activity of group formation.

2.1 Persuasive Technology Theory

It is believed that persuasion, as a practice, dates back to the beginning of mankind. Persuasion is the process of influencing other people's beliefs, attitudes, intentions, motivations, or behaviors towards some target (e.g., ideas, feelings, actions) (SEITER; GASS, 2004). Previously, mostly research on persuasion were concentrated on humans and how to address effective methods to influence others using communication (e.g., rhetoric). More recently, the advances in computing science have motivated researchers also to investigate the role of technology as a persuasive tool and how to design technology to influence human behavior (FOGG, 2002).

Persuasive Technology ¹ is an approach that intends to change user's attitudes and/or behavior using persuasion (FOGG, 1999). According to Fogg (2002), PT can be defined as "*a computing system, device, or application intentionally designed to change a person's attitudes or behavior in a predetermined way*" without coercion or deception. Despite the debate whether or not technology have always influenced people's life to some extent, research on PT makes a distinction between attitude and/or behavior change as a result of *non-intentional* interactions, and the changes originated from intentionally fully designed persuasive initiatives. PT is based on the endogenous intent of interactive technology (i.e., built-in intent) and not on exogenous one (i.e., intent originated outside the system) (FOGG, 2002). In addition, PT initiatives are not

¹ Captology and Motivation Technology also are denominations found in the literature. In this thesis we adopted the term Persuasive Technology.

based on coercion and deception, since the concept of *persuasion* implies that involved people are acting voluntarily.

Besides intentionality, the use of persuasive strategies must also be planned in terms of the design of the systems (HAMARI; KOIVISTO; PAKKANEN, 2014). This is important because while the intent determines the expected outcomes or changes in behavior or attitude, the persuasive strategy refers to the *usage* and the *user* of the persuasive technology, the message, and how to communicate it (OINAS-KUKKONEN, 2013).

PT have been investigated in several domains, for instance: marketing and e-commerce (KAPTEIN, 2011; KAPTEIN *et al.*, 2012; KAPTEIN *et al.*, 2015), health (ORJI; VASSILEVA; MANDRYK, 2014) and sports (HARJUMAA; SEGERSTÅHL; OINAS-KUKKONEN, 2009), ecological sustainability (FOSTER *et al.*, 2010; CENTIEIRO; aO; DIAS, 2011), and education (LUCERO *et al.*, 2006; GOH; SEET; CHEN, 2012). When looking for scientific theories to backup the design of PT, designers and researchers often focus on social science disciplines, specially psychology (KAPTEIN *et al.*, 2015). There are a huge number of motivation theories in the literature, and many of them have been, at least at some degree, being investigated in the persuasive technology field (FOGG, 2003). It is beyond of the scope of this thesis discuss all of these theories, instead in the next section we will present Self-Determination Theory. SDT is one of the most investigated motivational theory, not only in persuasive technology, but also in several other research fields. SDT is discussed here to help us develop an understanding of users' psychological needs and how gamification can be related to these needs, to persuade and engage users (RYAN; DECI, 2000b).

2.1.1 Self-Determination Theory

Individuals motivation and engagement can be explained by several motivational theories. Here, SDT is commented because has been extensively associated to gamification (DETERDING *et al.*, 2011; BORGES *et al.*, 2014; BORGES *et al.*, 2016a). In general, studies in the area of psychology divide human motivation into two groups: intrinsic motivation and extrinsic motivation. Intrinsic motivation is considered as one that originates within each human being independently of external stimuli, while extrinsic motivation is derived from external factors such as rewards or recognition, for example (RYAN; DECI, 2000b).

In SDT, motivation is stated as a type of construct that compels an individual towards an attitude or behavior (RYAN; DECI, 2000a). It is important to note that motivation alone might not be the only source of influence compelling individuals towards a goal, however it is a vital element in the learning process (DECI *et al.*, 1991), it must be investigated when looking to improve engagement and persuasion in such domain (DETERDING *et al.*, 2011; KAPP, 2012).

SDT seeks to explain how intrinsic and extrinsic motivators influence human behavior and the development of individuals. The three basic psychological needs, considered fundamental

to influence motivation are *autonomy*, *relatedness*, and *competence* (Figure 1). According to (RYAN; DECI, 2000a), by promoting the internalization of these feelings, individuals have the potential to carry out their activities with improved performance, persistence, and creativity, for instance.

- *Autonomy* - It is related to free will and the desire, or absence of, to perform a activity. When activities are carried out by self-interest, perceived autonomy tends to be high. Providing opportunities for choice, using positive feedback, *guiding* instead of *driving*, are good examples of how it is possible to promote autonomy and, as a consequence influence intrinsic motivation of individuals.
- *Relatedness* - It is experienced in social relationships in which one individuals feel connected to others. Feeling connected to other people, engaging in fruitful social interactions, tends to transmit security, making this type of motivation appealing. The integration of online games and social networks are examples of how relatedness (affinity) can work as motivational reinforcement.
- *Competence* - It is related to the need of the individuals in, when facing challenges, to feel capable of surpassing them efficiently. Therefore, providing opportunities to acquire new skills, tests that involve overcoming challenges are examples of activities able to amplify the perception of competence of the individuals and, therefore, influencing their intrinsic motivation.

Figure 1 – Human motivation - basic psychological needs according to Self-Determination Theory

Source: Ryan and Deci (2000b).

The principles of SDT are pertinent to studies also in education since it can help understanding the different manifestations of motivation, for example as a result of the imposition or negative implications in the teaching-learning process. Some Brazilian studies in the area of education have been already investigated how the motivation of teachers and students can

be enhanced based on the principles of SDT (SOBRAL, 2003; GUIMARÃES; BZUNECK; BORUCHOVITCH, 2003). For this reason, considering that gamification have been developed on a fine line between intrinsic and extrinsic motivators, in this work, we are also interested in investigating how game design elements can be used to promote learners' intrinsic motivation.

2.1.2 Gamification

Gamification-Based Persuasive Systems or just Gamification consists of using game design elements in non-game contexts, such as social networks, e-health, e-commerce, and educational systems, to motivate, persuade, and/or engage people towards an attitude or behavior (KAPP, 2012; DETERDING *et al.*, 2011; MARTENS; MÜLLER, 2017).

The techniques and resources used in digital games have elements capable of (i) motivate users, (ii) hold their interest, and (iii) challenge them to solve problems. In gamification approaches, these elements are not the center of the system, instead these elements have the purpose of attract users and motivate them to keeping using the system (DETERDING *et al.*, 2011).

For instance, Foursquare application (Figure 2) is an example of a gamified system. Foursquare is not a game. Foursquare is a location-based social network, which reached 10 billion “check-ins” in 2016 (BLANKFELD, 2017). Foursquare allows users to check-in at venues using a device specific front-end to the application (e.g., mobile website), each check-in might award the user with user-points or “badges”. Despite not being a game, Foursquare has a set of features usually found in games: points, badges, leaderboards, for instance, with the intent to captivate, motivate and keep users interested in the application.

Figure 2 – Foursquare application, from left to right, list of user's check-ins and badges earned

However, simply inserting game elements in a system and hoping for the best will not improve the user experience (KOIVISTO; HAMARI, 2014; ANDRADE; MIZOGUCHI;

ISOTANI, 2016). The same applies to gamification efforts that rely only on distributing points and badges (e.g., *pointfication*, *exploitationware*, shallow gamification) (WALZ; DETERDING, 2014). Therefore, building sound educational systems that capitalize on gamification techniques require careful analysis of the most suitable game design elements that will help to achieve the desired learning outcomes (KAPP, 2012).

Gamification can be an effective persuasive tool for motivating learners, and lately we have witnessed a growing interest in gamified learning systems (BORGES *et al.*, 2014). In intelligent learning environments, persuasive technologies have been used to increase students' engagement and to reduce the feeling of obligation towards executing pedagogical tasks (CHALLCO *et al.*, 2016b). However, as pointed out by Kaptein *et al.* (2015), a reliable use of persuasion strategies involves delivering the right message in a specific way at the precise moment. Despite this, figuring out what a right message is for a student and how to deliver it in a gamified learning system are still difficult tasks.

It is worth to point out that this thesis focus on covering research that explicitly match our definition of Gamification. In Annex A we provide some considerations about terms usually related to research on learning and game/gamification. Therefore, we are not considering research based on game-based learning, playful design, serious games, video games, or other uses of game concepts. In the next sections, we will comment some aspects of game design relevant to this thesis.

2.1.3 Game Design Elements

Game design elements (GDE) is a term used to cover a broad list of game mechanics, dynamics, and aesthetics used in the design and development of games (KAPP, 2012; ZICHERMANN; CUNNINGHAM, 2011). In the gamification process, these elements work as motivational *affordances* to deliver gameful experiences to the users, and as a consequence, trying to influence their behavior (HAMARI; KOIVISTO; SARSA, 2014b). A high-level definition of GDE categories, usually found in the literature, is as it follows:

- **Mechanics:** They define the rules, actions and behaviors allowed in the game, and they are characterized by game components at the level of data representation and algorithms:

Examples: Rules, goals (objectives), levels, number of players.

- **Dynamics:** characterize the run-time behavior of the mechanics reacting on player inputs;
Examples: Feedback, conflict, competition, cooperation, time pressure.

- **Aesthetics:** characterize the interaction with the game system (i.e., input-output and vice versa).

Examples: Sensation, fantasy, narrative, challenge, fellowship, discovery, expression.

As shown in Figure 3, starting from the designer's perspective, the mechanics rise the dynamic system behavior, which in turn produces aesthetic experiences that will be consumed by the player (HUNICKE; LEBLANC; ZUBEK, 2004). However, from the player's perspective, aesthetics set the *tone* of the experience as a direct result of player's reaction to the dynamics, in turn, dynamics are paced by the available mechanics. For this reason it is important to have both perspectives in focus, and neglecting none of them.

Figure 3 – Designers and players have different, but linked, perspectives of the game

Source: Hunicke, Leblanc and Zubek (2004).

To illustrate how game elements can be linked, we will provide an example of scenario using the game element *Challenge*. Challenge is an example of aesthetic element, and it is a powerful one since it poises an obstacle between the player and the reward/victory. For instance, challenge can be created by the dynamic *time pressure*, where the player has limited time to accomplish a task. In turn, time pressure to exist depends of mechanics such as *rules specification* (e.g., how much time does the player have?) and *rules implementation* (e.g., algorithms and data).

As an example of such approach, we can cite the Super Mario Bros[®] game franchise. In many games of the franchise, the character Mario[®] needs to reach the end of the stage before running out of time otherwise the player will fail the challenge (Figure 4). In Figure 5, the same situation applies, challenge based on time pressure, however in a non-game application. The application in question is Duolingo, a well known free language-learning platform. Duolingo is a successful example of how gamification can be skillfully applied to a system (HUYNH; ZUO; IIDA, 2016). In the example, the learner needs to complete a task in an specific amount of time to be rewarded, although the main objective of the application is not the learner's amusement. The main objective of Duolingo is teaching idioms, to do so, it employs diverse and well structured game design elements to keep users motivated and engaged.

GDE have been exhaustedly discussed in the gamification literature (KAPP, 2012; ROBINSON; BELLOTTI, 2013; WERBACH; HUNTER, 2012; ZICHERMANN; LINDER, 2010; ZICHERMANN; CUNNINGHAM, 2011; FERRO; WALZ; GREUTER, 2013). Many researchers have tried to summarize these elements and create a unified taxonomy. However up to this point, there is no consensus about an universal compilation (BORGES *et al.*, 2016a). For this reason, there are several lists, conceptual frameworks, and guidelines with compilations of game design elements in the literature (FERRO; WALZ; GREUTER, 2013). Regardless the

Figure 4 – Usage example of "challenge based on time pressure" in a game

Figure 5 – Usage example of "challenge based on time pressure" in a gamified application

overlaps or parallels found in these lists, they can great differ from one to another making the design and implementation of gamification techniques harder (SAILER *et al.*, 2017).

In this thesis, it is not our intention to propose a new compilation of game elements. Moreover, we will not try to explain the overlaps and relationships between each and all game elements. Instead, we are more interested in investigating how to systematically select game design elements to support the design of persuasive learning systems. And how we can tailor this game elements to users, based on user's susceptibility to influence principles. I will present and comment a compilation of GDE in Chapter 5.

2.1.4 Player Typologies

The concept of player types is based on the assumption that different persons have different reactions given a certain game element (FULLERTON, 2008). One of the first player typologies used in gamification was Bartle's Player Types ². However, since the publication of Bartle's seminal study, several other models have been proposed. In this section an overview of some important typologies in the context of this thesis is provided.

Richard Bartle co-created a text-based game called Multi-User Dungeon (MUD), the ancestor of today's Massively Multiplayer Online Role-Playing Games (MMORPG). He performed some observations in the game environment trying to figure out what players were looking for in the game (i.e., MUD). By analyzing the answers of a questionnaire and from observing players behaviors within the game, he conceived four player psychological portraits in a MUD: Killers, Achievers, Explorers and Socializers (BARTLE, 1996). The taxonomy provided by BARTLE are the foundations of player types research, but it has its limitations. For instance, Bartle's model was constructed using comparisons between scenarios that respondents must choose. As pointed by YEE, if a questionnaire has questions that force the respondent to choose between two scenarios, the answer may represent a dichotomy, and bias may occur towards various outcomes. In addition, as explained by BARTLE, the model was created to fulfill a different purpose and it was never intended to be used in the gamification domain. For instance, BARTLE alert that the model might be incomplete for other domains than MUD's and as a consequence, designers might be "forced" to fit players in some available category (i.e., therefore ignoring their personal traits) or even ignore "non-recognized" players types (i.e., players that do not "fit" any available types) (BARTLE, 2009).

According to (BATEMAN; LOWENHAUPT; NACKE, 2011), the creation of robust and efficient player models need be rooted on trait theory of players preferences. Nevertheless, while research on psychometric typology for personality has a long history, player typology and trait theories of play are still in their infancy. BrainHex is a player satisfaction model build on previous efforts from the Demographic Game Design model 1 (DGD1) and the Demographic Game Design model 2 (DGD2) (NACKE; BATEMAN; MANDRYK, 2014). BrainHex build up on insights from neurobiological findings from these models and presents seven different archetypes of players: Seeker, Survivor, Daredevil, Mastermind, Conqueror, Socialiser, and Achiever. These archetypes are related to typologies such as Myers-Briggs (MYERS; MCCAULLEY; MOST, 1985), and each one characterizes a specific player type. The model was validated using data collected from a survey and comparing the demographic data to different BrainHex archetypes. Using the results of the psychometric orientation of respondents, they established a relationships between personality types and BrainHex archetypes. Data was collected from 50,000 respondents.

The study that originated the seminal typology elaborated by BARTLE was conducted

² Richard Bartle created the model, the so called "Bartle's Player Test" was later implemented by Erwin Andreassen and Brandon Downey (BARTLE, 2009)

in an exploratory fashion, however without the support of more robust statistical analysis (YEE, 2006). In the research conducted by Yee (2006), a compilation of suitable motivations for playing in MMORPGs was created based on the literature (i.e., Bartle's Player Types) and open-ended responses from several surveys. Using this information, a unified Likert-type survey was created. The survey's target audience was MMORPGs players. Data from 3200 respondents was collected and Factor Analysis (FA) was used to investigate the survey answers. At the beginning, 10 factors were extracted, and after performing another analysis of these 10 factors, three main factors were identified: Achievement, Social and Immersion. A summary of these results is shown in Table 1.

Table 1 – Main components of motivations to play in MMORPGs

Main Component	Subcomponent	Factor Loading
Achievement	Advancement	0.85
	Mechanics	0.77
	Competition	0.68
Social	Socializing	0.74
	Relationship	0.62
	Teamwork	0.76
Immersion	Discovery	0.72
	Role-Play	0.70
	Customization	0.66
	Escapism	0.53

Source: Yee (2006).

Motivations to Play (YEE, 2006) has its roots on Bartle's model, but it differs from the original one in many points. The main difference between Yee's and Bartle's models is that instead of four main player types, YEE identified three main motivational components. In addition, these three components are composed of subcomponents. At the end, the model proposed by YEE does not attempt to identify in which archetype one player fits but rather to understand a set of components and how much each component can influence the player. In addition, by identifying the reasons that may arouse motivation to play, by analyzing the results of the scoring system developed, one can also identify what can be deemed less attractive for such an individual.

Building sound educational systems that capitalize on gamification techniques require careful analysis of the most suitable game design elements that will help to achieve the desired learning outcomes. In this sense, the representation of learner *roles*, which rely on sound pedagogical basis, instead of fixed player types is highly desirable (BORGES *et al.*, 2016a), as we will further explain in the next subsection.

2.1.5 From Player Types to Player Roles

As a first step towards these objectives, we set out to create models and a vocabulary to represent learner-player roles interactions in collaborative learning. Nevertheless, it is worth

emphasizing that the vocabulary and player roles presented here are by no means exhaustive. In this section, we present a subset of models we devised as well as the vocabulary gathered and organized to represent learner-player roles interactions in gamified CL contexts.

Currently, to the best of our knowledge, no research effort has proposed a link between player roles to learner roles in CL and gamification. In [Gil, Cantador and Marczewski \(2015\)](#), they present an e-learning environment wherein generic mechanics and player types found in the gamification literature were incorporated. They also investigated the effects of such mechanics into different learning activities aimed to observe the learning effectiveness of the selected mechanics and the relationship between the mechanics and player types. In [Wu \(2015\)](#), a gamified collaborative learning environment was built to foster group collaboration: the authors applied gamification techniques to motivate a group of learners while they performed a task in a collaborative fashion. During this investigation, the authors employed visible progress of task completion as feedback, and in [\(CHALCO *et al.*, 2015\)](#), an ontology to gamify CL scenarios is described, although the focus of the study is the formalization of basic concepts concerned to gamification as a persuasive tool in CL, and the relationship between player roles and suitable learner roles are not taken into account. Furthermore, despite many attempts to unify players' behaviors and, as a result, establish an ultimate taxonomy of players' types, few studies have investigated players' types from the standpoint of educational theories ([HAMARI; KOIVISTO; SARSA, 2014b](#); [BORGES *et al.*, 2014](#)). There is a lack of studies investigating what kind of player role a learner should play to trigger the desired behaviors in gamified CL settings.

Our approach for establishing player roles is based on the Motivations to Play theory ([YEE, 2006](#)). To help us better understand player's needs that drive motivations to play, we rely on Self-determination Theory concepts ([RYAN; DECI, 2000b](#)). We devised our definition of player roles crossing information extracted from (i) motivations to play, (ii) SDT concepts, and (iii) player's types found in the gamification literature. Considering that our main goal was not to come up with a new player typology, we decided to keep things simple, by initially limiting the number of player's types to five. Although this is not an exhaustive set of players, we believe that this granularity can cover a reasonable scope of the most common player types found in the gamification literature, therefore fulfilling the purpose of the definition of our player roles. After this step, we compared the chosen player's types with motivations to play, and psychological needs (extracted from SDT).

As shown in [Figure 6](#), we linked the components Achievement, Social, and Immersion, with the following psychological needs: Competence, Relatedness, and Autonomy, respectively. The component Achievement has the subcomponents: Advancement, Mechanics, and Competition. In order to keep things simple, as shown in [Figure 6](#), some subcomponents and psychological needs were grouped together according to their synergies. We related the subcomponents Advancement and Mechanics to the psychological need Competence. We decided to join them because we consider that they are associated with the player type: Achiever. To support this

decision we checked many player typologies (BATEMAN; LOWENHAUPT; NACKE, 2011; BARTLE, 1996; FERRO, 2016; ORJI; VASSILEVA; MANDRYK, 2014; KIM, 2014) and role definition guidelines (MIZOGUCHI *et al.*, 2007) looking for information that could help us devise appropriate player roles for each subcomponent.

We found, for example, that in the gamification literature, Achievers enjoy not only beating a game but also being the most successful player, accumulating rewards in the process. To do this, achievers strive to understand the game mechanics and/or they scrutinize the game to reach their goals. In other words, the achiever behavior are goal-oriented, and people experiencing this behavior will spend a lot of time to reach their goals. We used the same approach to connect the remaining components, subcomponents, psychological needs and player types.

Figure 6 – Motivations to play X Self-determination Theory X Player types

Motivations to Play [19]		Self-Determination Theory [13]			Player Types [26]
Component	Subcomponent	<i>Psychological needs</i>			<i>Common in the literature</i>
		Competence	Relatedness	Autonomy	
Achievement	Advancement	●			Achiever
	Mechanics	●			
	Competition	●			Killer
Social	Socializing		●		Socializer
	Relationship		●		
	Teamwork		●		
Immersion	Discovery			●	Explorer
	Customization			●	Creator

As seen in Figure 6, both Achievers and Killers belong to the component Achievement, however, while Achievers are more interested in increasing their in-game reputation by completing different tasks, Killers are more interested in tasks that involve besting other people in some sense. In other words, Killers are people-oriented, and they score high in the subcomponent Competition. Killers, in game design literature, are the type of players highly motivated by Competition. They find zero-sum game mechanics appealing (FERRO, 2016; KIM, 2014), so they enjoy rushing and competing against other people. Next, we grouped all social subcomponents in a single player type, Socializer. Socializers are motivated mainly by interacting with people (e.g., being in groups and teams, forming partnerships, and playing collaborative games). Like Killers, Socializers are also people-oriented, however, instead of emphasizing defeating other players, they value socializing, sharing experiences, building relationships, and performing shared tasks. Finally, Explorers are associated with the subcomponent Discovery.

Explorers are system-oriented players, and exploration is mainly what motivates these players: Explorers enjoy investigating the system's ins-and-outs (e.g., hidden or remote places, finding loopholes, knowing the rules that govern a space). Creators were linked to Customization: these players are also system-oriented, but they are more interested in customizing the system

or modifying the virtual world (e.g., backgrounds, fonts, buildings, characters, weapons, and vehicles).

Figure 7 – Player roles investigated in this thesis

Once we gathered all information presented in Figure 6, we devised the five player roles shown in Figure 7 and described in Table 2. Although we borrow all names from the gamification literature, it is important to note that, instead of player types, we are looking for the creation of a set of player roles. According to (MIZOGUCHI *et al.*, 2007), although there is no consensus about the definition of roles, it is possible to assume that a role is an entity that is played by another entity in a context. In this sense, *context* can be understood as something as a whole, including a relation in which the former *entity* is defined.

Table 2 – Player roles description

Player Role	Description
Achiever (goal-oriented)	They enjoy not only completing a game, but also being the best winner, accumulating all rewards the game can offer. They are motivated by receiving glory (points, titles, medals, trophies, achievements); gathering (virtual currency and goods); and collecting rare or all in-game items (equipment, weapons, armor, vehicles, mounts, pets).
Conqueror (people-oriented)	They enjoy rushing and competing against other people. Usually, they enjoy testing their skills and seeing how they stack up against other people. They find external ranking systems and zero-sum game mechanics appealing.
Humanist (people-oriented)	They enjoy socializing with people (e.g., being part of groups and teams, forming partnerships, and playing collaborative games). They value socializing, sharing learning, and relationship building via shared tasks.
Explorer (system-oriented)	They enjoy exploring the system by discovering the ins-and-outs (e.g., hidden or remote places, finding loopholes, knowing the rules that govern a space).
Creator (system-oriented)	They enjoy customizing the system (e.g., backgrounds, fonts, buildings, characters, armor, weapons, and vehicles).

Moreover, considering that these player roles are meant to be used in educational environments, we carefully chose these labels, among several labels found in the literature, to avoid possible negative connotations (e.g. killer, exploiter). As pointed by Kim (2014) and Heeter *et al.* (2009), to avoid the externalization of bad and/or undesirably behaviors, it is important not to provide the system with the kind of game design element that can lead to harmful behavior. As an

example, Blizzard's electronic card game Hearthstone[®] does not allow players to chat with each other³. There are pre-selected emotes that can vary slightly depending on the character. However, there is no way to send your custom text message to your opponent. The company recognizes the huge trade-offs involved in such decision, however, since the game can be very competitive, they stated that this was the right decision to keep Hearthstone[®] fun, safe, and appealing to most players (KUCHERA, 2017). By substituting the chat system to pre-selected emotes, Blizzard tailored their game in order to restrain inappropriate vocabulary and harassment.

Nevertheless, although one can argue that since the research focus is on collaborative learning activities, why players such as Achiever and Conqueror should be considered given that their specific nature is not collaborative at all. The answer is that it all depends on the context. The structure of the interaction between players is a choice to be decided early in any game project (or gamified project). Although the most well-known interaction pattern is the player-vs-player, there are other patterns to be considered (FULLERTON, 2008). Multiple Individual Players vs. Game, and Cooperative Play patterns for example (Figure 8), can be used to pose challenges to the users while working against the system in a collaborative fashion (e.g., tasks related to time limit or tasks that have to be performed against an Artificial Intelligence).

Figure 8 – Player Interaction Patterns

Source: Fullerton (2008).

2.1.6 Gamification Applied to Education

Students motivation can play a vital role in students academic performance and achievements since it can influence the amount of effort and time spent in learning activities (LINEHAN *et al.*, 2011). So, there is a growing interest in gamification as well as its applications and implica-

³ The chat system now is available, however only for players that have added each other to their respective friend lists.

tions in the field of education. This growing interest is mainly due to the potential of gamification techniques to motivate students during the process of learning (BORGES *et al.*, 2014). However, gamification has been used in education with mixed results (BERKLING; THOMAS, 2013; HAMARI; KOIVISTO; SARSA, 2014a; MEKLER *et al.*, 2015; LIEBEROTH, 2015; DICHEV; DICHEVA, 2017). Some empirical findings indicate that gamification can increase motivation and engagement in students; other findings highlight that gamification can be a distraction to students; and therefore it may end up hindering learning.

We carried out a systematic mapping study of research into gamification applied to education trying to identify studies covering and classifying the types of research being published and the most investigated topics in the area (BORGES *et al.*, 2014). At first, we ran some searches using a combination of candidate keywords. These trial searches combined the keyword *gamification* with some synonyms related to *education* and *learning*. No limit of publication date was used (i.e., data range). Even though, due to the small number of papers returned from the resulting strings, we decided that only the keyword *gamification* should be used. Later, by applying predefined inclusion criteria, we manually selected only research in the education field. These decisions allowed us to analyze a greater number of papers, lowering the odds of leaving relevant studies out of our final set. Using gamification as keyword, we performed searches on electronic databases that are known to cover relevant scientific journals and articles from a wide variety of domains such as Computer Science, Education and Educational Research, Science, Engineering, Medicine and Psychology. Initially, we retrieved 357 primary papers. However, only 48 candidate papers were obtained after applying the inclusion and exclusion criteria based upon title and abstract. Finally, after going over introductions and conclusions, we ended up with a final set of 26 primary papers as shown in Table 3.

Table 3 – Papers retrieved from each electronic database, total of candidate studies, and the final set .

Eletronic Database	Number
ACM Digital Library	144
IEEE Xplore	31
Elsevier (via Science Direct)	32
Springer	55
SCOPUS	95
TOTAL	357
Candidates	48
Final set	26

2.1.6.1 Discussion

In this section we analyze the results of our mapping study. The purpose of this section is to give an overview of how gamification has been used to support education. The information

drawn from the selected primary studies is also used to answer our mapping study's research questions. To answer our first question (i.e., in what educational contexts and levels have gamification been most investigated?) we analyzed the primary studies and categorized them according to the target audience (Table 4). In Table 4 we can observe that most primary studies present gamification approaches tailored towards supporting higher education students (46%). we can conclude that the answer to RQ1 is that gamification has been mostly applied in approaches to teaching students in higher education. On the other hand, among the selected primary studies, elementary education is the stage of education drawing less attention: only two primary studies, which accounts for only 8% of the selected studies, discuss gamification-based approaches for teaching elementary students. As for the other studies, six primary studies (23%) describe the benefits and shortcomings of gamification-based models and educational strategies. These six studies, however, fail to position themselves in "the big picture". In other words, the authors do not mention in which educational level (e.g., elementary or higher education) their approaches should be incorporated so that one can best grasp the benefits of such approaches in particular educational contexts. In fact, none of these six primary studies mention whether or not gamification can be applied in educational level curricula.

Table 4 – Primary studies categorized according to target audience or subject matter

Target audience	Number	Frequency(%)
Higher Education	12	46.15%
Non-specific context/level	6	23.08%
Training and Tutorials	3	11.54%
Languages	2	7.69%
Elementary Education	2	7.69%
Lifelong Education	1	3.85%

The other studies either discuss or propose using gamification models with the following purposes: training and tutorials (12%), teaching and learning languages (8%), and supporting students tackling lifelong education projects (1%). It is worth mentioning that none of the selected studies described gamification approaches whose target audience is preschool, high school, or disabled students. There has been a recent growing interest in research on developing e-learning environments that are equipped with gamification elements and techniques. Table 5 presents the primary studies clustered by date of publication. Although the first publications appeared only in 2011, the number of studies on gamification more than doubled from 2011 to 2012. As for 2013, taking into account only January and February, the months during which this study was carried out, three studies had already been published. It is important to note that several articles related to gamification have been published before 2011. Nevertheless, most of them were not related to education and none of them met the inclusion/exclusion criteria defined in our study. This result reveals that gamification applied to education is becoming a new research trend with room for new findings and improvements. To proper understand the impact

³ Further Education in Great Britain.

(positive or negative) and implications of using gamification in educational contexts there is a need for more research and empirical data.

Table 5 – Overview of the distribution of the selected studies throughout the years

Year	Quantity	Frequency (%)
2011	7	27
2012	16	62
2013	3	12

Most primary studies were published by either ACM DL (ACM Digital Library) or Springer, as shown in Table 6. The electronic databases, Elsevier (ScienceDirect) and IEEE (IEEE Xplore) had five and three selected studies, respectively. We also searched through Scopus, however, given that it was the last electronic database to be examined, most primary studies it indexes had already been selected from one of the aforementioned electronic databases. Four studies were selected from Scopus; these studies had not been returned by the other electronic databases.

Table 6 – Distribution of the primary studies according to electronic database

Electronic Database	Number	Frequency (%)
ACM Digital Library	7	27%
Springer	7	27%
Elsevier	5	19%
Scopus	4	15%
IEEE Xplore	3	12%

By analyzing where the primary studies were published, we found that there is no specific venue whose purpose is to bring together research on gamification applied to education. The most notable publication forums according to the number of selected primary studies are the following: the American Society for Engineering Education Annual Conference (ASEE) (two studies were published in 2012) and the ACM e-Learn Magazine (two studies as well). Furthermore, three primary studies were book chapters from the book *Serious Games and Edutainment Applications* published in 2011 by Springer. Regarding the publication types, we have selected studies that have been published in journals, magazines, conferences, workshops, symposia, and books.

Table 7 gives an overview of the primary studies distributed according to publication type. As shown in Table 7, most selected studies are conference publications. Journal publications are the second most common publication type. It is worth mentioning that most of these journals have a multidisciplinary scope.

Primary studies frequently use the term *motivation* to justify the research in question or the main reason behind investigating gamification. Nevertheless, after an in-depth analysis of

Table 7 – Primary studies organized by publication type

Publication Type	Number	Frequency (%)
Conference	11	44%
Journal	7	28%
Book Chapter	3	12%
Periodical	2	8%
Symposium	1	4%
Workshop	1	4%

these studies, we found that several objectives fall under the term motivation. we were able to identify seven different objectives:

- **Behavioral change** - fostering changes of behavior by rewarding adequate actions and penalizing unsatisfactory ones; Socialization: allowing for both socialization mechanisms and group learning;
- **Mastering skills** - improving certain abilities of the students;
- **Challenging** - proposing challenges that give extra meaning to the learning process;
- **Engagement** - engaging students in learning activities that are more interesting and easier to follow;
- **Improving learning** - maximizing the acquisition of knowledge;
- **Guidelines** - discussing the benefits of gamification as a means to motivate students and deal with some of the learning process problems.

Our results demonstrate that there are some overlaps between these seven classification categories. Apart from identifying the objectives of the primary studies, it is also important to characterize the type of research that was carried out and reported in these studies. Towards this end, we applied the classification proposed in . Such a classification comprises the following research types:

- **Validation Research** - studies that fall into this category describe a novel technique, approach, or strategy that has not been implemented in practice, but whose effectiveness has been evaluated to some degree through laboratory studies.
- **Evaluation Research** - this category contains studies that empirically evaluate a technique, approach, or strategy in practice or real settings.
- **Position Papers** - these studies report the authors' point of view. Research in this category does not contain evidence that backs up the authors' opinion.

- **Philosophical Papers** - studies in this category are similar to position papers, however, they shed light on new ways through which educational approaches can benefit from gamification.
- **Solution Proposals** - studies that describe a solution technique, approach, or strategy and argue for its usefulness, such a solution is either novel or extends an existing approach; studies in this category usually present examples and good line of argumentation (but not strong empirical data).
- **Experience papers** - these studies are concerned with reporting the author's experience during the implantation of a new approach.

Rather than plotting frequency tables to illustrate the distribution of the studies according to research type and objectives, we decided to generate a bubble plot (Figure 9), but the primary studies summarized in Figure 9 are also shown in Table 7. The resulting bubble plot is intended to be seen as a map of research on gamification used in conjunction with education. A bubble plot has two x-y scatter plots containing bubbles in category intersections. The size of these bubbles is determined by the amount of primary studies that have been classified in the pair of categories in question.

Such a visual summary gives an overview that enables researchers to pinpoint categories that have been drawing most attention as well as the ones that have not been much investigated. Therefore, by analyzing such a map it is possible to identify gaps and opportunities for future research. The bubble plot generated from our selected studies is shown in Figure 9. By analyzing Figure 9, we can identify that the research objective of most studies is to evaluate (Evaluation) the engagement (Engage) of the students through gamification (13 studies). It is also possible to identify that there are no studies on Experience or Validation, which answers **RQ2** (*What types of studies have been most investigated in gamification and education?*). This indicates there is a lack of validation research that helps to propose novel techniques/methods and test them in well-thought-out controlled laboratory experiments. Similarly, it is necessary for more research to be done with the help of end users, i.e. teachers, to report personal experiences regarding the application and implications of using gamification in learning environments. Appendix C synthesizes the frequency of primary studies according to research objective. A complete list of the final subset is provided.

A Venn diagram was drawn to clarify the distribution of the overlapping studies (Figure 3). For simplicity's sake, we decided to include only four categories in the diagram. As shown in the diagram, 9 papers overlap 4 research objectives. Some studies encompass only two or three research objectives: (i) engagement and behavioral change; (ii) socialization and engagement; and (iii) improving learning, behavioral change, and engagement. This suggests that motivating students is not a straightforward task that can be accomplished by employing only one strategy.

Figure 9 – Map containing the distribution of gamification research by study type (x axis) and research objectives (y axis)

However, the amount of studies that employ the four main research objectives indicates that researchers have been striving to come up with more sound solutions to motivate students.

Figure 10 – Overview of the four categories with the highest number of papers and the overlap among them

Only one study mentions that computer-supported collaborative learning (CSCL) is suited to develop applications that help students to socialize and organize themselves in groups. However, this study does not cover how to undertake the integration of computer-supported collaborative learning, gamification, and educational approaches. Therefore, the answer to RQ3 (What gamification approaches have been most investigated in the field of CSCL?) is that there is a lack of approaches that combine gamification and computer-supported collaborative learning.

Figure 11 – Distribution of gamification research by study type and research objectives

	Behavioral Change (19)	Challenging (4)	Engagement (24)	Improving Learning (19)	Mastering Skills (13)	Guidelines (2)	Socialization (13)
Evaluation	[2] [4] [9] [14] [18] [32] [33] [34]	[6] [9] [10] [33]	[2] [3] [4] [6] [9] [10] [14] [18] [20] [21] [32] [33] [34]	[2] [3] [4] [6] [10] [14] [18] [21] [32] [34]	[6] [9] [10] [14] [20] [21] [32] [33]		[2] [9] [18] [20] [32] [34]
Experience							
Opinion	[8]		[8]	[8]			[8]
Philosophical	[1] [7] [11] [23]		[1] [7] [11] [23]	[1] [7] [11] [23]			[1] [7] [11] [23]
Solution	[13] [15] [25] [29] [31] [35]		[13] [15] [25] [29] [31] [35]	[15] [25] [29] [35]	[15]	[17] [28]	[13] [31]
Validation							

2.1.6.2 Threats to Validity

In order to ensure an unbiased selection process, the Research Questions, inclusion criteria, and exclusion criteria were established before the conduction of the systematic mapping. Furthermore, the selection process was carried out in an independent fashion by each involved author. To mitigate any selection bias and improve validity, the inclusion or exclusion of controversial studies was jointly decided. Nevertheless, we cannot rule out threats from a quality assessment perspective because during the selection process no scores were assigned to studies.

Another threat to validity consists of whether we selected all relevant studies in the area. Although such a threat cannot be ruled out, we tried to mitigate it by taking into account several important search engines. Therefore, we surmise that these search engines are prone to contain the majority of the relevant studies. In the future, we intend to update this scoping study by taking into account more search engines. The coherency of our classification scheme also represents a threat to the validity of this mapping study. As pointed out by (PETERSEN *et al.*, 2008), one of the problems of mappings studies is how to determine the proper way to categorize the resulting studies.

2.1.6.3 Concluding Remarks of the Systematic Mapping

The main purpose of our mapping study is to provide an overview of what has been investigated in the context of gamification applied to education. To fulfill our goal, we followed a systematic methodology, i.e., systematic mapping. We defined three research questions to be answered by our mapping. RQ1: In what educational contexts and levels has gamification been most investigated? RQ2: What types of studies have been most investigated in gamification and education? RQ3: What gamification approaches have been most investigated in the field of CSCL?

According to our results, most studies were published in conferences and have focused on Higher Education (RQ1 – see Table 4) to foster the engagement of students through learning activities that build on gamification concepts (RQ2 – see Figure 11). We also identified that there is a lack of approaches that combine gamification and CSCL (RQ3).

The novelty of this research is that, to the best of our knowledge, this is the first systematic mapping covering research into gamification applied to education. Another contribution of this research is the map (Figure 9) we have created. By analyzing such a map it is possible to identify in which way gamification has been explored in educational contexts; thereby determining research gaps and future research opportunities.

More recently, (i.e., February, 2017), we run a new search using the keyword *gamification*. The purpose was to observe at which extent the number of publications in the field has increased since our first study. Figure 12 shows the results of this search. As one can see, indeed there is a significant increase in the number of publications since 2013.

Figure 12 – Number of papers retrieved using the keyword *gamification* - March, 2017

It is important to say we did not analyze the additional publications returned in this last search, and Figure 12 was included here to illustrate a point of view. The numerical results were included here by way of comparison with the number of results observed in the previous search. So, the reason why we did not update the systematic mapping is due to the high number of returned papers and lack of resource to process them. It will be necessary to review and rewrite the research protocol (e.g., keywords, search string) to include new keywords that will help tuning the results towards research focused in education.

In this section we summarized the main results of our literature review. Using this systematic method it was possible to aggregate and categorize primary studies, creating an overview of the research area in question (PETERSEN *et al.*, 2008). Appendix B contains supplementary information, such as: the rationale that backs up the literature review, statistics performed, and the final set of selected papers.

2.2 Group Formation in Computer-Supported Collaborative Learning

Collaborative learning (CL) has been around for quite some time, but recently it gained prominence because of advances in computer technology (e.g. widespread use of tablets and mobile phones) and the widespread use of Internet-based educational tools (e.g. LMSs and MOOCs). As pointed out by [Stahl, Koschmann and Suthers \(2006\)](#) the Internet has brought up renewed interest in investigating the benefits of computer support when applied to CL. These advances have set the stage for Computer-Supported Collaborative Learning (CSCL), which is a pedagogical strategy where individuals study in groups, and knowledge is gained and constructed through discussion, argumentation, exchange of ideas, conflict resolution, and so on. In such a pedagogical strategy, computers play a key role in supporting the learning process by making feasible the design, orchestration and assessment of group activities in several different contexts and situations ([ROSHELLE; TEASLEY, 1995](#); [STAHL; KOSCHMANN; SUTHERS, 2006](#)).

Many studies have investigated the benefits of CSCL ([DILLENBOURG, 2002](#); [STAHL, 2004](#); [BARKLEY; MAJOR; CROSS, 2014](#); [ISOTANI *et al.*, 2009b](#); [LAURILLARD, 2009](#); [STAHL; KOSCHMANN; SUTHERS, 2006](#)). According to the findings of the community, collaboration has a positive influence on the learning process, mainly when it is well designed and properly introduced. Therefore, a CSCL environment and CL activities should be carefully designed; otherwise there is no guarantee that the learning results will meet students' and teachers' expectations. In this context, group formation plays a fundamental role. It influences how students perceive the environment, interact with peers, use available didactic materials, and take part in learning activities and processes ([DILLENBOURG, 2002](#)).

Group formation in CSCL refers to strategies, algorithms, techniques and methods to cluster individuals according to several criteria with the objective of creating well-thought-out groups that will lead students to better interact with each other and maximize their learning gains. when a group is adequately created, every student brings something relevant to the table, adding improvements to the group learning experience. To proper select students to create effective groups, characteristics such as, knowledge, learning style, performance in previous learning activities, and language barriers, to name a few, have to be considered in hopes of improving learning interactions and benefits ([ISOTANI *et al.*, 2009b](#)).

Although many studies have investigated the benefits of group formation in CSCL, to date there is a few studies that have analyze the achievements of the research published on the topic and categorized them according to their contribution ([CRUZ; ISOTANI, 2014b](#)). For example, to the best of our knowledge, there is no study summarizing the main group formation approaches, the key students characteristics that are taken into account during group formation, educational level in which the approaches are meant to be applied, most common learning activities, and so on.

To fill such a gap and provide an overview of this research area, we carried out a process to systematically review the literature, known as systematic mapping process (DYBÅ; DINGSØYR, 2008). It requires creating a protocol to systematically search and analyze published articles of a given research area. Upon carrying out this systematic mapping, we went through 3571 papers about CSCL, among them, 423 were related to group formation, and only 106 met the criteria for inclusion of articles defined in this study. These 106 papers were selected and categorized according to their contribution. In particular, this work intends to answer the following questions regarding the research on group formation in CSCL: (i) What are the most investigated characteristics of group formation in the domain of CSCL? (ii) At what educational level group formation has been most investigated and applied to? (iii) What research methods have been most used for evaluating the formation of groups? (iv) What are the main venues in which research in this area has been published?

Another contribution of our systematic mapping is that by analyzing its results it is possible to identify the ways in which group formation, when applied in the context of CSCL, has been explored so far. researchers can refer to this systematic mapping to determine research gaps and decide (Figure 13) on future research directions. Moreover, we conceive an *infographic* that summarizes all data presented in this paper, to provide a quick overview of the results presented (Available at: <<http://infografico.caed-lab.com/mapping/gfc/>>).

In this section, we provides a background and a framework to classify and understand the research on group formation. Moreover, we further analyzes the results of our systematic mapping on group formation by describing the most widely investigated topics on group formation and also elaborates on their practical implications. Finally, we cover threats to validity, and concluding remarks of the mapping study. Appendix B presents the rationale and discuss the protocol we followed during the conduction of this systematic mapping.

2.2.1 Framework to Classify and Understand Research on Group Formation

There are several denominations for the act of grouping learners in the context of collaborative learning, such as, group/team composition (Hsu et al. 2008) group/team formation (YANNIBELLI; AMANDI, 2011), grouping students (ALFONSECA *et al.*, 2006), clustering students (CHIU; HSIAO, 2010). Basically, these denominations have the same meaning, as the act of bringing together students in effective learning groups (ISOTANI *et al.*, 2009b). In this work, we adopt the term group formation, which is the most widely term used in the investigated studies.

Although the term "effective" can have different meanings among researchers, in this field is often used as a synonym for the proper allocation of resources to enhance the learning process (ISOTANI *et al.*, 2009b). These resources can be tangible (e.g. learning materials and

Figure 13 – Infographic (Full view available at: <http://infografico.caed-lab.com/mapping/gfc/>)

tools to support collaboration) or intangible (e.g. knowledge and skills to be learned). Most research on group formation have focused on how to allocate these resources based on the learners profiles, on the technologies involved, or on the tasks to be performed (CL techniques, also known as CL best practices) (MAGNISALIS; DEMETRIADIS; KARAKOSTAS, 2011). Using learners' profiles helps instructors adequately deliver custom content to satisfy, not only individual necessities of the learners, but also group's necessities (ALFONSECA *et al.*, 2006; GREER; BULL, 2000; OUNNAS; DAVIS; MILLARD, 2009; BEKELE; MCPHERSON, 2011) while inputs from the environment, can give more information that can help to understand the collaborative context and as a result, to improve grouping quality (MUEHLENBROCK, 2005; VILLASCLARAS-FERNÁNDEZ *et al.*, 2009). Finally, there are other approaches for group formation that relies on using specifications of CL techniques to acquire sufficient information to group the learners (ISOTANI *et al.*, 2009b).

Generally, the formation of groups can be performed randomly (e.g. assigning learners in the groups by chance), self-selected (i.e. the learners choose with whom they want to study), or it can be carried out by an instructor or computing system, based on some criteria (IKEDA; GO; MIZOGUCHI, 1997; ALFONSECA *et al.*, 2006; BEKELE; MCPHERSON, 2011; OUNNAS; DAVIS; MILLARD, 2009; GREER; BULL, 2000). As discussed by (DILLENBOURG; JERMANN, 2007) and (LAURILLARD, 2009), the benefits of collaborative learning arise only when there is a detailed and proper planning of components and collaborative mechanisms. Considering these, many authors have raised concerns regard random selection and self-selected approaches since these approaches can result in unequal participation such as, students in the same group working at a different pace, off-task behavior, or even increasing students' resistance to group work (BARKLEY; MAJOR; CROSS, 2014; DILLENBOURG, 2002; ISOTANI *et al.*, 2009b). Moreover, one way to increase the chances of forming groups more capable to achieve the desired learning goals is assigning learners to groups using approaches based on CL techniques (BARKLEY; MAJOR; CROSS, 2014; DILLENBOURG, 2002). Regardless of the strategy used, the research in the area sought to investigate ways to influence positively the behavior of individuals to form groups where their presence and that of their peers are relevant; that interactions are significant; and to maximize the chances that knowledge construction will occur in more favorable conditions.

As discussed in the previous paragraphs, there are several topics being investigated under the umbrella of group formation research. To better understand the contribution of the community we propose a framework based on our understanding of the field. This framework (Figure 14) is composed of six main categories and their relationships:

1. **Planning:** the formation of groups can either follow a set of criteria (i.e., systematic group formation) or happen randomly (i.e., unsystematic group formation). The criteria define the conditions that govern group formation, and the clustering algorithms determine how students should be selected and grouped together.

2. **Initiative:** we identified two types of initiatives: spontaneous and controlled. Spontaneous group formation uses only the preferences of students to forming groups. This allows for the formation of like-minded groups of students. Controlled group formation, on the other hand, entails putting forward criteria and algorithms aimed at guiding the formation of groups. It might lead to heterogeneous groups in hopes of taking advantage of the resulting diversity of backgrounds as well as enhancing the overall learning experience.
3. **Diversity of population:** Given each particular criterion, the population diversity in a group can be considered either homogeneous (i.e., whose participants have the same or similar trait) or heterogeneous to various degrees (i.e., participants differ from each other in at least one trait), depending on the amount of distinct individuals in the group regard the considered criterion.
4. **Distribution approach:** Despite how many criteria a group formation strategy uses, if students end up distributed either in homogeneous or heterogeneous groups, we named the distribution approach as being Simple. However, when more than one criterion is used, the distribution of students can result in one (or more) criterion used to group the students homogeneously, while another different criterion (or criteria) being used to distribute the students heterogeneously. As a result, these groups can be considered homogeneous and heterogeneous at the same time, given the considered criterion. We named such distribution approach as Hybrid distribution.
5. **Computer-supported:** group formation can be very simple by using only one criterion (e.g. gender) or quite complex (using several criteria and algorithms). it is possible to categorize studies whose group formation approach relies on computational support and studies that report on approaches that do not rely on any sort of automated support for group formation.
6. **Rationale:** studies can also be classified in terms of how they back up their approach for group formation. In this framework we classify three types: studies that do not present any arguments that back up their approaches, studies whose group formation approach is borne out by empirical evidence, and studies that draw on assumptions from pedagogical theories.

The categories are connected in the framework according to the following rationale: in general, the formation of groups is based on information (or lack of information) on the learner profiles. The formation of groups can be planned or being randomly carried out. In the case of being planned, it can be based on grouping any criteria. Several criteria can be used, such as information about the students, students' preferences, or even constraints of the system or environment. When the students decide the clustering process, the initiative is spontaneous. When students do not participate in the selection process, and any other criterion is used to

distribute them in groups, group formation is called controlled. Criteria can be used both to group students with bases in their similarities (homogeneous groups) and/or in their differences (heterogeneous groups). In simple distribution, the groups are mutually exclusive, being either homogeneous or heterogeneous; however, there are hybrid approaches in which groups are, at the same time, homogeneous and heterogeneous. The formation of groups can be done manually, or it can rely, wholly or partially on computational systems. Finally, the rationale provided in the studies allows us to understand whether the study is based on any pedagogical approach or based on empirical evidence; yet it is still possible to find studies which neither one nor another kind of justification for the formation of groups is provided.

Figure 14 gives an overview of our framework that can be used to classify, analyze and understand different types of research on the topic. The categories in the framework are tailored to give an overview of the efforts that have been carried out in the area, support the comprehension of the most investigated topics, and highlight the interacting and overlapping topics. Nevertheless, it is worth emphasizing the categories we came up with are not exhaustive. That is, they do not cover all the dimensions of the research spectrum of group formation in the context of CSCL. For example, the group activities were planned to occur face-to-face or in a distance learning way? The activities will occur synchronously or asynchronously?

In addition, we created three categories not showed in Figure 14. The purpose of these categories is to support gathering information about the way the selected researches have being conducted, and not directly about the group formation process.

- **Educational level** (or learning activities): By analyzing in which in educational contexts group formation has been explored, one can determine research gaps and future research opportunities;
- **Research methods:** This category characterizes the type of research that has been carried out and reported in the studies;
- **Publication type:** As for the publication types, we have selected primary studies that have been published in conferences, journals, and workshops.

2.2.2 Systematic Mapping Results

In this section, we summarize the analyze the results of our systematic mapping. We draw information from the primary studies in order to answer the research questions (RQs) of our mapping study. In Appendix B we provide the complete rationale that backs up our mapping, and also is discussed the protocol we followed during the conduction of this systematic mapping.

Figure 14 – Overview of the framework to classify and understand research on group formation

2.2.2.1 RQ1 - What are the most investigated characteristics of group formation in the domain of CSCL?

The majority of the primary studies (101 out of 106) report on approaches for planned group formation, i.e., the formation of groups is based on pre-established criteria. The most widely used criterion is the level of knowledge of the students, which is used in 46 of the selected studies. Controlled group formation is used in 90 primary studies. In terms of distribution, most primary studies rely on heterogeneous groups: 84 studies propose the formation of heterogeneous groups. Nevertheless, only in 50 out of these 84 studies simple heterogeneous groups are the only possible outcome. According to our results, 82 studies capitalize on some sort of technology to automate and support group formation. Only 37 studies exploit educational or pedagogical theories to justify their rationale for the group formation approach.

2.2.2.2 RQ2 - At what educational level (or learning activities) group formation has been most investigated and applied to?

In order to answer RQ2, we classified the selected studies in terms of their target population. In the context of this paper, target population refers to the stage (or level) at which educational activities take place or the type of educational activities. As shown in Figure 14, the group formation approaches proposed in most studies (56) emphasize tertiary education (viz., undergrad students). Few studies focus on applying group formation approaches to other educational levels (or stages). For instance, our results would seem to suggest that there has been scant research on the impact of group formation when applied to early childhood education (1), graduate students (1), e-Health students (1), language-learning activities (1), primary education students (3), and secondary education students (6). 36 primary studies fail to specify the target population of their proposed approach. Also, these studies present theoretical models that represent solutions that have not been implemented or fully tested yet.

most research on group formation applied to CSCL has been geared towards undergrad students: approximately 52% (56 primary studies) of the studies tackle group formation at this educational stage (level).

2.2.2.3 RQ3 - What type of research is the most common in the field?

The classification proposed in [Wieringa et al. \(2005\)](#) comprises the following research types. Validation Research, studies that fall into this category describe a novel technique, approach, or strategy and have not been implemented in practice, but its effectiveness has been evaluated to some degree through laboratory studies. Evaluation Research, this category contains studies that empirically evaluate a technique, approach, or strategy in practice or real settings. Position Papers, these studies report the authors' point of view. Research in this category does not contain evidence that backs up the authors' opinion. Philosophical Papers, studies that present a new of perceiving things or new guidance for a domain, often using taxonomies and conceptual frameworks. Solution Proposals, Studies in this category are usually not present in-depth validation of the described technical solution but tend to describe a proof of concept by way of example or a sound prototype running. Experience papers, these studies are concerned with reporting the author's experience during the implantation of a new approach. As some selected primary studies did not fit well into the categories above, we extended the classification scheme, by adding a research type category namely Tools. In this category are the studies whose main contribution is the developed tool, often in the form of a research prototype.

After reading the primary studies, we identified four research methods. As indicated in Table 8, the research methods in the primary studies fall into one of the following categories: (i) Solution proposals, (ii) Evaluation, (iii) Opinion, and (iv) Tools. Solution proposals are by far the most common research method, including 77 studies, 17 primary studies are concerned with some evaluation, and only one study falls into the opinion category. Moreover, the main

contribution presented by 11 studies boils down to the implementation of a tool to automate and support group formation, falling into the tools category.

As discussed in the previous section, the research method used in the majority of the primary papers is solution proposal: 77 studies present group formation approaches that can be applied to CSCL environments. Conversely, the least explored category is opinion. Only one study describes the author's view about group formation applied to CSCL environments and the implications thereof.

2.2.2.4 RQ4 - *What are the main venues in which research in this area has been published?*

As shown in Figure 15, most primary studies are indexed in IEEE (IEEE Xplore) and Elsevier (26 and 24 papers, respectively). ACM Digital Library indexes 19 of the selected papers, 14 papers were retrieved from Scopus, and Springer and Web of Knowledge (WoK) had six papers each. The electronic database with the least amount of selected papers was Engineering Village (5 papers). It is worth mentioning that Springer, WoK, and Engineering Village were the last electronic databases we went through; consequently many of the papers returned by these sources had already been retrieved and selected from other databases. Apart from these studies, 6 selected journal papers were retrieved from SciVerse Hub.

Most primary studies were published in journals. Computers & Education is the venue with the highest number of selected studies (10), followed by another journal, Computers in Human Behavior and for the proceedings of the Conference on Innovation and Technology in Computer Science Education (ITiCSE), both with six studies.

2.2.3 Mapping Analysis

Drawing on the information from the primary studies, we identified that group formation usually encompasses three fundamental steps that resemble the Input-Process-Output (IPO) model. In this context, group formation approaches receive information about students as input and then some processing or computation is performed on such information, and the outcome is information on how students should be placed in groups. Basically, these IPO steps can be performed (i) without a computational support (e.g. manually carried out by the instructor), (ii) be partially computerized (e.g. spreadsheets, LMS), or (iii) may be automatically carried out by a computer system.

Moreover, a central topic discussed in some of the primary studies is the strategy used to group students. As mentioned in Section 4, group formation can be carried out in a random fashion (i.e., by chance), or it can be controlled (i.e., criteria-driven group formation). As mentioned, criteria-driven group formation can fall into two categories: spontaneous group formation and controlled group formation. In the former, students are self-assigned to groups, yielding self-selected groups. In the latter, instructors or other agents handle group formation,

resulting in instructor-formed groups. Evidence suggests that the main advantages of spontaneous group formation are related to self-motivation, which often leads to a more positive experience throughout the learning activities. However, since self-selected groups are made of participants that share common interests or get along with each other, the same self-selected groups might be repeatedly formed. A clear shortcoming of this approach is that some individuals might be left out. ostracized students might face difficulties coping with learning activities on their own, leading to unsatisfactory results.

Clearly, the group formation strategy influences the diversity of groups. Random approaches tend to result in heterogeneous groups. Nevertheless, since groups are formed by chance, it is possible that this approach generates single-gender groups or groups whose most elements belong to a given gender. Another problem with random approaches is that they can also form groups of students that have already mastered the subject in question or groups whose students have struggled to grasp the subject. To enforce group member diversity, therefore making the students interacting with a broad range of peers, students can be clustered in groups based on some criteria. The use of criteria adds a much more fine-grained control over group formation. Moreover, using criteria, it is also possible to create hybrid groups. As mentioned, hybrid group formation approaches employ a multitude of criteria to place students in groups that can be homogeneous and heterogeneous at the same time. However, when more criteria are employed; more information needs to be processed: this means that as the number of criteria increases, the need for computational support also becomes more critical. In our systematic mapping, we found that hybrid group formation is proposed along with tools that automate group formation.

Devising effective and theoretically sound group formation approaches is a notoriously complex task. Group formation approaches have to take into account many factors as for instance: (i) students' knowledge, (ii) how students interact with each other, (iii) preferences, needs or limitations of the instructors, environment and students. Given the importance of well-founded group formation approaches, we set out to investigate the rationale behind the approaches proposed in the primary studies. In a way, all primary studies justify the usefulness of their approaches. Some studies, however, fail to describe the theories, concepts, and ideas that underpin their group formation approach. This can be a worrisome finding since, according to the impossibility of justifying either theoretically or pedagogically the selection of participants to compose a group is one of the main weaknesses of the available methods, and a strong reason for teachers' hesitation in adopting systems with group formation capabilities.

Finally, in order to clarify the classification scheme elaborated; we analyzed the group formation approach found in [Moreno, Ovalle and Vicari \(2012\)](#), as follows. In Figure 15, the results of the analysis using such classification scheme are synthesized. Colored boxes indicate the classification path.

- Planning - The paper aims in proposing a systematic criteria-based method for group formation that relies on genetic algorithms to process three characteristics of the students: student knowledge levels, student communicative skills, and an estimate of student leadership skills.
- Initiative - The system is in charge of clustering the students based on the chosen criteria.
- Population diversity – The criteria are used to form both, homogeneous and heterogeneous groups.
- Distribution approach – A hybrid approach is used since the authors main goal is to achieve groups that are as similar as possible (homogeneous) to some characteristics of the total sample of students, however also taking into account the heterogeneity of each one.
- Computer-supported – Genetic algorithms are used to optimize the odds of using an arbitrary number of student characteristics to form hybrid groups.
- Rationale – The group formation approach was tested with undergrad students; however, we were not able to identify the justification (neither pedagogic nor instructional) regards the selection of the audience, the learning process, and the learning goals. Still, the study justifies the group formation approach backing up on the benefits of using genetic algorithms to manipulate and manage a considerable amount of students' characteristics. The paper comments that these three characteristics were based on a literature review.

2.2.4 Threats to Validity

A potential threat to validity is the inability to ensure that all relevant studies were selected. There is a possibility that some studies have been omitted considering that not all electronic databases were consulted. However, all consulted electronic databases are considered important forums of publications, susceptible to contain relevant studies. It can be considered that the chances that relevant studies have been resolved, or at least been mitigated. Also, we cannot eliminate threats to the validity of the quality point of view of the selected studies, because, during the selection process, we have not assigned scores to the studies. The research questions and the inclusion and exclusion criteria were drawn up before performing the systematic mapping to ensure an impartial selection process. However, the consistency of the elaborate classification scheme can also pose a threat to validity since the knowledge to elaborate it is often only achieved at the end of the selection process (DYBÅ; DINGSØYR, 2008).

It is important to mention that the difference between the initial quantity of articles and the final selection can be regarded as normal in this type of study. The main objective of a systematic mapping is to provide a broad overview of which have been published in the area of interest. Due this, one important characteristic of kind of study is to avoid imposing many

Figure 15 – This figure shows the characterization of Moreno et al. (2012) work's using the classification scheme created in this systematic mapping

restrictions on the selection of primary studies (DURELLI *et al.*, 2013). Another possible threat to validity results from the operation of some electronic libraries and search systems. In some search engines, despite the use of keywords and wildcards, they often returned items fleeing the scope of the keywords used, therefore demanding further analysis of the undesired studies and manual intervention to eliminate them.

2.2.5 Concluding Remarks of the Systematic Mapping

The categorization scheme we devised can be used to aid analyzing and understanding proposed group formation approaches. Moreover, it may be useful as a support tool to aid planning new ones. As a future work, we plan to optimize and extend the actual structure of the classification scheme. For example, as Massive Open Online Courses (MOOCs) are proliferating with huge number of participants with different backgrounds, culture and time zones (just to emphasize few points of interest) there is a need for new strategies for group formation in this

kind of environment. Traditional approaches used for face-to-face learning or even in traditional e-Learning environments maybe can not be appropriate for MOOCs. Although 25% of the studies state their approaches are suitable for online learning, only 1% comment that their approaches are suitable for asynchronous group learning tasks, 7% for synchronous, 19% can be used in both scenarios, however, 74% did not comment if the group interactions describe in the studies were planned to be executed synchronously or asynchronously.

Using the information extracted from the selected studies, we shed light on the most investigated approaches to group formation, the education stages in which these approaches are applied; the most used research methods, and the most common publication types. Besides the growing number of publications and the variety of computational approaches to support group formation, we identified that, the lack of presenting a rationale explaining the group formation approach can be a problem, and furthermore it can be exploited to open significant new opportunities for future research.

Group formation is one of the most important steps during the planning stages of CSCL activities. Due to the many elements that need to be taken into account during group formation, devising a sound group formation approach is considered a complex task. Although research in CSCL has come a long way, most group formation efforts fail to take into account motivational aspects during group formation. Rather, we found that most existing approaches emphasize the use of basic information about the students (e.g., proficiency) during group formation. Another contribution of our systematic mapping is that by analyzing its results it is possible to identify the ways in which group formation, when applied in the context of CSCL, has been explored so far. researchers can refer to this systematic mapping to determine research gaps and decide on future research directions. Finally, the conceived infographic available at: <http://infografico.caed-lab.com/mapping/gfc/> summarizes all data presented in this paper, and can provide a quick overview of the results.

PERSUASION PROFILING

As pointed out by [Kaptein et al. \(2009\)](#), a reliable use of persuasion strategies involves delivering the right message in a specific way at the precise moment. Yet, trying to figure out what is *the right message* for a student and how to deliver it at the *right time* are still difficult tasks. As shown in ([GRAM-HANSEN; SCHÄRFE; DINESEN, 2012](#)) and ([ZULKIFLI et al., 2013](#)), the design and implementation of persuasive systems (e.g., persuasive learning systems) are complex tasks since it is hard to estimate the effectiveness of those strategies regarding each learner. One promising way to improve the effectiveness of technology-based persuasive interventions relies on the design of personalized persuasive principles (i.e., backed up by social psychology theory) and tailored to fit user's personality traits. Thus, we can design the *right message*, and deliver it at the *right time* to the *right user* ([KAPTEIN et al., 2012](#); [ORJI; VASSILEVA; MANDRYK, 2014](#); [KAPTEIN et al., 2015](#)). [KAPTEIN et al.](#) introduced persuasion profiles in the context of Human-Computer Interaction (HCI) in 2009. Later, the benefits of using persuasive profiles have been examined in several studies ([KAPTEIN; ECKLES, 2010](#); [KAPTEIN, 2011](#); [KAPTEIN et al., 2012](#); [KAPTEIN; Van Halteren, 2013](#); [HAMARI; KOIVISTO; PAKKANEN, 2014](#); [ORJI; VASSILEVA; MANDRYK, 2014](#); [KAPTEIN et al., 2015](#)).

Persuasion profiling relies primarily on measuring user's susceptibility to persuasive principles ([KAPTEIN et al., 2015](#)), thus addressing the challenge of enabling the personalization of persuasive attempts. Secondly, delivering personalized content based on user's profile. Since the design of effective persuasion profiles demands the capacity to measure user's susceptibility to persuasive principles (e.g., influence principles), Kaptein and colleagues perceived the need of developing a psychometric instrument capable to measure user's responsiveness to persuasive principles in a more systematic way ([BUSCH; SCHRAMMEL; TSCHELIGI, 2013](#); [KAPTEIN et al., 2012](#); [MODIC; ANDERSON, 2014](#)). Thus, they developed and validated a 26-Item questionnaire called Susceptibility to Persuasion Scale (STPS) ([KAPTEIN et al., 2012](#)).

Besides STPS, we found ¹ only two other initiatives of the development of measurement scales in persuasive technology literature. First, we found a generalized modular psychometric tool to measure Individual Susceptibility to Persuasion II (StP-II) (MODIC; ANDERSON, 2014). One differential mentioned by the authors is that their scale covers a wide scope of persuasive principles. They ran an exploratory factor analysis and reliability test on StP-II (N=279 subjects) with 10 subscales, and covering 54 items. According to the authors, the tests confirmed the internal reliability of the scale.

The second one, instead of covering a wide range of persuasive principles, Busch and colleagues developed and validated an inventory for measuring susceptibility to persuasion of a subset of well-known persuasive principles (BUSCH; SCHRAMMEL; TSCHELIGI, 2013). They performed some analysis and reliability tests using data from 167 subjects. The original scale has five subscales, covering 40 items. According to the authors, the tests confirmed the reliability of only three subscales, while two others did not show enough internal consistency. Therefore, the later subscales were excluded from the final version.

Finally, the third scale found was STPS (KAPTEIN *et al.*, 2012). STPS is based on the six social influence strategies compiled by Cialdini (1993). Although still there is no consensus about an specific number or influence principles (KAPTEIN *et al.*, 2015), in his books, CIALDINI has demonstrated numerous positive usages of such compilation. STPS is an explicit approach to profile users. Explicit profiling is a meta-judgmental measurement that invite users to think and to reflect upon their own personal traits (BASSILI, 1996). By examining the strength of agreement of each factor, it is possible to measure individual's susceptibility (or the resistance) to influence principles. Using the results of these measurements, designers of persuasive technology can extract useful information to identify effective persuasive principles that can be helpful during the design and development of, for example, persuasive learning systems. A well-known limitation of such approach consists in the user's susceptibility to socially desirable answers effect (BUSCH; SCHRAMMEL; TSCHELIGI, 2013). However, when users' answers are interpreted in association to demographics data and operative measures, the information gathered still can help on the design of better solutions then the *one-size-fits-all* approach, commonly found in the majority of the persuasive technology interventions (ORJI; VASSILEVA; MANDRYK, 2014; KAPTEIN *et al.*, 2015). Figure 16 shows a hypothetical persuasion profile with measurements of perceived persuasiveness for each of the six Cialdini's influence principles.

- **Consistency and Commitment** - We want to act consistently with our commitments and values (FESTINGER, 1962; DEUTSCH; GERARD, 1955; CIALDINI, 1993).
- **Authority** - We look to experts to decide what to do. (MILGRAM; GASTEREN, 1974; KELMAN; HAMILTON, 1989; BLASS, 1991; MARTIN; HEWSTONE; MARTIN, 2003; MODIGLIANI; ROCHAT, 1995; CIALDINI, 1993; FUEGEN; BREHM, 2004).

¹ available on Internet to download

Figure 16 – Example of a hypothetical persuasion profile

- **Scarcity** - The less available a resource, the more we want it. (CIALDINI, 1993; LYNN, 1991; WEST, 1975; BROCK, 1968; LYNN, 1989).
- **Reciprocity** - We feel obliged to return favors (CIALDINI, 1993; GREENBERG, 1980; KOMORITA; HILTY; PARKS, 1991).
- **Liking** - The more we like people, the more we want to say yes to them (CIALDINI, 1993; GAMER, 2005; HORNSTEIN; FISCH; HOLMES, 1968).
- **Consensus** (Social Proof) - We look to others to guide our behavior (AJZEN; FISHBEIN, 1980; CIALDINI, 1993; GOLDSTEIN; CIALDINI; GRISKEVICIUS, 2008).

By analyzing Figure 17 our approach for tailoring influence principles to player roles relies, first on identifying the player role, as commented in the previous chapter. Next, it is necessary identify the persuasive profile of the individual. However up-to-date, to the best of our knowledge, there is no questionnaire tailored to Brazilian Portuguese speakers that can be used to probe into the effectiveness of persuasive technologies. Thus, as a second step towards our investigation of the use of gamification-based persuasive principles, in this next section we describe how we carried out to translate, adapt and validity a Brazilian Portuguese version of the STPS. In Chapter 4, we explain how we devised a solution for tailoring influence principles to player role in order to create a persuasion-based profile for gamified environments. The idea is using such profiles to feed recommender algorithms to allow the customization of the content to be present to the student, now appropriately profiled.

Figure 17 – Our approach for tailoring influence principles to player roles

3.1 Brazilian Portuguese Cross-Cultural Adaptation and Validation of the Susceptibility to Persuasion Scale

The translation and adaptation of a psychological instrument is a complex task (BORSA; DAMÁSIO; BANDEIRA, 2012). There are different ways to adapt such instruments; however, there is no consensus about a unique solution (PESCE *et al.*, 2005). Our adaptation is based on guidelines found in Beaton *et al.* (2000) and Herdman, Fox-Rushby and Badia (1998). The guidelines provide by these researchers have essential information for obtaining the desired equivalence between the original instrument and the adapted one. Moreover, they also advise about fundamental steps towards testing the acceptance level of the adapted instrument. We used the STPS version presented in (KAPTEIN *et al.*, 2012), originally composed of 32 items. We chose to translate the STPS based on these characteristics:

1. **The questionnaire is technology agnostic:** designers can evaluate the users without being concerned about the technologies involved;
2. **It is quick and easy to fill:** It can reach a wide range of users;
3. **It provides simple scores, easy to understand:** Therefore, a wide range of stakeholders can manage the questionnaire (e.g., project managers, computer programmers, system analysts);
4. **Backed up by empirical evidence:** To the extent of our knowledge, STPS was the only questionnaire with the characteristics mentioned in 1, 2, and 3; which has been used in the design and development of adaptive persuasive systems empirically tested and validated (KAPTEIN *et al.*, 2009; KAPTEIN, 2011; KAPTEIN *et al.*, 2012; KAPTEIN *et al.*, 2015).

3.1.1 Study Design and Methods

We performed a cross-cultural adaptation and validation divided in two main phases, each one composed of several steps (HERDMAN; FOX-RUSHBY; BADIA, 1998; BEATON *et al.*, 2000). In *phase I*, all efforts were focused in performing the translation, adaptation, and obtaining a conceptual and linguistic equivalent questionnaire. In *phase II*, we set out to validate the target Br-STPS questionnaire. We evaluated the psychometric properties of the translated questionnaire based on real data collected from the main test. We performed some diagnostic checks on the data collected from the main test, before performing factor analysis (TABACHNICK; FIDELL, 2012).

Phase I is focused on the cross-cultural translation and adaptation process, and presents the following steps: *translation, reconciliation, back translation, translation synthesis, pre-final version* (i.e., adaptation), *pilot-test*, and *final version* (i.e., consolidation of the translation and content adaptation). Phase II is focused on *validating the psychometric properties and reliability* of the construct.

3.1.1.1 Phase I - Cross-Cultural Translation and Adaptation

In this section we will summarize the technical aspects of the first phase.

- Step 1: Translation: the original STPS version was translated from English to Brazilian Portuguese by two researchers, both Brazilian Portuguese native speakers;
- Step 2: Reconciliation: two other researchers compared the two Brazilian Portuguese documents generated during the first step. Based on these two documents, these researchers devised a new version (i.e., reconciliation version), which merges the best chunks of the previous translations into a new document.
- Step 3: Back translation: Two independent translators translated the reconciliation version from Brazilian Portuguese to English. Both translators have sound background on technology, but no training in health, and no knowledge about the original questionnaire.
- Step 4: Translation synthesis: Another independent collaborator worked on the two back-translated questionnaires, comparing them to the original STPS, and summarizing them in only one translation (choosing the most accurate statements from each back-translation). This collaborator has many years of experience working as English as a Second Language (ESL) teacher in the United States.
- Step 5: Pre-final version: A committee of three judges developed the pre-final version of Br-STPS comparing the original questionnaire and the final back-translated one. All three collaborators have a PhD, two of them in Computers Science, and one in Psychology.

- Step 6: Pilot-Test: We ran a pilot test with 10 subjects. We were able to assess the easiness and/or difficult to understand and to fill the questionnaire. We used the information gathered to improve the pre-final version.
- Step 7: Final version: The pre-final version (i.e., updated after step six) presented and discussed it with nine Brazilian postgraduate and postdoctoral students from our research group. We asked these researchers to go over the updated pre-final version and suggest how each sentence could be improved (e.g., grammar checking, meaning, colloquialism, complexity). The feedback from these students was used to improve the the final version of the Br-STPS.

The complete list of translated items (N=32) used for evaluation is presented in Table 8.

3.1.1.2 Phase II - Questionnaire Validation

A Facebook application was developed in Ruby (MATSUMOTO, 2017) using Ruby on Rails framework (HARTL, 2016) with PostgreSQL database (The PostgreSQL Global Development Group, 2017). A prototype version of the application was used to run the pilot test. Later, after the activities previously described in step 7, we run the main test using the application show in Figure 18. To perform the pilot test, we sent invitations to a mail list asking for participants. Later, to perform the main test, we recruited participants using our Facebook application through a process of snowballing (DENSCOMBE, 2014).

We decided to collect data on Facebook, because of its potential as a research tool (WILSON; GOSLING; GRAHAM, 2012). Facebook has a powerful potential since it can provide access to large and diverse population (KOSINSKI; MATZ; GOSLING, 2015). Although Facebook users do not consist of a perfect representative population (i.e., since most users tend to be younger and better educated than the overall population), still thanks to its huge amount of users, Facebook can be helpful since even underrepresented groups can be relatively large and more reachable than using other ways (i.e., printed questionnaires) (WILSON; GOSLING; GRAHAM, 2012). Moreover, we took in consideration the potential to *going viral*, since it is an expensive an powerful feature that have been investigated recently (KOSINSKI; MATZ; GOSLING, 2015). Figure 19 shows an example of how the questions were presented online.

We took advantage of a feature provided by the application program interface (API) of Facebook to collect users' login basic demographic information automatically (Source code 1). Thus, we did not asked for users' demographic information explicitly; however, we informed them about it, and only collected demographic information in agreement with privacy policy of Facebook. We did this to reduce the number of questions and overall amount of time to fill up the questionnaire therefore reducing potential resistance of respondents to answer it (i.e., resistance to answer long questionnaires, and to give personal or sensitive information online) (COMREY,

Table 8 – Items used to measure susceptibility to persuasion translated to Brazilian Portuguese

Principle	Abbreviation	Susceptibility item
<i>Scarcety</i>	Scarce_1	Eu acredito que produtos raros são mais valiosos que produtos produzidos em larga escala.
	Scarce_2*	Caso a minha loja favorita estivesse prestes a fechar as portas, eu a visitaria mais uma vez, pois essa seria minha última chance.
	Scarce_3	Eu me sentiria feliz se fosse a última pessoa a comprar um produto que esgotou.
	Scarce_4	Quando algum dos meus produtos favoritos está quase fora de estoque, costumo comprar mais de uma unidade para não ficar sem.
	Scarce_5	Produtos que são difíceis de encontrar tem um valor especial.
<i>Reciprocity</i>	Recip_6	Eu sempre retribuo um favor.
	Recip_7	Se alguém faz alguma coisa por mim, eu tento fazer algo com a mesma importância em retribuição.
	Recip_8	Quando eu ganho um presente, sinto a necessidade de retribuir o presente recebido.
	Recip_9	Quando alguém me ajuda com o meu trabalho, eu sinto a necessidade de retribuir e ajudar aquela pessoa.
	Recip_10	Quando um membro da família me faz um favor, é quase certo que irei retribuir.
<i>Commitment</i>	Commit_11*	Quando deixo de comparecer a alguma reunião ou coisa do tipo, eu faço o máximo para compensar os envolvidos.
	Commit_12	Eu sempre compareço aos compromissos que eu agendo.
	Commit_13	Eu tento cumprir todas as minhas promessas.
	Commit_14	Quando faço planos costumo escrevê-los, assim demonstro meu empenho em cumpri-los.
	Commit_15	Uma vez que me comprometo a fazer algo, com certeza irei fazê-lo.
<i>Liking</i>	Like_17	Eu aceito sugestões que partem da minha rede social.
	Like_18	Quando eu gosto de alguém, geralmente acredito na palavra dessa pessoa.
	Like_19*	Eu geralmente faço favores para as pessoas que eu gosto.
	Like_20	A opinião dos meus amigos é mais importante que a opinião dos outros.
	Like_21	Se eu não tenho certeza sobre algo, normalmente aceito a opinião de pessoas que gosto.
<i>Authority</i>	Autho_22*	Eu sempre sigo as recomendações do meu médico.
	Autho_23	Quando um professor me diz algo, eu costumo acreditar que seja verdade.
	Autho_24	Eu normalmente acredito na palavra de pessoas que ocupam algum cargo de autoridade.
	Autho_25	Sou mais inclinado(a) a fazer algo que me mandam do que se me pedirem.
	Autho_26	Costumo acreditar mais em uma autoridade do que em um colega.
<i>Consensus</i>	Autho_27*	Eu sempre obedeco às ordens dos meus superiores.
	Consen_28*	Quando alguém da minha rede social recomenda um livro, eu geralmente o leio.
	Consen_29*	Quando me encontro em uma situação em que não sei me comportar, eu geralmente observo os outros a fim de saber como proceder.
	Consen_30	Eu farei algo, desde que saiba que outras pessoas também o estão fazendo.
	Consen_31	Eu normalmente espero que outras pessoas me digam o que fazer.
	Consen_32*	É importante para eu saber que me enquadro em um ambiente ou grupo.

1988; WORTHINGTON; WHITTAKER, 2006). The questionnaire's validation was performed analyzing data collected from this online questionnaire.

Figure 18 – The initial screen of the *Teste: Influência Persuasiva* on Facebook

Source code 1 – Exemple of an login function written in JavaScript SDK on Facebook

```

1:  FB.login(function(response) {
2:      // handle the response
3:  }, {scope: 'public_profile'});
  
```

Source: [Facebook for Developers \(2017\)](#).

The sample collected from Facebook consist of 582 participants. Data were collected from July to August, 2016. After eliminating invalid questionnaires (i.e., incomplete, blank, or gamed (i.e., timestamps were checked and questionnaires answered before a threshold of ten minutes were discarded) a total of 481 valid answers were processed. Participant's demographic information of the final subsample is shown in Table 9.

Table 9 – Participant's demographic information

N = 481	
Gender	Female (254), Male (227).
Age	13-24 (212, 44%), 25-34 (167, 35%), Over 35 (102, 21%)

Figure 19 – Example of how the questions were presented online

The screenshot displays a web-based survey titled "Teste de Persuasão". At the top, there is a search bar and a logo. Below the title, a progress bar indicates the current question. The question text is "1 - Eu aceito sugestões que partem da minha rede social." (I accept suggestions that come from my social network). Below the question, there is a horizontal scale with five points: "Concordo", "Concordo Parcialmente", "Não sei", "Discordo Parcialmente", and "Discordo". A "Próxima questão >>" button is located at the bottom right of the question area.

3.1.2 Data Analysis

Initially, we performed some diagnostic checks to verify the factorability of the sample. The statistics analysis were calculated using R software (R Development Core Team, 2008), and the packages Psych (REVELLE, 2016) and lavaan (ROSSEEL, 2012). The initial diagnostic checks performed show that:

1. 25 out 32 items correlated at least 0.3 with another (item-total correlation corrected for item overlap and scale reliability (REVELLE, 2016));
2. Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.82 (i.e., significantly greater than 0.6 (KAISER, 1974));
3. Bartlett's test of sphericity was significant at $\chi^2(546) = 3463.1$, p-value < 0.001 (BARTLETT, 1954);
4. Overall Cronbach's α coefficient was 0.82 indicating the potential reliability of the questionnaire's internal consistency (TAVAKOL; DENNICK, 2011).

Based on these positive results we proceed with FA (TABACHNICK; FIDELL, 2012). We adopted the threshold of 0.3 for discriminant validity (i.e., item loading factor in the primary

factor), and 0.20 for converging validity (i.e., cross-loadings on secondary factors) (WORTHINGTON; WHITTAKER, 2006; RUMBERGER, 2011; TABACHNICK; FIDELL, 2012).

As a first step, we calculated the reliability of each subscale and eliminated the items whose elimination would lead to an increase in the significance of reliability. A total of four items were eliminated. The elimination of unreliable items before performing FA aims to maximize the convergent and discriminant validity of the subscales (RUMBERGER, 2011). Items were eliminated until (a) the elimination of any remaining items could no more contribute to increase the reliability of the subscale (RUMBERGER, 2011) or (b) it is recommend to keep a minimum of at least three items in each subscale (i.e., factor) (WORTHINGTON; WHITTAKER, 2006; RUMBERGER, 2011). In Table 10 it can be seen all eliminated items in this step.

Table 10 – Increase in reliability after removal of unreliable items

Step		Commitment	Consensus
1	Initial α	.51	0.48
2	Item removed	Commit_16	Consens_28
	Adjusted α	0.56	0.54
3	Item removed	Commit_11	
	Adjusted α	0.65	

In the second step, to decide the number of factors to retain we performed a scree test with Parallel Analysis (PA) and looking at the number of Eigenvalues before the inflexion point. PA was used to minimize the risks of underfactoring (i.e., selecting too few factors) or overfactoring (i.e., selecting too many factors) that could affect the robustness of the factor analytic solution and the validity of our factor model (HORN, 1965). Figure 20 shows the eigenvalues of the extracted solution used in the scree test. The adjusted eigenvalues (retained) shows a clear cutoff before the inflection point, indicating the viability of a six-factor solution (SACCENTI; TIMMERMAN, 2017).

It should be noted that FA is a dynamic process (Figueiredo Filho; Silva Júnior, 2010) and selecting items to be removed in each step is made subjectively (RUMBERGER, 2011). Thus, as the third step, we created several models considering (a) the six-factor structure of the original scale, (b) the scree test results based on PA, (c) the number of items selected in each turn (SACCENTI; TIMMERMAN, 2017). Solutions from six to nine factors were each examined. We performed a Principal Component Analysis (PCA) because the main purpose at this point was to identify and compute composite scores for all latent variables (KAPTEIN *et al.*, 2012).

Based on criteria of adequacy (goodness fit) a six-component solution was choose and further examined with Varimax and Oblimin rotation (TABACHNICK; FIDELL, 2012). There was little difference between both solutions, thus we examined the outputs of both and decide to use an Oblimin rotation for the final solution (OSBORNE, 2015). We removed six more items that violated either the assumption of low loadings or high cross-loadings (RUMBERGER,

Figure 20 – A scree plot with the eigenvalues (y-axis) and the extracted factors (x-axis), with six factors positioned before the inflection point

2011). Table 11 gives an overview of the loadings² of each items that were calculated based on the five-component solution with 24 items. Items marked with * are removed from the final scale.

In the fifth step, we proceeded with the CFA to verify the correctness of the six-component model with 23 items. The results of the CFA shown acceptable good model of fit, with ratio of χ^2 (387.45) to 215 *df* and $p < 0.001$. The Comparative Fit Index (CFI) was higher then 0.9; the Tucker-Lewis fit index (TLI) also higher then 0.9, and the Root Mean Square Error of Approximation (RMSEA) and Standardized Root Mean Square Residual (SRMS) lower then 0.5. Those values indicate a good fit between the model and the observed data. Overall Cronbach's α (0.74). A summary of these results are presented in Table 12.

We computed composite scores for each one of the six subscales, by averaging on 2-5 items in each subscale (KAPTEIN *et al.*, 2012). Table 13 shows the composite scores and descriptives for each subscale. The results for skewness and kurtosis were in acceptable ranges (i.e., ± 2) considering the social nature of the research (GRAVETTER; WALLNAU, 2013). Overall, most items shown a moderate internal consistence, except for the subscale Liking that presented poor reliability index (GLIEM; GLIEM, 2003). Although reliability indexes provides important information, neither high and low values, *per se*, imply in a perfect scale, being recommended caution when interpreting such results. Moreover, when the number of items in the subscale are small, Cronbach's α values can be also quite small (TAVAKOL; DENNICK, 2011). Thus, no *post-hoc* modifications were made from the analysis because of (a) the other positive

² Loadings smaller than 0.3 were suppressed.

Table 11 – Factor loadings based on PCA with Oblimin rotation

	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Comp. 6
Scarc_1		0.75				
Scarc_2*	0.34	0.43				
Scarc_3		0.57				
Scarc_4		0.45				
Scarc_5		0.77				
Recip_6	0.73					
Recip_7	0.75					
Recip_8	0.64					
Recip_9	0.70					
Recip_10	0.67					
Commit_12				0.74		
Commit_13				0.59		
Commit_14				0.40		
Commit_15				0.76		
Like_17					0.39	
Like_18					0.50	
Like_19*						
Like_20					0.58	
Like_21					0.48	
Auth_22*				0.31		
Auth_23			0.56			
Auth_24			0.78			
Auth_25			0.44			
Auth_26			0.67			
Auth_27*			0.47	0.31		
Consens_29*						
Consens_30						0.67
Consens_31						0.56
Consens_32*						

Table 12 – Values of selected fit statistics for six-factor CFA model

Index	Value	Fit	Theoretical support
χ^2	387.45		
<i>df</i>	215		[Tabachnick and Fidell (2012);
RMSEA	0.04	≤ 0.6	Osborne (2015);
SRMR	0.05	≤ 0.8	Kaptein <i>et al.</i> (2012);
CFI	0.91	≥ 0.9	Schreiber <i>et al.</i> (2006);
TLI	0.90	≥ 0.9	Tavakol and Dennick (2011)]
Cronbach's α	0.74	≥ 0.7	

good-fit indexes (OSBORNE, 2015) and (b) by simulating the elimination of the remaining items indicated a negative impact on the overall reliability of the scale (i.e, overall Cronbach's α) (RAUBENHEIMER, 2004; SCHREIBER *et al.*, 2006).

Table 13 – Overview of the composite scores and descriptive statistics for the Br-StPS

Subscale	#items	Mean (SD)	Skewness	Kurtosis	Cronbach's α
Scarcity	4	3.17 (1.05)	-0.09	-0.73	0.63
Reciprocity	5	2.38 (0.98)	0.66	-0.02	0.79
Commitment	4	1.80 (0.78)	1.30	1.70	0.54
Liking	3	2.56 (0.89)	0.53	-0.19	0.50
Authority	4	3.21 (0.93)	0.00	-0.62	0.59
Consensus	2	3.42 (1.22)	-0.39	0.22	0.63

3.1.3 Results Discussion

The results of the FA (N = 481) shows six components in the adapted scale, explaining 51% of the total variance. We used the threshold of 0.3% to keep components. Our results were not the same found [Kaptein et al. \(2012\)](#) in the original questionnaire. Towards fulfilling the item equivalence between the original and translated questionnaire, we eliminated 9 items during the cross-cultural adaptation process. From the original 32 translated items, three items presented cross-loadings higher then 0.3, while three other presented loadings lower than 0.3. Considering that the target questionnaire must cause on the target language respondents the same sort of effect caused in the respondents of the original one, it seems that the semantic equivalence (i.e. capacity of conserving the meaning of the words from the original questionnaire to the adapted version) was obtained for the majority of the items. The component Consensus end up with only two items, given the low loadings of Consens_29 and Consens_32. Although three is usually the minimum number of Likert-items to be retained in a scale, for multicomponent scales (i.e., as in our scale), a minimum of two can be a accepted, if the overall goodness of fit could benefit of the elimination ([RUMBERGER, 2011](#)).

Although in our translation it was necessary to discard more items than was discarded during the validation process of the original questionnaire, the reduction of the number of variables had the purpose of maximizing the explanatory power of the set of all variables, thereby facilitating the process of identifying a subset of variables able to evaluate the same trait (component). As it happened during the validation of the original questionnaire, many items show cross loadings in another component. For example, the item Auth_22 (*Eu sempre sigo as recomendações do meu médico*)³ loaded in another component. When reading Auth_22 again and by looking at the cross-loading value (0.31) it becomes clear that for some of our respondents the question was interpreted as a quest about *Commitment*. Our guess is that the semantic equivalence of some items was not achieved since the message implied by some items may have more than one connotation for different Brazilian speakers.

The objective of the measurement equivalence is to ensure that the adapted version is as reliable as your original version in terms of psychometric properties reliability. As expected by

³ I always follow advice of my general practitioner.

the authors, the questionnaire's final version is different from the original created by [Kaptein et al. \(2012\)](#). In our translation, the items were administrated using a 5-point scale. The endpoints of the questionnaire were labeled with "Completely Agree" and "Completely Disagree". The midpoints were labeled "Agree", "Don't Know", and "Disagree". Although there is no consensus about the ideal number of points in Likert scales, most researchers seem to agree that, each scale has unique characteristics which demands an appropriate solution for each scenario. Since we administrated an online version of the questionnaire, we decide to use a 5-point scale, instead of a 7-point. We believe a 5-point scale is sound enough to measure the users' traits in our online scenario, while at the same time avoiding overloading them. However, more research will be necessary to understand whether the changes in the format (number of points), instructions (online disclaimer), and type of administration (online) may have (or not have) affected the operational equivalence between the questionnaires, therefore influencing the adaptation results.

A conceptual equivalence between questionnaires means that the adapted questionnaire conveys the same concepts present in the original questionnaire albeit being in a different language. Therefore, the we did not achieved a complete cross-cultural adaptation and translation, and the target scale is a new one with a different number of items ([RUMBERGER, 2011](#)). Overall, the analysis shows that the questionnaire's final version, with 23 items and 6 components has moderate internal consistence (Cronbach's $\alpha = 0.74$). The selected items do not present cross-loadings, and all have loadings higher than 0.30 in only on component [25]. Finally, to satisfy the functional equivalence, we have summarized all parts of the cross-cultural adaptation process, therefore, we are able to replicate the adaptation process. Although we finished the adaptation process with a slightly different scale, our results indicate that the final version of our questionnaire has moderate internal consistence, the subscales are moderately consistent, and all goodness of fit are above the standard values, thus it can adequately identify which influence principles have more impact on Brazilian user' decisions.

3.2 Persuasion Profiling Report

At end of the online questionnaire, we presented to the participants a summary of their profile (Figure 21). We give them a visual feedback highlighting which influence principles can present more and less influence in their personality. We also asked the users if they agreed with the results.

From 546 users (raw answers), 302 did not answered this last question, while 223 said they agree with the results, and only 21 said they disagree. Given the low number of the users that have disagreed, we manually checked the questionnaires' answers of these users, and despite their disagreement, all answers given by these users lead to the results we delivered, so we were unable to visually observe problems to justify the disagreement. In other words, if someone was marked as sensitive to Authority, the score of the answers already lead to such result.

Figure 21 – Example of the report presented to the participants at the end of the online survey.

TAILORING INFLUENCE PRINCIPLES FOR GAMIFICATION IN EDUCATION

Research has already shown that tailored persuasive approaches can improve user's motivation towards targeted behaviors and attitudes (FOGG; NASS, 1997; HAMARI; KOIVISTO; PAKKANEN, 2014; ORJI; VASSILEVA; MANDRYK, 2014). Thus, in order to design persuasive interventions to enhance gamification, we set out to adapt the Susceptibility to Persuasion Scale from English to Brazilian Portuguese. Next, we aimed to identify where influence principles can be related to individuals motivations to play to enhance the persuasiveness of gamified systems. Hence, in this chapter we present the study we conduct to explore the relationships between player roles and influence principles. To measure susceptibility to influence principles, students were required to fill in the already mentioned Br-STPS, and to investigate user's player roles, the QPJ-Br. Specifically, we were interested in observing the relationship between the six Cialdini's influence principles and five player roles based on motivations to play (BORGES *et al.*, 2016a). In the next sections, we will describe the material and methods used in the study, data analysis, and validation.

4.1 Data Collection

We conduct the study with 152 (N=152) students at the Universidade do Estado de Minas Gerais (N=120) and Instituto Federal Sul de Minas Gerais (N=32), both at Passos city, state of Minas Gerais, Brazil. Subjects were all undergraduate students enrolled, respectively, on Information System and Computer Science programs. Data was collected during three days from 21 to 23, November 2016. Average time spent to answer the questionnaires was about 30 minutes. Besides the main questionnaires (i.e., Br-STPS and QPJ-Br), we also collected student's demographic information. Appendix A has the questionnaires we used.

After eliminating invalid questionnaires (i.e., incomplete, blank, or gamed) we started to

process a final sample comprising information on 149 participants (N=149) as shown in Table 14. All participants declared they already are familiar, at least at some extent, with playing video games (e.g., computer, consoles, and/or smartphones).

For simplification purpose, in this study participants were classified in one of the five player roles investigated. Although a player can score in multiple player roles, according to motivations to play theory (YEE, 2006)), usually a single player role can emerge as the dominant one. We did this in order to keep the investigated hypothetical model more simple and to minimize the number of variables and observations involved (i.e., considering the size of the sample) (CHIN, 1998).

For illustration purpose, subject labeled *User_144* scored: Achiever (17.27%), Humanist (12.73%), Explorer (12.73%), Conqueror (10.91%), and Creator (11.82%), in this study we classified the dominant player role of *User_144* as been *Achiever* based on the value of the observed scores. In case of draw (i.e., a subject got equal scores in more than one category), we individually analyzed the scores of the subject to decide which player role to keep. We did this by comparing the subject's scores and Yee (2006) observations regards the relationship between the three main components of motivations to play theory and respective subcomponents.

Table 14 – Students demographic information

Participants N = 149	
Age	Male 18-25 (105), 26-48 (28) Female 18-25 (13), 26-48 (3)
Gender	Male (133), Female (16)
Academic Year	First (59), Second (38), Third (26), Fourth (26)
player role (Dominant)	Achievers (72), Explorers (22), Conquerors (8), Humanists (38), Creators (9)

Figure 23 shows estimations of the number of students susceptible for each influence principle. The majority of students manifested some degree of influence to consensus, scarcity, reciprocity, commitment, and liking. Authority was the principle with the lower number of individuals influenced, only 34 individuals were estimated as susceptible to authority, while 89 scored high in resistance against it. The estimations presented in Figure 23 are consolidated values for all influence principles, therefore there is an overlap of individuals. In Figure 24, we present an example of persuasion profile of one subject. The higher values indicate the estimated effect of the respective influence principle, while the lower values the estimated resistance.

4.2 Data Analysis

T-tests were used to investigate gender differences while correlations were used to investigate age differences among the students. Table 15 shows the results. The reported differences between gender are significant at least $p < .05$. Measure of the effect size of the gender differences

Figure 22 – Distribution of the students according to their dominant player role N = 149

Figure 23 – Number of individuals estimated as influenced (left) and resistant (right) to the six influence principles N = 149

(t-tests) indicates an approximation of the overall variance in the player role that can be explained by gender alone (FIELD; MILES; FIELD, 2012).

Table 15 – Age differences in player roles

Age Correlation Coefficients (M/F)	
<i>Achiever</i>	-0.18 / -0.17
<i>Humanist</i>	-0.21/ -0.13
<i>Explorer</i>	-0.22 / -0.12
<i>Conqueror</i>	-0.13 / 0.30
<i>Creator</i>	-0.21 / 0.00

Figure 24 – Example of one persuasive profile (User_144), the higher scores indicate the estimated persuasiveness, while lower scores, estimated resistance

By looking at Table 16, we can see that male players scored higher as achiever, humanists, explorers and conquerors, while female players were the majority of creators. Creators are driven by opportunities for self-expression (KIM, 2014), and according with a survey data from over 270,000 gamers (YEE, 2017), 49,950 (18.5%) are female, and the game genre preferred by most female players (69%) are Match 3 and Family/Farm Sim games (i.e., tile-matching and sand box/simulation games, respectively).

Table 16 – Gender differences in player roles

Gender Differences		r
<i>Achiever</i>	Male>Female	0.08
<i>Humanist</i>	Male>Female	0.29
<i>Explorer</i>	Male>Female	0.57
<i>Conqueror</i>	Male>Female	0.62
<i>Creator</i>	Female>Male	-

Among males, the category with the higher measure of the effect size was conqueror, what is in consensus with research conducted by several other authors since male players tend to be more driven by *zero-sum* games (JUUL, 2009). Older achievers and humanists, both male and female, are slightly unlikely young players. Young male explorers and conquerors seems to be more driven towards exploration and zero-sum activities. Young and older female creators did not show significant differences, while it seems that older male players are less driven to customization.

Next, I employed Partial Least Square (PLS) Structural Equation Modeling (SEM) to investigate possible relationships between players types and influence principles. We chose

PLS-SEM mostly because it is a less strict approach than others, when concerning the size and distribution of sample (HAIR, 2013). We performed the analysis exploring several models on SmartPLS 3.0 (RINGLE; WENDE; BECKER, 2017). First, we tested the adequacy of the sample to determine whether it was worthwhile to proceed or not with PLS-SEM. Reliability (Cronbach's α) was 0.75. I conduct FA using R with the package Psych, and dropped items with a threshold of 0.3 to assure convergent and discriminate validity (WORTHINGTON; WHITTAKER, 2006; RUMBERGER, 2011; TABACHNICK; FIDELL, 2012).

When investigating hypothetical relationship between variables using SEM, there are at least two important measures to determine: path coefficient (β) and its respective level of significance (p). Thus, we calculated both for each model designed. Path coefficients are important to observe the influence of a variable on another one (CHIN, 1998), the results of our measurements are summarized in Table 17.

Table 17 – Standardized path coefficients of each model for player roles and influence principles. The reported values are significant at $p < 0.05$ while suppressed values are not

	Gender	Humanist	Conqueror	Achiever	Creator	Explorer
<i>Scarcity</i>	M	-	0.47	0.29	0.31	0.43
	F	-	-	0.28	0.30	0.48
<i>Reciprocity</i>	M	0.38	-	0.38	0.26	-
	F	0.36	-	0.39	-	-
<i>Commitment</i>	M	-	0.31	0.36	0.26	0.37
	F	-	0.29	0.31	0.24	0.34
<i>Liking</i>	M	0.29	0.35	-	-	-
	F	0.26	0.31	-	-	-
<i>Authority</i>	M	-0.22	-	-	-0.27	-0.27
	F	-	-	-	-	-0.24
<i>Consensus</i>	M	0.41	0.42	-	0.48	-
	F	0.39	0.37	-	0.49	-

4.3 Comparison of Perceived Susceptibility to Persuasion and Player Roles

In order to observe differences and similarities on students' predisposition to influence principles, we tested one model for each player role. The results show that the five player roles (Humanist, Conqueror, Achiever, Creator, and Explorer) are slightly different in terms of the influence of each principle. By analyzing Table 17, we can also observe similarities and differences between male and female participants regards the susceptibility of each player role.

Scarcity: the proposed model aims to investigate whether each player role presents the same reaction to the scarcity principle. Surprisingly, the higher coefficient observed came from *conquerors* and *explorers*, while *achievers* has the lowest level observed (except for *humanist*

which was not significant at $p < 0.05$). Explorers are always looking for opportunities to expand their knowledge about the system (i.e., game, virtual world, LMS). It seems that applying the scarcity principle in order to unlock new experiences (i.e., maps, paths, content) can influence explorers towards acting.

Reciprocity: significant coefficients were observed in *humanists* and *achievers*. Humanist coefficient is consistent with our expectations since they are people-oriented, so the principle of given and taken indeed influences these individuals. Achievers are goal-oriented, their results seem to indicate that in order to reach their objectives they are prone to do something in exchange, provided they will receive the expected reward.

Commitment: we were able to observe values significant at $p < 0.05$ for all player roles (*conqueror*, *achiever*, *creator*, and *explorer*) except for humanists. The other player roles shown moderated influence of commitment in their perceived susceptibility. Although male explores presented the higher coefficient (0.37), none of values are extremely higher than the overall observations. So, using commitment in a system may be a good choice for one-size-fits-all approaches (except for humanists which we were unable to observe the perceived susceptibility), since it has the power to moderately influence all other player roles.

Liking: as expected, *conquerors* and *humanists* coefficients shown they are moderately influenced by the liking principle. This is consistent with the observed nature of each one (i.e., people-oriented). Surprisingly however was that male conquerors exhibit the higher coefficient (0.35). We cannot elaborate further based only in these coefficients, but in the literature, male conquerors are highly driven by interacting *on* other players. So, it seems that providing ways for (not harmful) interaction in a system indeed can influence male conquerors towards acting.

Authority: surprisingly, the authority principle shown negative coefficients for three male player roles (humanists, creators, and explores) and one female player role (explorer). As it seems, the students these students were not influenced by authority, instead, using authority might have be counter-productive in this cases. Creators and explorers are driven by the need for autonomy therefore to some extent, it may be able to explain the aversion to authority. Although we were unable to observe the coefficients for all player roles, the results of the average number of students susceptible to authority were much lower than the average number observed for the other five principles, as shown in Figure 23.

Consensus: *humanists*, *conquerors*, and *creators* were the player roles with moderate influence to consensus. Humanists and conquerors are people-oriented so it makes sense being influence by consensus (social proof) since individuals susceptible to this principle tends to not only observer others behavior but also to change their own behavior to be in conformity with the norms of the group. Creators are system-oriented, so it was a surprise the coefficients observed. We can only speculate that maybe the customization and free-to-chose features they enjoy might also be moderated by the general tendencies exhibit by the whole group. In other words, maybe by observing group tendencies (i.e., fashion trends likewise) it help creators to follow or reject

group tendencies.

4.4 Mapping Influence Principles to Game Design Elements

The design of sound persuasive interventions requires not only, careful analysis of appropriate gamified activities (e.g., environment's design) and meaningful rewards (e.g., suitable game elements) but also, the ability to designate appropriate players' roles for each learner, as seen in chapter 2. Among other solutions, many researchers and practitioners have been investigating, how to chose appropriate GDE to develop more efficient persuasive systems. Usually this works present compilations of suitable GDE considered appropriated for the majority of the learners (i.e., one-size-fits-all). The intention behind such compilations can be mainly explained by the necessity to support researchers and practitioners, since the high number of GDE, their overlaps and relationships can be overwhelming. Moreover, there is no such thing as a ultimate compilation, or a definitive list of GDE and categories. Said that, it is not our intention explain all possible overlaps and relationships among GDE neither present a definitive list. Instead, the information shown in Table 18 and Table 19 were gathered to help us to better understand how to tailor influence principles to harness GDE towards the design of persuasive learning systems.

4.5 Applying Influence Principles to Gamification

1. Identify the target behavior

The first step should be identifying the target behavior the designer wants to influence (e.g., join the group). This is important because the selection of GDE may be influenced by the domain.

2. Determine users' player roles

This step is composed of two parts. First, it is necessary to identify suitable player roles for the group of users (e.g., motivations to play). Next, based on the set of player roles, the designer needs to decide how many roles each player are able to play. This will help to decide which and how many GDE will be part of the system.

3. Identify users' susceptibility to persuasion

As shown in this chapter, evidence suggests that perceived susceptibility to influence principles differs from one player to another. Thus, it is necessary to measure each user's combination of susceptibility to persuasion to allow designers to choose the appropriate *persuasive frame* GDE.

Table 18 – General guidelines to choose appropriate influence principles

Influence principle	Cognitive shortcut	Effect	How to start
Reciprocity	Give and take	An obligation to give An obligation to receive An obligation to repay	Start the exchange Be proactive Give something away Make concessions
Commitment (Consistency)	We like to do what we say	We act in a way that is consistence with our values and identity.	Get a commitment Identify user's traits Activate self-concept Make your request
Authority	Expert appeal	We are rewarded for behaving in accordance with authority figures	Show you're the expert Show what experts are saying Back up your claims with evidence from experts Be inspiring Be confident
Scarcity	Less is best and loss is worst	We are more likely to want something if it is rare, priceless, hard to obtain	Get users to take action by making things available for a limited time or providing limited units
Liking	We feel compelled to say yes to people we like or know	I like you, thus I think you are trustful I like you, I cannot say NO to you You like me, so I need help you	There are different paths to improve Liking: Similarity: we like people who are like us. Familiarity: repeated positive interaction with a person, organization, or interface encourages liking. Cooperation: we like people who want to help. Association: we like people who share our values. Praise: we like people who compliment us.
Consensus (Social Proof)	We like to observe other people's behavior to see what is considered normal, then we act in the same way	Obligation to follow what is considered normal	Show users how many individuals are performing/using something

4. Determining the design approach

Next, designers need to decide for the granularity of the system's personalization. This decision can be taken by observing the number of target users, and the results of both measures, player roles and susceptibility to persuasion. It all depends on the target group. If justified, a one-size-fits-all approach could be adopt (e.g., given the degree of similarities among the users). Personalized approaches either can be fully personalized (i.e., adapted for each individual) or partially personalized (i.e., adapted for group of individuals that share similarities).

5. Choosing the appropriate influence principle

The perceived persuasion of each influence principle can be different to various player

Table 19 – Influence principles and suitable examples of game design elements

Influence principle	Game Design Element
Reciprocity	Give away for free (virtual goods, information, extra time, extra life, skip-task, power to choose or unlock) Ex.: Free-lunch
Commitment (Consistency)	Ask users to perform small tasks (answer a question, play a mini-game, make a comment, watch a short video), once we get the action done (establish commitment), publish/inform the results, thus users will be more prone to perform next requests (consistence). Ex.: Leaderboards, murals, e-mail list
Authority	Use aesthetics (icons, ranking images, badges, seals, logos) representing associations, clubs, bureaus, universities, etc. Ex.: Photographs of real people (not draws or cartoons)
Scarcity	Countdown Limited stock Hard to obtain Depends on time or effort to get it Deadline Discounts Offers exclusivity Ex.: Seasonal events, loss aversion
Liking	Take advantage of user' networks Provide history background Improve sense of membership Ex.: Groups, guilds, covenants; storytelling, avatar, shared group flag/badge/color/mascot, shared virtual space
Consensus (Social Proof)	Validation images and logos User counters Number of social share/users Ex.: Reviews, testimonials, leaderboards, panels

roles, as summarized in Table 17. The negative association suggest that the pair influence principle-player role might not be the most efficient choice and should be avoided. A positive association by the other hand suggest that the pair can influence the player. The results are in alignment with Orji, Vassileva and Mandryk (2014) and Kaptein *et al.* (2015), who found that there are cases in which the one-size-fits-all approach can be not only inefficient, but also harmful, since it can discourage the desired behavior. Table 20 shows the best and worst influence principles for each male player role. From left to right, the influence principles are listed according to the highest to the lowest value of each path coefficient measured. In Table 21, shows the the best and worst influence principles for

each female player role.

Table 20 – Best and worst influence principles for each male player role. From left to right, the principles are listed according to the highest path coefficient measured

Player Role	Influence Principle	
	<i>Best</i>	<i>Worst</i>
Achiever	Reciprocity, Commitment, Scarcity	N/A
Creator	Consensus, Scarcity, Commitment	Authority
Conqueror	Scarcity, Consensus, Liking, Commitment	N/A
Explorer	Scarcity, Commitment	Authority
Humanist	Consensus, Reciprocity, Liking	Authority

Table 21 – Best and worst influence principles for each female player role. From left to right, the principles are listed according to the highest path coefficient measured

Player Role	Influence Principle	
	<i>Best</i>	<i>Worst</i>
Achiever	Reciprocity, Commitment, Scarcity	N/A
Creator	Consensus, Scarcity, Commitment,	N/A
Conqueror	Consensus, Liking, Commitment	N/A
Explorer	Scarcity, Commitment	Authority
Humanist	Consensus, Reciprocity, Liking	N/A

6. Map the desired influence principles to the game design elements

As pointed out by (ORJI; VASSILEVA; MANDRYK, 2014; DROZD; LEHTO; OINAS-KUKKONEN, 2012; KAPTEIN *et al.*, 2015) most persuasive solutions are not directly implemented in the system. Thus, translating the persuasive strategies to game design elements is a task that depends not only of the target groups, but also of many other project characteristics. In Table 18 we commented Cialdini's six influence principles, and in Table 19, by way of example, we provide a list of game design elements and concepts usually found in the literature. The list is shown to illustrate a point of view and it is not exhaustive since mapping an extensive *principle-to-game* design element compilation is beyond of the scope of this thesis.

4.6 Concluding Remarks

Research in persuasive technology has show the importance of tailored persuasive approach to persuade users effectively. Gamification interventions by the other hand still are focused on one-size-fits-all solutions or designing by intuition. In this chapter we summarized a study we conducted to investigate whether influence principle can be related to player roles or not. We did not present a definitive list of GDE and their relationship to each and all Cialdini's

six influence principles. The GDE listed were extracted from many sources from game and gamification design theory. We mapped some influence principles to GDE as an exploration of potential affinity, but not a definitive one. In addition, we applied the results of the models at a level of the population. As any model, the scheme presented is a simplification of the reality and, as such, it has some drawbacks, as for example, the results apply for the majority of the observed population, however we can not assume that it will work for all population. Last, although the observed models can present some benefits to designers, by any means they represent a better or definitive solution than other game design approaches. The guidelines presented here can be used by designers to plan more persuasive gamification interventions and also, it can be used to back up the rationale behind the selection of GDE.

TOWARDS PERSUASIVE LEARNING DESIGN

5.1 Definition

In the previous chapter we presented some evidence of the relationship between influence principles e player roles. Thus, in this chapter we presented the results of a study designed to measured the perceived persuasiveness of a non-gamified and gamified Graphical User Interface (GUI). This section details the experiment setup we used to investigate the perceived persuasiveness of gamification-based user interfaces principles. We designed the experiment to examine whether a gamified interface (i.e., which displays gamified UX features) enhances the perceived persuasiveness in comparison to a non-gamified interface (i.e. a version of the interface that displays only basic UX features). Specifically, a LMS-like system was mocked up and walked through by experts ¹. We designed an non-gamified version, and a gamified one, each one consisting of three units: *Semana_1*, *Semana_2*, and *Semana_3* ².

User interface prototypes (e.g., mock-ups, wireframes) have been proven as reliably tool in web development, and they are technically valuable for designers, developers, and end-users (KOHAVI *et al.*, 2009). We chose mock-ups for two main reasons. First, they are easy to understand and elicit responses from end-users (RICCA *et al.*, 2010). Second, actual implementation of a system demands not only many additional design decisions, but also development decisions, adding several tasks that demands time and effort (MUKASA; KAINDL, 2008), while mock-ups allow researchers to present the essence of an idea in a less costly fashion (FERRI, 2016).

To perform the study, we created surveys using Google Forms. We used Google forms in

¹ One post-doctorate and three doctorate students in our research group, and one professional with a degree in pedagogy.

² *Semana* is the Brazilian Portuguese word for week.

Figure 25 – Mock-ups illustrating LMS-like scenarios non-gamified (left) and gamified (right)

the study because it is free and easy to create and administrate surveys promptly (GEHRINGER, 2010). Prior the execution of the main study, a pilot study was conducted. The pilot study was conducted with four participants recruited by convenience among fellow students. The results of the pilot study confirmed the suitability of the study and they were used to perform some adjusts on the mock-ups (LAZAR; FENG; HOCHHEISER, 2010). After this improvements and positive feedback, we decided to proceed with the study. Thus, our research questions (RQs) can be formalized as the following:

RQ1: In terms of perceived persuasiveness, has a gamified interface more influence on users than a non-gamified?

RQ2: In terms of perceived persuasiveness, has a tailored gamified interface more influence on susceptible users than on resistant ones?

The experimental design we used to evaluate this question is sixfold, comprising the following steps: (i) demographic information, (ii) player types questionnaire, (iii) susceptibility to influence principles questionnaire, (iv) basic psychological need satisfaction and frustration questionnaire, (v) interface evaluation, and (vi) perceived persuasiveness questionnaire. As detailed in the following subsections, the RQ was used as the basis to formulate the hypotheses we used in this study.

5.1.1 Goal definition

Basically, defining the scope of an experiment abridges to setting its goals. Towards this end, we used the organization proposed by the Goal/Question/Metric (GQM) template (WOHLIN *et al.*, 1999), describing our experimental goals in five parts: object of study, purpose, perspective, quality focus, and context.

Object of study: The objects of study are two versions of and LMS-like user interface, namely, non-gamified and gamified.

Purpose: the purpose of this experiment is to evaluate two approaches to invite students to CL groups in a system with respect to their perceived persuasiveness. Specifically, we investigate whether a gamified interface is more persuasive over the non-gamified interface. The experiment provides insight into how much persuasion is enhanced by a gamified interface. It is also expected that the experimental results can be used to bolster up the persuasive systems design. In this case, our gamified interface conforms with persuasive systems design concepts by enhancing the gamification elements with tailored influence principles and thus enhancing perceived persuasiveness of target users.

Perspective: this experiment is run from the standpoint of a researcher.

Quality focus: the primary effect under investigation is perceived persuasiveness as measured by the score obtained by the subjects using either of two versions of interfaces.

Context: this experiment was carried out using 18 undergraduate and graduate students as subjects (N=18). We invited 102 students enrolled in a Software Engineering course. Of this total, 61 students agreed to participate in the first part, and only 18 students attended the final part of the experiment. The experiment was carried out part in the facilities of the University of São Paulo and online. Following this template, our experiment can be summarized as follows:

Analyze gamified and non-gamified interfaces
for the purpose of comparing
with respect to perceived persuasiveness
from the point of view of a researcher
in the context of adult students enrolled in a university course.

5.2 Planning

5.2.1 Hypothesis Formulation

We formalized our research questions (RQs) into hypotheses so that statistical tests can be carried out. In the first box we present the formulated Hypothesis for RQ1, and in the second box, the formulated Hypotheses for RQ2. Figure 26 shows the hypothesized relationships between the constructs we observed in the study and the pathways relevant to answer RQ2.

Formulated Hypothesis for RQ1

Null hypothesis, H1a: there is no difference in the perceived persuasiveness between gamified and non-gamified GUIs (measured in terms of the score ratio given by the subject's to the GUIs) which can be formalized as:

- **H1a:** $\mu_{\text{gamified interface}} = \mu_{\text{non-gamified interface}}$

Alternative hypothesis, H1b: there is difference in the perceived persuasiveness between gamified and non-gamified GUIs (measured in terms of the score ratio given by the subject's to the GUIs) which can be formalized as:

- **H1b:** $\mu_{\text{gamified interface}} \neq \mu_{\text{non-gamified interface}}$, for at least one pair (gamified/non-gamified)

Figure 26 – Hypothesized relationships between the constructs observed in the study and respective pathways elaborated to answer RQ2.

Formulated Hypotheses for RQ2

Null hypothesis, H2a: Player role has no influence on perceived need satisfaction.

Alternative hypothesis, H2b: Player role has influence on perceived need satisfaction.

Null hypothesis, H3a: Player role has no influence on the on the perceived persuasiveness to use the system.

Alternative hypothesis, H3b: Player role has influence on the on the perceived persuasiveness to use the system.

Null hypothesis, H4a: Perceived need satisfaction has no influence on the perceived persuasiveness to use the system.

Alternative hypothesis, H4b: Perceived satisfaction has influence on the perceived persuasiveness to use the system.

Null hypothesis, H5a: Perceived susceptibility to persuasion has no influence on the player role.

Alternative hypothesis, H5b: Perceived susceptibility to persuasion has influence on the player role.

5.2.2 *Variable Selection and Metrics*

Here we clarify the dependent variable we set out to measure. Since it is complex to gauge the persuasiveness of the game elements and the *amount/quality* of motivation triggered, we settled on comparing the user's perceived persuasiveness by asking them for feedback on the perceived persuasiveness of each group of interfaces, and observing how perceived persuasiveness of the gamified interface relates to player types, susceptibility to persuasion, and perceived need satisfaction. So the operational definition of our variable is explained as subject's favorable impressions (i.e., score ratio) towards the graphical user interface mock-ups (DROZD; LEHTO; OINAS-KUKKONEN, 2012).

5.2.3 *Selection of subjects*

Subjects are chosen based on convenience (i.e., adult students enrolled in a university course).

5.2.4 Experiment Design

Aimed at verifying RQ1, we applied a standard design with one factor and two treatments (WOHLIN *et al.*, 1999). The main factor of the underlying experiment, an independent variable, is perceived persuasiveness. The treatments or levels of this factor are the two interfaces, namely, non-gamified and gamified. However to answer RQ2 we did not use an experimental design since we run a path analysis trying to investigate hypothesized causal relations. Essentially, path analysis is not a substitute for experimental studies, but in our case it can be more useful considering the social nature of our variables (KREUTZER; DELUCA; CAPLAN, 2011). In this case, hypothetical models with the possible set of pathways are drawn containing the observed variables and non-recursive directions of the hypothesized causal relations between the variables (Figure 26). In order to collect data we performed a test following guidelines from Kohavi *et al.* (2009), Kohavi *et al.* (2012) and Rivero *et al.* (2014).

5.2.5 Instrumentation and Validity Evaluation

Susceptibility to persuasion, player types, need satisfaction, and perceived persuasiveness feedback on the interfaces were found through surveys handed out online. All instruments were previously validated in Borges *et al.* (2017), Andrade *et al.* (2016), Cordeiro *et al.* (2016), and Drozd, Lehto and Oinas-Kukkonen (2012), respectively.

1. Br-STPS - Brazilian Portuguese Susceptibility to Persuasion Scale;
2. Questionário Perfil do Jogador - Português do Brasil;
3. BPNSFS - Basic Psychological Need Satisfaction and Frustration Scale questionnaire;
4. Perceived persuasiveness;

5.2.6 Data Collection

Our experiment was broken down into two parts, consisting of the following steps listed in chronological order:

Part 1 - all participants answered the proposed surveys:

- Demographic information;
- Br-STPS - Brazilian Portuguese Susceptibility to Persuasion Scale;
- Questionário Perfil do Jogador - Português do Brasil.

Part 2 - random assignment, as mentioned, subjects were assigned to treatments at random:

- BPNSFS questionnaire;
- Graphical user interface evaluation (feedback on the persuasiveness).

Respondents of the main study were a convenience sample of 102 bachelor and graduated students enrolled in a Software Engineering course at University of São Paulo, Brazil. All students received an invitation and instructions about the forthcoming study. A total of 61 students volunteered to participate. Data were collected from March to April, 2017. We discarded (a) answers of the subjects that did not attend both parts of the study, and (b) all invalid questionnaires (i.e., incomplete, blank, or gamed³). A summary of participant's demographic information (N=18) is shown in Table 22. The majority of the participants were male (77.7%), mostly between 20 and 29 years old (83.3%) and pursuing a bachelor degree (77.2%).

Table 22 – Sample characterization (N=18)

		# of students	% of students
Gender	Female	4	22.3%
	Male	14	77.7%
Age	18-19	2	11.1%
	20-29	15	83.3%
	30-39	1	5.6%
Education (pursuing)	Bachelor's degree	13	77.2%
	Master's degree	3	16.7%
	Doctorate	2	11.1%

5.2.7 Data Analysis

This section examines whether there are significance between a gamified and a non-gamified interface harnessed by influence principles. It also involves examining the relationship between the perceived persuasiveness of the influence principles and the player types. The statistics analysis were calculated using R software (R Development Core Team, 2008) with the package Psych (REVELLE, 2016). In this section, we present the several steps necessary to analyze the collected data.

5.2.7.1 Descriptive statistics

Player roles were defined through QPJ-BR (ANDRADE *et al.*, 2016) and Borges *et al.* (2016a), and distribution of the estimated players roles are shown in Figure 27. Each bar represents one subject and the respective measurements for each player role. We normalized the data to a maximum of 100 points, and each player type varying from five (minimum score)

³ Responses from participants who contradictorily answered the attention questions.

to twenty (maximum score). According to Yee (2006) and as seen in Figure 27, a player can manifest interest in more than one category. However, usually players tend to manifest more affinity in few *dominant* player types. For example, subject 1 in Figure 27 scored in all five categories, however subject 1 scored higher as Explorer (17.6). Thus, in this study we classified the participants in one dominant player role by looking at highest scores obtained. We did this mainly for simplification sake, due the high number of variables vs observations (CHIN, 1998) and also based on the results presented at the end of Chapter 4.

Figure 27 – Distribution of the participants according to the estimated player roles N =18

Susceptibility to persuasion was measured using Br-STPS (BORGES *et al.*, 2017) and Need for satisfaction and frustration was measured with BPNSFS (CORDEIRO *et al.*, 2016). Figure 28 shows the distribution of the participants according to the scores of the estimated susceptibility to persuasion.

From Table 23 the scores given by the subjects to the interfaces did not greatly differ between non-gamified version of the interface and the gamified. The standard deviation for SI2 was smaller than for the other two non-gamified interface, while the standard deviation values for the gamified presented less variation. The Max values given to the non-gamified interface was unexpectedly higher in comparison with the gamified and the underlying hypothesis. Box plots were created for all versions of the interfaces (Figure 29). The box plots for GI1 and GI2 reveal a moderated consistence among the gives scores, and only GI3 shows that the scores increased slightly in the last week. The box plots for the non-gamified interface shows the same tendency, although the variation from totally disagree to totally agree was much more lower for the SI2 compared to SI3.

From Figure 29 we also can see that in the box plots for the gamified interface, the

Figure 28 – Distribution of the participants according to the estimated susceptibility to persuasion to each influence principle N =18

Table 23 – Descriptive statistics summarizing the scores given by the subjects to each interface

	<i>Standard Interface</i>			<i>Gamified Interface</i>		
	SI1	SI2	SI3	GI1	GI2	GI3
Max	27.00	24.00	28.00	24.00	25.00	26.00
Min	12.00	13.00	15.00	8.00	8.00	8.00
Mean	19.67	19.50	22.17	16.91	17.73	19.55
Median	19.00	20.00	22.50	17.00	17.00	20.00
Standard Deviation	5.09	3.99	5.49	4.66	4.90	5.26

lower tails in all three box plots are equal to the lower value possible (Totally Disagree). We individually analyzed answers of subjects on the extreme whiskers, but we did not treat them as outliers because of the very nature of Likert scales (i.e., subjectivity) (KLINE, 2005). The minimum score, per interface, is 4 (Strongly Disagree), and the maximum is 28 (Strongly Agree).

5.2.7.2 Hypothesis Testing

Table 24 summarizes descriptive statistics for the research constructs used. The validity of the scales were assessed in terms of internal consistency, discriminant validity, and items loadings. Although we observed some borderline results, as for example Cronbach's alpha for the QPJ-Br, we decided to proceed with the analysis given the other overall positive goodness-of-fit (RUMBERGER, 2011).

Answer for RQ1: In terms of perceived persuasiveness, has a gamified interface more influence on users than a non-gamified?

For the present RQ, we specify the direction of the difference in advance as: feedback on

Figure 29 – Individual box plots summarizing the data from the gamified interfaces (above) and non-gamified (below): from left to right, the scores given by the subjects to each version of the interface organized by week

Table 24 – Construct means and reliability scores for total sample

Construct	# items	Mean SD	Composite reliability	Cronbach's alpha
Susceptibility to persuasion (Br-STPS)	6	0.30 ± 0.76	0.90	0.70
Player roles (QPJ-Br)	5	0.68 ± 0.15	0.70	0.68
Perceived need satisfaction (BPNSFS)	3	0.72 ± 0.24	0.69	0.71
Perceived persuasiveness	3	0.88 ± 0.13	0.62	0.90

the gamified interface will be better than on the non-gamified interface. This can be verified by calculating the mean of the gamified interfaces (GI) scores to be significantly greater than the mean of the score of the non-gamified (standard interface- SI). Distribution of the samples are normal tested with Shapiro-Wilk test (TABACHNICK; FIDELL, 2012). Although the number of subjects in each group is different, the t-test can still be performed (WOHLIN *et al.*, 1999). Clearly, by looking at the results shown in column M_{GI-SI} at Table 25, the results are in the opposed hypothesized direction. It seems that the feedback given to the gamified interface was lower compared to the non-gamified feedback. Now we determine the confidence on the results by running t-tests. From Table 25 we can see the results of the t-tests. The p-values measured in each test are greater than 0.05. It turns out that we cannot reject the null hypothesis (**H1a**).

We also calculated Effect Size (ES) and Confidence Interval (CI), since these indicators are not affected by sample size (ROBERTSON; KAPTEIN, 2016). We used the guidelines shown

Table 25 – Results from the t-tests N=18

Factor	$M_{GI} - M_{SI}$	DF	t-value	p-value	ES	CI
GI1 vs SI1	16.91-19.67 = -2.76	11.41	-1.44	0.177	0.64	[-0.27, 1.53]
GI2 vs SI2	17.73-19.50 = -1.77	14.54	-1.21	0.244	0.54	[-0.35, 1.43]
GI2 vs SI2	19.55-22.17 = -2.62	12.20	-1.32	0.211	0.59	[-0.31, 1.48]

in AnnexB to analyze the implications of the ES and CI. No calculated CI include zero, and the absolute value of the effect size of all GUIs are greater than 0.05 (for simplifications sake we assumed them as large following guidelines found in Robertson and Kaptein (2016)). Also, the range of CI is large, thus there are some grounds to believe that there is an ongoing effect, although with our data, the actual effect can be much smaller (or larger) than our estimations.

Since there are many cases in which the p-value consistence is dependable of the number of the observations (ROBERTSON; KAPTEIN, 2016), we checked whether the size of the population might have some influence on the high p-values results. To verify that, first we used a Bayesian bootstrap method to resample our data (RUBIN, 1981). In statistics, bootstrapping are methods to sampling with replacement that allows assigning several measures of accuracy to the resampled data. We used Bayesian bootstrap because it uses a more powerful multinomial distribution than standard bootstrapping methods (BÅÅTH, 2015). Next, we run t-tests against the resampled dataset with 200 observations. This time all p-values were significant at 0.001. That is, increasing the sample size from 18 to 200 would give us significant results. Therefore, further examination is required (WOHLIN *et al.*, 1999).

Answer for RQ2: In terms of perceived persuasiveness, has a tailored gamified interface more influence on susceptible users than on resistant ones?

In order to investigate the remaining hypothesis we come up (from H2 to H6), the answers of the group that interacted with the gamified GUIs were further examined. The total sample size of the this group was 12 (N = 12). We used PLS mostly because it is a less strict approach than others, and it still can provide valid results in case of small samples due to the non parametric characteristics (TENENHAUS *et al.*, 2005; WOLF *et al.*, ; HAIR, 2013). We performed the analysis exploring several models on SmartPLS 3.0 (RINGLE; WENDE; BECKER, 2017).

Figure 30 shows a path diagram that summarizes the results of our structure model analysis. As explained in Chapter 4, the objective of PLS is to demonstrate explained variance in latent variables (R^2) to show the strength of the relationship between latent variables (β), by estimating t-values and respective p-value (CHIN, 1998). Since p value is a continuous measure of evidence highly affected by the size of the sample (Figueiredo Filho *et al.*, 2013) and the given preliminary stages of our exploratory study, we established a less strict threshold of 10% for p value ($p < 0.1$) (KNAUB, 1987). Also, prior the path analysis, we assessed the reliability and validity of the model, as summarized in Table 24.

Figure 30 shows the results of the PLS analysis. Most results show some evidence to support the model, although the relationship between player role and perceived need satisfaction ($\beta = -0.06$, $p = 0.8$) was not supported. The remaining hypothesis were all significant. Perceived susceptibility to persuasion ($\beta = 0.65$, $p = 0.001$) explains 42 percent of the variance in player role. Player role ($\beta = -0.45$, $p = 0.1$) and perceived need satisfaction ($\beta = -0.59$, $p = 0.02$) explain 52 percent of the variance in perceived persuasiveness.

Figure 30 – Path diagram displaying the results of the PLS analysis

We found a strong relationship between perceived susceptibility to persuasion and player role ($\beta = 0.65$, $p = 0.001$). Due to the limitations imposed by our sample size, we were unable to investigate the strangeness of the relationship for subgroups (i.e., male and female). Further analysis between perceived susceptibility to persuasion and each player roles shown some interesting results. Although overall standardized effect size shows a positive influence path between the constructs, individual analysis of the player roles shows a different story. Only humanist and creator shown a positive path coefficient, while the other three player roles shown a negative relationship. Creator was the strongest positive relationship between perceived susceptibility to persuasion and player role ($\beta = 0.64$, $p = 0.001$) while achievers the strongest negative ($\beta = -0.74$, $p = 0.001$).

We did not presented our further examination on the relationships between each player roles and perceived need satisfaction to perceived persuasiveness because sub-groups analysis did not achieved the statistical significance threshold. Table 26 show the path coefficients and R^2 for overall perceived susceptibility to persuasion and each player role.

However the most interesting finding was the negative effect of the tentative to persuade the subjects. Although player role and perceived need satisfaction explain 52 percent of the

Table 26 – Path coefficient and R^2 for PSP→Play Role

Player role	Coefficient (β -values)	R^2
<i>Achiever</i>	-0.74	0.54
<i>Explorer</i>	-0.43	0.18
<i>Humanist</i>	0.56	0.32
<i>Conqueror</i>	-0.45	0.24
<i>Creator</i>	0.64	0.41

variance in perceived persuasiveness, in both cases we measured a significant negative direct effect. Thus, evidence indicates that subjects already motivated (high scores in need satisfaction) and with a player mindset established (high scores in at least one dominant player role) were less prone to be persuaded. In other words, with this population, we did not observe the presumed effect (positively influence all users to accept the invitation to join the learning groups, as asked by the system), instead we observed that the subjects with higher scores in need satisfaction reacted negatively to the persuasive attempt.

Figure 31 shows a correlogram of the perceived persuasiveness and perceive need satisfaction correlations. In the correlogram, blue means a positive correlation, red a negative one, the little pie charts shows the proportional value of the correlation. Crossed pie charts did not reach significance. Although only three observations reach the threshold for significance, we still can derive some interesting observations. GUI1 used mainly the Authority principle, as we can see students with higher scores in relatedness and competence (i.e., satisfied, not demotivated) shown low perceived persuasiveness. GUI2 mainly used reciprocity principles, and students who scored high in competence had low rates of perceived persuasiveness.

Figure 31 – Correlogram of perceived persuasiveness and perceived need satisfaction

We will now answer the remaining hypotheses, related to RQ2. The hypothesis are repeated here for convenience.

- **Null hypothesis, H2a:** *Player role* has no influence on perceived *need satisfaction*.

Answer: observed coefficients for the relationship between player role and perceived need satisfaction did not achieve the statistical significance threshold, then the hypothesized path H2 was trimmed (SASSENROTH, 2013). Therefore, we cannot reject the null hypothesis (H2a).

- **Null hypothesis, H3a:** *Player role* has no influence on the *perceived persuasiveness* to use the system.

Answer: we observed that player role (and perceived need satisfaction together) explained 52 percent of the variance in perceived persuasiveness. By observing the coefficient weight of the relationship between player role and perceived persuasiveness ($\beta = -0.45$, $p = 0.1$) we can refute the null hypothesis (H3a), backing up the alternative that player roles has influence on the perceived persuasiveness on the intention to comply with the system's request to join groups.

- **Null hypothesis, H4a:** Perceived *need satisfaction* has no influence on the *perceived persuasiveness* to use the system.

Answer: Perceived need satisfaction contributed to 52 percent of the variance in the answers of perceived persuasiveness construct (along with player role). The weight of the coefficient between both constructs was significant ($\beta = -0.59$, $p = 0.02$), thus we can refute null hypothesis (H4a), backing up the alternative that perceived need satisfaction can influence the intention to comply with the system.

- **Null hypothesis, H5a:** Perceived *susceptibility to persuasion* has no influence on the *player role*

Answer: Perceived susceptibility to persuasion explained 42 percent of the variance in player role, and the relationship between perceived susceptibility to persuasion and overall player roles weighted ($\beta = 0.65$, $p = 0.001$). Also, we were able to test other models for each player role. Each player role tested shown different significant results that explains the variance of the influence of the persuasion strategy on each player role. Since p-value achieved the statistical significance threshold, we can refute the null hypothesis (H5a). That is, evidence suggest that different player reacts in different ways to persuasion attempts. Therefore we can conclude that choosing a counter-tailored persuasive strategy can trigger a backfire effect.

5.3 Know Limitations

First, we tested the hypothesis regarding higher persuasiveness for students evaluating a gamified interface than a non-gamified. The results were not clear whether a gamified interface is more persuasive than a non-gamified interface. We conjecture that one of the factors that affected the test is related to social desirability bias. In self-reported measures, as the ones used in this study, in some situations subjects tends to gave not a genuine answer but instead what they considered the *desirable answer* (ARMITAGE; CONNER, 1999). Another factor we conjecture that might have affected the results of the tests was the size of the sample we were able to collect. We used a convenience sample, thus we could not generalize the conclusions. An important issue raised with the experiment it was the lack of commitment of the subjects to finish the study. We invited a population of 102 students, 61 attended the first part, and in the second and final step, only 26 subjects participated. Finally, we evaluated the quality of the answers of this subset, and after eliminating invalid questionnaires we were able to use the answers of only 18 subjects.

5.4 Concluding Remarks

Selecting effective persuasive strategies is difficult. Most of this complexity is related to the task of selecting appropriate strategies that can stimulate one user without halting the motivation of other one. This is important because when students perceive a counter-tailored influence attempt they can react negatively to it, triggering a backfire effect. As discussed we classified the students in one dominant player role and compared their susceptibility to persuasion of each influence principle searching for behavioral patterns. We observed a moderated tendency on less motivated students to be more likely to accept the suggestions of the prototypes, whereas users with above-average motivation (among observed students) reacted negatively to influence attempts by showing low perceived persuasiveness. As shown in this chapter, evidence suggests that perceived susceptibility to influence principles differs from one player to another. We believe that measuring main user's combination of susceptibility to persuasion and motivation to play can help designers and practitioners to decide for the appropriate *persuasive frame* to implement the desired GDE. Given the focus of the research herein described, in the present chapter, despite the size of the investigated sample, the information extracted from the study was significant and the experience was useful and gave us evidence that our theory is viable and propitious.

CONCLUSIONS AND FUTURE WORK

In this chapter, we revisit the research problem and the RQs (Section 6.1). Outlining the findings of our research, we further elaborate on the advantages and disadvantages of tailoring influence principles to gamification (Section 6.2). This chapter also restates the contributions (Section 6.3), discusses the current limitations of our conceptual frameworks, psychometric instrument, and models developed, suggests future research directions (Section 6.5), and ongoing partnerships (Section 6.6). We conclude the chapter with discussing on the relevance of this research (Section 6.8).

6.1 Research Problem and RQs Revisited

Our surveys of the literature, along with our own experiences, led us to believe that most research on gamification have been focused on the positive outcomes although fewer attention have been paid to the ways to implement gamification. Few efforts have tried to implement gamification with the support of social psychology theories. We argued that tailoring gamification initiatives to users in education could offer several advantages. First, it would open up possibilities for further improvement of meaningful gamification approaches. In other words, gamified educational software would better motivate students when personalized and back up by social psychology theories, therefore avoiding the implementation of shallow gamification approaches.

Second, it would be possible to enhance the efficacy of gamified interventions by avoiding the implementation of counter-tailored persuasive strategies. So, this dissertation tackled the research problem of investigating whether gamification can be enhanced to provide a sound basis for implementing sound gamified interventions that might help the design and development of gamified leaning systems. Based on this research problem, two RQs were formulated. Considering our findings, these RQs are answered as follows.

- **RQ1:** How can gamification be harnessed to increase its efficacy at motivating individuals to join constraint-based groups in CSCL?
 - Given the results of our systematic mappings, we observed that (a) most group formation strategies are constraint-based, which from the cognitive viewpoint is the best solution, from a motivational viewpoint this is not always true; in addition, (b) most gamification strategies are focused on extrinsic rewards and one-size-fits-all solutions. In most cases the rationale behind (a) and (b) approaches is given the lack of constructs and models tailored to aid researchers and practitioners designing and developing personalized gamified solutions. Thus, we addressed RQ1 by designing, adapting and implementing a testing infrastructure within several psychological constructs. Next, we set out to demonstrate the feasibility of capitalizing on influence principles to tailor gamification. We designed approaches to investigate the perceived persuasiveness of six influence principles to five player roles, and the resultant models were used to guide the design of tailored gamified user interfaces that were used in an experiment. The models created are presented in Chapter 4, and therefore can facilitate the design of tailored persuasive interventions. The feasibility of the models is presented in Chapter 5, where several mock-ups were presented to students and the perceived persuasiveness investigated. Thus, the answer to RQ1 is that one way that gamification can be harnessed to support group formation is by tailoring its content with susceptibility to persuasion of the individuals.
- **RQ2:** Is there value in tailoring gamification to harness willingness to join groups?
 - Our results suggest that the benefits provided by gamification might be suited to influence learners to join a group. On the other hand, acquiring necessary knowledge about users and avoiding delivering counter-tailored solutions to users has proved challenging. Essentially, the problem is understanding to what extent users are genuinely (i.e., intrinsically) complying with the request, or under the pressure to accept the it. In our experience, we did not observe difference in the rate of acceptance to join a group using a non-gamified and a gamified interface. We found however evidence of different rates of acceptance and rejection among users of the gamified interface. Although our observations failed to reach power analysis standards, we notice small evidence that might not be desirable using motivation on subjects with high measurements of need satisfaction. And for those subjects with moderate or low measurements of need satisfaction, tailored solutions seem to work better than random or counter-tailored ones. Summing up, our findings indicate that the answer to RQ2 is that tailoring gamification interventions can benefit the rates of compliance however on individuals in need of such incentives.

6.2 Persuasion Profiling: What are the advantages of tailoring gamification interventions with influence principles?

Basically, further investigation is necessary, but evidence suggests that susceptibility to persuasion works better on individuals with moderate to low measures of need satisfaction, and has a counter effect on individuals already motivated. Moreover, in both studies shown in chapter 4 and 5, most of the students reacted negatively to the Authority principle, regards the measurement of their need satisfaction.

For instance, in our experiences most creator, explorer and humanist students have positive reactions to scarcity, while authority aroused strongly rejection. Analyzing users' persuasion profile and knowing beforehand what triggers and halts their users could help researchers and practitioners to better accomplish their role, deliver more reliable systems, and avoid the negative effects of counter-tailored solutions. That is, one-size-fits-all gamification relies on primarily analyzing and understanding the target group. Tailored solutions demands a deeper analysis of the target group to delivery appropriate content.

Since there are all kind of costs involved in designing and developing a complete custom learning system, prior understanding of the target group can be useful to maybe eliminated superfluous or unnecessary personalizations. Our results suggest that gamification can benefit from the use of influence principles to enhance meaningful personalization.

6.3 Summary of Contributions

We systematically surveyed the literature describing research into group formation and gamification. In the CSCL domain, we found that most studies are concentrated on constraint-based group formation for boosting performance and learning gains. Furthermore, the results of this systematic mapping suggest that the cognitive path are by far the most investigated within academic settings, and that the motivational path has grab fewer attention. In the gamification on education domain, we found that most studies are concentrated on the hypothesized benefits of gamified learning systems and less on the way to systematic implement the use of gamification in education. These findings add to a growing body of literature on understanding trends in CSCL and gamification research. Our conceptual framework and the categorization scheme we devised can be used to aid analyzing and understanding proposed group formation approaches. Moreover, it may be useful as a support tool to aid planning new ones. We also create an infographic to summarize our findings, available at: <http://infografico.caed-lab.com/mapping/gfc/>

Our cross-cultural adaptation and validation of the Susceptibility to Persuasion Scale is a vital step towards the development of an adaptive persuasive system in the field of Computer-

Supported Collaborative Learning (CSCL) in Brazilian Portuguese. For the Brazilian community, we have start validating a measurement tool that can help all those interested in the design and development of adaptive persuasive systems. Overall, although our final version ended up with less questions then the original one, the results of the adapted questionnaire are similar to the results found in the original one. We were able to find six factors underlying the adapted STPS, with overall Cronbach's alpha 0.78. Moreover we are making available the online application we developed so, researchers and practitioners interested in using the Br-STPS online can benefit of our application. We also developed a survey generator to feed our Facebook application, therefore minimizing the inherent problems associated to hard coded content. In the actual version, our tool can only manage one kind of survey at time (e.g.: Br-STPS). We intend to make tool available so people interested in an application can create and manage their own questionnaires.

Also, we devised a conceptual framework that outline ways to relate player roles found in game design and gamification literature and possible ways to tailor persuasive strategies based on Cialdini's six influence principles in a systematic way. We posit that is possible to improve learners' experience, by providing personalized situations, thereby contributing to minimize potentially harmful aspects of gamification, such as being disruptive or unattractive to some users. By identifying learners' motivation to play, we can choose appropriate players' roles for each learner. Moreover, instead of classifying learners in a static manner, we devised roles that can be played in order to satisfy not only constraints related to the learning objectives but also the kind of constraints regarding the gamified CL environment. Although some studies have already applied gamification in different cases, most efforts fail to provide a rationale to back up these research efforts. Furthermore, some studies do not rely on social psychology theories, relying only on ad hoc choices of both gamification techniques and persuasive strategies.

The implementations to investigate the perceived persuasiveness were discussed in terms of the web-based mock-ups implemented. We argue that this is not a limitation. We believe that most of the ideas that were discussed can be transferred into other design and implementation solutions (KOHAVI *et al.*, 2009; RICCA *et al.*, 2010).

6.4 Limitations

While our conceptual frameworks, models, and proof-of-concept designed supports our hypothesis that gamification can be tailored and augmented with influence principles, its design has some limitations.

- Limitations of the Br-STPS:
 - Towards fulfilling the item equivalence between the original and translated questionnaire, we eliminated 09 items during the cross-cultural adaptation process. Although this can be considered a normal outcome when translating and adapting psychometric

instruments, we end up with an adaptation of the original instrument. Our guess is that the semantic equivalence of some items was not achieved since the message implied by some items may have more than one connotation for different Brazilian speakers.

- Limitations of our definition of player roles:
 - We presented a non-exhaustive compilation of behaviors and player's types. It is important to remember that, as stated before, there is no guarantee that all behaviors can be useful or appropriate for an educational environment, therefore behaviors should be carefully chosen to avoid triggering undesirable interactions.
 - We used such information as a starting point to devise appropriate behaviors that one can use in a gamified CL environment to foster learning. By appropriate we mean behavior that is able to motivate learners to play and at the same time satisfies their respective psychological needs established by SDT. As any model, the scheme presented in is a simplification of the reality and, as such, it has some drawbacks, as it cannot be extended for an entire population.
- Limitations of the guidelines for tailoring influence principles to gamification:
 - We did not present a definitive list of GDE and their relationship to each and all Cialdini's six influence principles. The GDE listed were extracted from different sources related to game and gamification design literature.
 - The relationships between influence principles to GDE can be seen as a first step towards the exploration of affinity, but not a definitive guide. In addition, we applied the results of the models at a level of the high-educated population, so the results cannot be extended to the population.
 - Although the observed models can present some benefits to designers, by any means they represent a better or definitive solution than other game design approaches.
- Limitations of the inherent to the mock-ups usage:
 - In our experiment we quantified and validated the perceived persuasiveness of influence principles and gamed design elements throughout prototypes. In particular, we used the same approach as by (RICCA *et al.*, 2010; DROZD; LEHTO; OINAS-KUKKONEN, 2012; ORJI; VASSILEVA; MANDRYK, 2014). As we explained before, to reduce this potential threat, the prototypes were carefully built by a team of professionals, some of them with at 10 years of experience in the web design and development.

6.5 Future Research Directions

We believe that the resulting constructs, guidelines and models can be seen as an important step towards facilitating the creation of students models in intelligent learning systems. The research described in this document can be continued in several directions:

- Although functional, the conceptual frameworks are subject for further improvements. The frameworks could benefit from the implementation of systems to automatize their utilization and to persist the results obtained.
- In addition, we are continuously analyzing and improving the proposed player roles model.
- Br-STPS is implemented as a Facebook application. We intend to create a new version that runs independent of Facebook's support. This independent version can be used as a tool for researchers and practitioners (e.g., teachers) interested in evaluate susceptibility to persuasion of group of users (e.g., students in a class) and generate reports summarizing the findings.
- In the experiment described in Chapter5 we were unable to observe whether a gamified interface can be more persuasive than a non-gamified one. In future work we intend to investigate more appropriate ways to present all necessary information to the subjects and how to measure their answers in more consistent ways.
- Also, in the experiment described in Chapter5 we were unable to observe all possible relationships (neither positive or negative influence) between each influence principle and player roles, thus further examination is required.
- Regarding current and future work in the proposed approach, it is our intention to continue testing and validating it through the development of a real application. We are particularly interested in:
 - Mapping elements of persuasive design (persuasive UX design) and game elements, to support the development of gamified web systems;
 - How to avoid the use of so many questionnaires to create students' persuasion profiling;
 - How the information summarized in the persuasion profiling can be used to adapt the system to user's need.
 - How to employ Recommendation System theory to make use of all devised information.

6.6 Partnerships

- **Project:** Augmented reality application to teach solid geometry
 - *Lead researchers:* Prof.Dr. Marcelo de Paiva Guimaraes (Faculdade Campo Limpo Paulista) and Prof. Dr. Diego Roberto Colombo Dias (Universidade Federal de São João del Rei)
 - *Theme:* Teaching solid geometry concepts is notably complex. Part of this difficulty stems from the fact that textbooks illustrate inherently three dimensional content using two dimensional images. This study investigated the advantages of using augmented reality to teach solid geometry concepts to school children aged eight to nine years. Thus, this project conjectures that augmented reality can be used to better impart solid geometry knowledge to students while at the same time engaging students and increasing their rapport throughout the learning process (ALVES *et al.*, 2017).
 - *Publication:* ALVES, B.; DIAS, D. R. C.; **BORGES, S. S.**; DURELLI, V. H. S.; BRESSAN, P. A.; MARTINS, V. F.; de Paiva Guimarães, M. On Capitalizing on Augmented Reality to Impart Solid Geometry Concepts: An Experimental Study. In: . Universal Access in Human–Computer Interaction. Designing Novel Interactions: 11th International Conference, UAHCI 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9–14, 2017, Proceedings, Part II. Springer International Publishing, 2017. p. 105–117.
- **Project:** A gamified web application to teach Refactoring
 - *Lead researcher:* Prof. Dr. Rafael Serapilha Durelli (Universidade Federal de Lavras)
 - *Theme:* This project aims to investigate how gamification can be used to improve teaching refactoring in software engineering courses.
 - *Website:* <http://pesquisa.dcc.ufla.br/refactory/>

6.7 Publications and Related Work

During the development of this research, several articles were published with different relevance for this thesis. Other scientific contributions were made, although with the participation of the author of this thesis as a collaborator.

6.7.1 *My Peer-reviewed publications*

6.7.1.1 *Journal Papers*

1. **BORGES, S. S.**; REIS, H. M.; MARQUES, L. B.; DURELLI, V. H. S.; BITTENCOURT, I. I.; JAQUES, P. A.; ISOTANI, S. Reduced GUI for an interactive geometry software: Does it affect students' performance? *Computers in Human Behavior*, v. 54, p. 124–133, 2016.
2. **BORGES, S. S.**; REIS, H.; MORO, L.; DURELLI, V.; ISOTANI, S. Agrupamento Balanceado de Sujeitos a fim de Testar a Interface Gráfica de um Software de Geometria Interativa. In: *RENTE*. 2013. v. 11, n. 1, p. 1–10.

6.7.1.2 *Book Chapter*

1. **BORGES, S. S.**; MIZOGUCHI, R.; DURELLI, V. H. S.; BITTENCOURT, I. I.; ISOTANI, S. A Link Between Worlds: Towards a Conceptual Framework for Bridging Player and Learner Roles in Gamified Collaborative Learning Contexts. In: . *Advances in Social Computing and Digital Education*. Springer International Publishing, 2016. v. 677, p. 19–34.

6.7.1.3 *Full Conference Papers*

1. **BORGES, S. S.**; MIZOGUCHI, R.; DURELLI, V. H. S.; BITTENCOURT, I. I.; ISOTANI, S. Towards a Conceptual Framework for Bridging Player Roles and Learner Roles in Gamified Collaborative Learning Contexts. In: *2nd International Workshop on Social Computing in Digital Education*. 2016. p. 1–13.
2. **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 - SAC '14*. New York, New York, USA: ACM Press, 2014. p. 216–222.
3. **BORGES, S. S.**; REIS, H. M.; DURELLI, V. H. S.; BITTENCOURT, I. I.; JAQUES, P. A.; ISOTANI, S. Gamificação Aplicada à Educação: Um Mapeamento Sistemático. In: *Simpósio Brasileiro de Informática na Educação*. 2013. p. 234–243

6.7.1.4 *Short Conference Papers*

- **BORGES, S. S.**; ISOTANI, S.; DURELLI, V. H. S.; REIS, H. M. Brazilian Portuguese Cross-Cultural Adaptation and Validation of the Susceptibility to Persuasion Scale (BR-STPS). In: *IEEE 17th International Conference on Advanced Learning Technologies*. Timisoara: IEEE Computer Society, 2017. p. 1–2.

- **BORGES, S. S.**; ISOTANI, S. An Approach for Spontaneous Formation of High- performance Groups in Intelligent Collaborative Learning Environments Using Gamification. In: 3rd Workshop on Intelligent Support for Learning in Groups. Hawaii, 2014. p. 2–5.

6.7.2 Collaborations in other peer-reviewed publications

6.7.2.1 Journal Papers

1. CHALLCO, G. C.; ANDRADE, F. H. ; **BORGES, S. S.**; BITTENCOURT, I. I.; ISOTANI, S. Toward A Unified Modeling of Learner’s Growth Process and Flow Theory. *Journal of Educational Technology & Society*, v. 19, n. 2, p. 13, 2016.
2. HENRIQUE, J.; **BORGES, S. S.**; GUILHERME, I. R; REIS, H. M. Softwares de Geometria Interativa para Deficientes Físicos e Intelectuais : Um Mapeamento Sistemático. *RENTE*, v. 14, n. 2, p. 10, 2016.
3. REIS, H. M.; **BORGES, S. S.**; ISOTANI, S. Análise de Usabilidade de Sistemas de Geometria Interativa para Tablets. *Renote*, v. 12, n. 1, p. 1–10, 2014

6.7.2.2 Full Conference Papers

1. DURELLI, V. H. S.; DURELLI, R. S.; **BORGES, S. S.**; ENDO, A. T.; ELER, M. M.; DELAMARO, M. E. On the costs of applying logic-based criteria to mobile applications : An empirical analysis of predicates in real-world Objective-C and Swift applications. In: *SAST 2017 – 2o Simpósio Brasileiro de Teste de Software Sistemático e Automatizado*. 2017. p. 1–8.
2. ALVES, B.; DIAS, D. R. C.; **BORGES, S. S.**; DURELLI, V. H. S.; BRESSAN, P. A.; MARTINS, V. F.; de Paiva Guimarães, M. On Capitalizing on Augmented Reality to Impart Solid Geometry Concepts: An Experimental Study. In: . *Universal Access in Human-Computer Interaction. Designing Novel Interactions: 11th International Conference, UAHCI 2017, Held as Part of HCI International 2017, Vancouver, BC, Canada, July 9–14, 2017, Proceedings, Part II*. Springer International Publishing, 2017. p. 105–117.
3. ISOTANI, S.; PEDRO, L. Z.; REIS, H. M.; **BORGES, S. S.**; LOPES, A. M. Z.; SOUZA, J. P. T.; BRANDÃO, A. A. F.; BRANDÃO, L. O. Interactive geometry goes mobile with GeoTouch. In: *IEEE. Advanced Learning Technologies (ICALT), 2014 IEEE 14th International Conference on*. 2014. p. 181–185.
4. PEDRO, L. L. Z.; **BORGES, S. S.**; LOPES, A. M. Z.; SOUZA, J. P. T.; BRANDÃO, A. A. F.; BRANDAO, L. O.; ISOTANI, S. Projeto e Desenvolvimento de um Aplicativo de Geometria Interativa para Dispositivos Móveis. In: *Anais do Simpósio Brasileiro de Informática na Educação*. 2012. p. 26–30.

5. REIS, H.; **BORGES, S. S.**; ISOTANI, S.; GASPARINI, I. Rehabilitation Using Kinect and an Outlook on its Educational Applications: A Review of the State of the Art. In: Anais do XXVI Simpósio Brasileiro de Informática na Educação (SBIE 2015). 2015. p. 8.
6. REIS, H. M.; **BORGES, S. S.**; DURELLI, V. H.; Fernando de S. Moro, L.; BRANDAO, A. a.F.; BARBOSA, E. F.; BRANDAO, L. O.; JAQUES, P. a.; BITTENCOURT, I. I.; ISOTANI, S. Towards Reducing Cognitive Load and Enhancing Usability through a Reduced Graphical User Interface for a Dynamic Geometry System: An Experimental Study. In: 2012 IEEE International Symposium on Multimedia. IEEE, 2012. p. 445–450
7. REIS, H. M.; **BORGES, S. S.**; GRIFFITHS, P. a.; MORO, L. F. S.; ISOTANI, S. Interação em Interfaces de Softwares de Geometria Interativa: Um Mapeamento Sistemático. In: Simpósio Brasileiro de Informática na Educação. 2013. p. 255–264.

6.7.2.3 Short Conference Papers

1. ZEM-LOPES, A. M.; PEDRO, L. Z.; ANDRADE, F. R. H.; ISOTANI, S.; **BORGES, S. S.**; ISOTANI, S. Tecnologias da Web Semântica em Ambientes Educacionais: uma Revisão Sistemática. In: Simpósio Brasileiro de Informática na Educação. 2013. p. 977–981.

6.8 Overall Conclusions

This research has provided insights into the importance of tailoring persuasive interventions to students with different motivations to play. It also supplied insights on how tailored influence principles can capitalize on students' motivations to play to motivate them towards action. Although many studies have already applied gamification in different cases, most efforts fail to provide a rationale to back up these research efforts. Furthermore, some studies do not rely on sound social psychology theories, relying only on ad hoc choices of gamification techniques.

Designing personalized persuasive systems is difficult. Most of this complexity can be associated to the design of models that represents individuals or group of individuals. Moreover, selecting persuasive strategies to influence and motivate users is made usually by intuition and relying on shortcomings of personality traits abstractions. In this study, we provided sound ways to associate persuasive strategies based on influence principles to motivations to play. We outlined ways to relate player roles found in game design and gamification literature and possible ways to connect these player roles to persuasive strategies in a systematic way. We posit that is possible to improve learners' motivation, by providing personalized situations, thereby contributing to minimize potentially harmful aspects of gamification, such as being disruptive or unattractive to some users. By identifying learners' motivation to play, we can choose appropriate players' roles for each learner in different gamified learning scenarios. Moreover, instead of classifying learners in a static manner, we devised roles that can be played in order to satisfy not

only constraints related to the learning objectives but also the kind of constraints regarding the gamified learning environment.

Thus, this study also presented the translation, cultural adaptation, and initial validation of the Brazilian Portuguese version of the STPS questionnaire. First, we translated and adapted the original STPS. Afterwards, we set out to validate the target STPS questionnaire. After the first phase, we obtained a new instrument that is equivalent to the original in terms of semantic and content. In the second phase, we probed into the validity and reliability of the resulting questionnaire with 582 participants. For this research, the adaptation and validation of such instrument was a vital step measuring students susceptibility to persuasion, for the Brazilian community, we have start validating a measurement tool that can help all those interested in the design and development of adaptive persuasive systems. Our results indicate that the final version of our questionnaire, which contains 23 items and 6 components, has a reasonable internal consistence (Cronbach's = 0.74) and can adequately identify which influence principles have more impact on user' decisions.

In addition, we also provide evidence that less motivated students were more prone to accept the suggestions coming from a system than students with above-average motivation scores. We also observed that in the three studies we conducted ($N = 648$), Authority was always the less efficient influence principle. Most students had a negative reaction to its use. Not all students had a negative reaction; however, the fewer students who had a positive one show a low average rate of perceived persuasiveness. We can conjecture that when facing imposed requests, most learners will comply with the system (if not optional, as most solutions found in the literature) however at the risk of demotivating them. On the other hand, when students have option, especially well motivated users can perceive extraneous attempts of motivation as an disturbance and refuse to comply. While, less motivated students can benefit of tailored persuasive attempts, more likely to create a positive experience. Therefore, designers and practitioners can promote learners motivation by avoiding elements that demotivated them, posing unnecessary interventions, and tailoring persuasive strategies for students in need of it.

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GLOSSARY

Endogenous: Originating internally.

Exogenous: Originating externally.

Nintendo: Japanese multinational company headquartered in Kyoto, Japan.

Primary studies: published articles in a given field of interest.

Systematic mapping: a method that involves searching the literature for gauging the extension and the amount of primary studies.

STUDY INSTRUMENTS

Informações pessoais

Gênero: ☐ Masculino ☐ Feminino ☐ Outro ☐ Prefiro não informar

Idade: ☐ anos

Ano na faculdade: ☐ 1º ano ☐ 2º ano ☐ 3º ano ☐ 4º ano

QUESTIONÁRIO PERFIL DO JOGADOR

Instruções: Este questionário tem como objetivo conhecer os padrões de interação dos usuários de jogos digitais (vídeo games, jogos online e/ou jogos de celular). Por favor escolha um dos números na escala que melhor expresse a sua opinião em relação a si mesmo e assinale-o, colocando uma cruz (X) na coluna correspondente à sua opinião. Não existem respostas certas, nem erradas!

Parte I - Utilize a seguinte escala:

1-Nada importante | 2-Pouco Importante | 3-Tanto faz | 4-Importante | 5-Muito importante

Para você, o quão importante é...

1. Tornar-se muito bom em um jogo?
2. Comparar seu desempenho em relação a outros jogadores?
3. Acumular recursos, itens ou dinheiro em um jogo?
4. Conseguir recompensas por completar um desafio?
5. Ser bem conhecido no jogo?
6. Conhecer as regras do jogo?
7. Prever os movimentos de um oponente ou situações do jogo?
8. Competir com outros jogadores?
9. Estar em vantagem em relação aos outros jogadores?
10. Combinar cor e estilo das roupas/armaduras/itens de seu personagem?
11. Fazer com que a aparência do seu personagem seja diferente da aparência do personagem

dos outros jogadores?

12. Concluir os objetivos ou etapas do jogo apenas com as suas habilidades, sem a ajuda de ninguém?

13. Conhecer coisas sobre o jogo das quais a maioria dos outros jogadores não tem conhecimento?

14. Coletar objetos ou itens que não fornecem pontos nem ajudam a progredir no jogo de forma direta?

15. Ajudar outros jogadores?

16. Conversar com outros jogadores?

17. Fazer parte de um grupo (guilda, party, equipe)?

18. Conseguir concluir os objetivos ou etapas do jogo sem a ajuda de outros jogadores?

19. Cooperar com outros jogadores do grupo?

20. Entender as regras, os cálculos e detalhes por trás do funcionamento do jogo?

21. Fazer amizade com outros jogadores?

22. Inventar histórias para seus personagens?

23. Gastar bastante tempo na tela inicial do jogo criando seu personagem até ele ficar do jeito que você quer?

Parte II - Utilize a seguinte escala:

1-Nunca | 2-Raramente | 3-Não tenho certeza | 4-Frequentemente | 5-Sempre

Com que frequência você...

1. Joga para evitar pensar sobre algum problema ou preocupação da vida real?

2. Joga para relaxar após um dia de trabalho/estudo?

3. Joga para escapar da realidade?

4. Joga para derrotar outros jogadores?

5. Joga porque gosta de explorar cada mapa ou região do jogo?

6. Joga porque gosta de interpretar diferentes personagens em um jogo?

7. Joga porque gosta de estar imerso em um mundo de fantasia?

8. Passa muito tempo procurando itens e acessórios para customizar a aparência do seu personagem ou o jogo em si?

9. Faz coisas que incomodam outros jogadores?

10. Tem conversas significativas com outros jogadores?

11. Conversa com outros jogadores (online) sobre seus problemas/questões pessoais?

12. Aceita ajuda de outros jogadores para resolver problemas na vida real?

13. Tenta provocar ou irritar de propósito outros jogadores?

Questionário – SATISFAÇÃO COM TRABALHOS OU ATIVIDADES DE ESTUDO EM GRUPO (BPNSFP)

Instruções: Abaixo, vamos fazer algumas perguntas relacionadas suas experiências com relação a trabalho em grupo. Por favor escolha um dos números na escala que melhor expresse a sua opinião em relação a si mesmo e assinale-o, colocando uma cruz (X) na coluna correspondente à sua opinião. Não existem respostas certas, nem erradas!

Utilize a seguinte escala:

1-Discordo totalmente | 2-Discordo | 3-Não sei | 4-Concordo | 5-Concordo totalmente

Quando participo de atividades de estudo em grupo...

1. Eu sinto que tenho bastante liberdade e posso escolher as coisas que quero fazer.
2. A maioria das tarefas que faço, sinto que faço “porquê tenho de fazer”.
3. Eu sinto que as pessoas com quem me importo também se preocupam comigo.
4. Eu me sinto excluído (a) do grupo que quero participar.
5. Eu me sinto confiante de que posso fazer as coisas direito.
6. Eu tenho sérias dúvidas se consigo ou não fazer as coisas direito.
7. Eu sinto que minhas decisões no grupo refletem exatamente o que quero fazer.
8. Eu me sinto forçado (a) a fazer várias coisas que se pudesse escolher eu não faria.
9. Eu me sinto conectado (a) às pessoas que se importam comigo e são importantes para mim.
10. Eu sinto que as pessoas que são importantes para mim são frias e distantes comigo.
11. Eu me sinto competente naquilo que faço.
12. Eu me sinto desapontado (a) com meu desempenho no grupo.
13. Eu sinto que minhas decisões expressam quem eu sou realmente.
14. Sinto-me pressionado a fazer muitas coisas.
15. Eu me sinto próximo e conectado as outras pessoas que são importantes para mim.
16. Tenho a impressão de que as pessoas com quem passo o tempo não gostam de mim.
17. Eu me sinto competente para alcançar meus objetivos.
18. Eu me sinto inseguro (a) sobre minhas habilidades.
19. Eu sinto que tenho feito o que realmente me interessa.
20. As tarefas que me dão parecem um monte de obrigações.
21. Eu me sinto confortável junto às pessoas do grupo.
22. Eu sinto que o relacionamento com o grupo é superficial.
23. Eu sinto que posso realizar tarefas difíceis com sucesso.
24. Eu me sinto um fracasso por causa dos erros que cometo.

Questionário – SUSCEPTIBILIDADE À ELEMENTOS DE PERSUASÃO em PORTUGUÊS DO BRASIL

Instruções: Abaixo, vamos fazer algumas perguntas relacionadas suas experiências com relação a trabalho em grupo. Por favor escolha um dos números na escala que melhor expresse a sua opinião em relação a si mesmo e assinale-o, colocando uma cruz (X) na coluna correspondente à sua opinião. Não existem respostas certas, nem erradas!

Utilize a seguinte escala:

1-Discordo totalmente | 2-Discordo | 3-Não sei | 4-Concordo | 5-Concordo totalmente

De um modo geral...

1. Eu acredito que produtos raros são mais valiosos que produtos produzidos em larga escala.
2. Eu me sentiria feliz se fosse a última pessoa a comprar um produto que esgotou.
3. Quando algum dos meus produtos favoritos está quase fora de estoque, costumo comprar mais de uma unidade para não ficar sem.
4. Produtos que são difíceis de encontrar tem um valor especial.
5. Eu sempre retribuo um favor.
6. Se alguém faz alguma coisa por mim, eu tento fazer algo com a mesma importância em retribuição.
7. Quando eu ganho um presente, sinto a necessidade de retribuir o presente recebido.
8. Quando alguém me ajuda com o meu trabalho, eu sinto a necessidade de retribuir e ajudar aquela pessoa.
9. Quando um membro da família me faz um favor, é quase certo que irei retribuir.
10. Eu sempre compareço aos compromissos que eu agendo.
11. Eu tento cumprir todas as minhas promessas.
12. Quando faço planos costumo escrevê-los, assim demonstro meu empenho em cumpri-los.
13. Uma vez que me comprometo a fazer algo, com certeza irei fazê-lo.
14. Eu aceito sugestões que partem da minha rede social.
15. Quando eu gosto de alguém, geralmente acredito na palavra dessa pessoa.
16. A opinião dos meus amigos é mais importante que a opinião dos outros.
17. Se eu não tenho certeza sobre algo, normalmente aceito a opinião de pessoas que gosto.
18. Quando um professor me diz algo, eu costumo acreditar que seja verdade.
19. Eu normalmente acredito na palavra de pessoas que ocupam algum cargo de autoridade.
20. Sou mais inclinado (a) a fazer algo que me mandam do que se me pedirem.
21. Costumo acreditar mais em uma autoridade do que em um colega.
22. Eu farei algo, desde que saiba que outras pessoas também o estão fazendo.
23. Eu normalmente espero que outras pessoas me digam o que fazer.

Escala para medir a persuasão percebida das estratégias da interfaces do usuário

Cenário: Você está cursando uma disciplina online em sua universidade e os exercícios e trabalhos são realizados em grupo. O site da disciplina apresenta sugestões de grupos para a realização das atividades.

Instruções: Considere que você está usando o sistema apresentado na imagem acima. Em uma escala de 1 a 7 (sendo 1 - Discordo totalmente e 7 – Concordo totalmente), o quanto você concorda com cada uma das perguntas abaixo?

1. O sistema teria me influenciado.
2. O sistema teria me convencido.
3. O sistema teria sido relevante para mim.
4. O sistema teria me feito entrar no grupo sugerido.

Imagens utilizadas em cada semana da simulação sem elementos de persuasão e gamificação:

Figure 32 – Semana 1 - Sem customizações

Considere que você está usando o sistema apresentado na imagem acima. Em uma escala de 1 a 7 (sendo 1 - Discordo totalmente e 7 – Concordo totalmente), o quanto você concorda com cada uma das perguntas abaixo?

a) O sistema teria me influenciado	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
b) O sistema teria me convencido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
c) O sistema teria sido relevante para mim	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
d) O sistema teria me feito entrar no grupo sugerido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente

Figure 33 – Semana 2 - Sem customizações

Considere que você está usando o sistema apresentado na imagem acima. Em uma escala de 1 a 7 (sendo 1 - Discordo totalmente e 7 – Concordo totalmente), o quanto você concorda com cada uma das perguntas abaixo?

a) O sistema teria me influenciado	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
b) O sistema teria me convencido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
c) O sistema teria sido relevante para mim	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
d) O sistema teria me feito entrar no grupo sugerido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente

Figure 34 – Semana 3 - Sem customizações

Considere que você está usando o sistema apresentado na imagem acima. Em uma escala de 1 a 7 (sendo 1 - Discordo totalmente e 7 – Concordo totalmente), o quanto você concorda com cada uma das perguntas abaixo?

a) O sistema teria me influenciado	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
b) O sistema teria me convencido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
c) O sistema teria sido relevante para mim	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
d) O sistema teria me feito entrar no grupo sugerido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente

Imagens utilizadas em cada semana da simulação personalizada com elementos de persuasão e gamificação:

Figure 35 – Semana 1

Considere que você está usando o sistema apresentado na imagem acima. Em uma escala de 1 a 7 (sendo 1 - Discordo totalmente e 7 – Concordo totalmente), o quanto você concorda com cada uma das perguntas abaixo?

a) O sistema teria me influenciado	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
b) O sistema teria me convencido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
c) O sistema teria sido relevante para mim	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
d) O sistema teria me feito entrar no grupo sugerido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente

Figure 36 – Semana 2

Considere que você está usando o sistema apresentado na imagem acima. Em uma escala de 1 a 7 (sendo 1 - Discordo totalmente e 7 – Concordo totalmente), o quanto você concorda com cada uma das perguntas abaixo?

a) O sistema teria me influenciado	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
b) O sistema teria me convencido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
c) O sistema teria sido relevante para mim	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
d) O sistema teria me feito entrar no grupo sugerido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente

Figure 37 – Semana 3

Considere que você está usando o sistema apresentado na imagem acima. Em uma escala de 1 a 7 (sendo 1 - Discordo totalmente e 7 – Concordo totalmente), o quanto você concorda com cada uma das perguntas abaixo?

a) O sistema teria me influenciado	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
b) O sistema teria me convencido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
c) O sistema teria sido relevante para mim	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente
d) O sistema teria me feito entrar no grupo sugerido	Discordo totalmente	1	2	3	4	5	6	7	Concordo totalmente

RATIONALE: SYSTEMATIC MAPPING ON GROUP FORMATION IN CSCL

B.1 The Systematic Mapping Process

As a research area advances, the amount of studies published in that area tends to increase. Thus, obtaining an overview of an established research area can be a complex undertaking. Evidence-based Software Engineering (DYBÅ; DINGSØYR; HANSEN, 2007) proposes a set of guidelines to support the conduction this sort of investigation. More specifically, these guidelines outline how to identify, evaluate, interpret, and analyze primary studies (DYBÅ; DINGSØYR, 2008). The main assumption is that those guidelines, which are expressed and embodied in systematic mappings and systematic reviews, lead to more consistent results that can be more easily replicated. Therefore, to obtain a bird's eye view of the approaches that have been used for group formation within CL environments, we carried out a systematic mapping study. Systematic mappings are also known as scoping reviews (PRETORIUS; BUDGEN, 2008), and they involve methodologically searching the literature to ascertain the nature and broadness (i.e., type and amount of primary studies) of the existing, published research on a particular topic (MAGNISALIS; DEMETRIADIS; KARAKOSTAS, 2011). In research, primary studies are examples of original research (KITCHENHAM, 2004).

The systematic mapping herein described is based on the guidelines proposed by (PETERSEN *et al.*, 2008), and according to them the key steps of a systematic mapping are the following:

1. Definition of research questions (RQs),
2. Searching for relevant studies,
3. Screening of studies,

4. Keywording of abstracts, and
5. Data extraction and mapping.

Figure 38 illustrates these steps as well as the order in which they are performed. As shown in Figure 1, the conduction of each step results in an intermediate result. The main contribution of a systematic mapping is made up of these intermediate results. The following subsections briefly describe how we carried out the steps in Figure 1 and the intermediate outcomes of these steps.

Figure 38 – Systematic mapping main steps

Source: Petersen *et al.* (2008).

B.1.1 Definition of the Research Questions

As mentioned, the main goal of this systematic mapping is to gather data on and look at the state-of-the-art of research on group formation in the context of CSCL environments. It is worth mentioning that the RQs in a systematic mapping are framed in such a way as to drive the selection of primary studies and the analysis that takes place in the subsequent steps. The RQs that drove this systematic mapping are outlined in Table 27.

Table 27 – Research questions on the study

#	Research Question
RQ1	What are the most investigated characteristics of group formation in the domain of CSCL?
RQ2	At what educational level (or learning activities) group formation has been most investigated and applied to?
RQ3	What type of research is the most common in the field?
RQ3	What are the main venues in which research in this area has been published?

During this step we also defined the scope of our systematic mapping, outlining its population, intervention and expected results: Population: primary studies examining varying aspects of the formation of groups in the context of CSCL. Intervention: primary studies that either apply, discuss, or propose strategies, approaches methods, or techniques for group formation or report on experiences with group formation. Expected Results: an overview of the

state-of-the-art of group formation. It is expected that, apart from providing a summary of what has been investigated in this research area, the results contribute to the identification of new avenues for research on group formation applied to CSCL by highlighting areas require more research.

B.1.2 Searching for Relevant Studies

We created a search string by combining some terms, their synonyms, and acronyms. The initial set of terms was defined after an interview with a specialist and based on the preliminary scanning of 10 primary studies manually selected. The final set of terms is shown in Table 28. The search encompassed the electronic databases that are deemed as the most prominent scientific sources and, therefore, prone to include relevant primary studies (Dybå et al. 2007). We searched the following electronic databases: ACM Digital Library, IEEE Xplore, Elsevier (via ScienceDirect), Springer (via ScienceDirect), Wiley Online Library, Web of Science, EngineeringVillage and SCOPUS. It is worth mentioning that we did not place any restrictions on date of publication when searching for primary studies.

Table 28 – Terms used in electronic libraries for the research of systematic mapping

Main term	Alternative terms
Computer-Supported Collaborative Learning Group Formation	CSCL Team Creation OR composition OR organization OR distribution OR clustering OR grouping OR design OR management

Table 29 presents the total amount of papers returned, the number of candidate studies after skimming through titles and abstracts, and the final set of primary studies. The next subsection elaborates on how we arrived at the final set of primary studies.

Table 29 – Total of returned papers, selected candidates, and the final set

Papers	#
Returned	3571
Candidates	423
Final set	106

B.1.3 Screening

The purpose of this step is to assess the suitability of primary studies with respect to the RQs. Therefore, in this step; all papers are evaluated against predefined inclusion and exclusion criteria that reflect the RQs. After applying these criteria (Table 4) to titles and abstracts, the

initial set containing 3571 papers was reduced to 423 candidate studies. After going over the candidate set, we ended up with 106 primary studies (Figure 2).

Figure 39 – Overview of the systematic searching process

Table 30 – Inclusion and exclusion criteria for screening of returned items.

Criteria	Rules
<i>Inclusion</i>	<ul style="list-style-type: none"> - Articles containing selected keywords; - Articles published by December 2014. - Articles in English.
<i>Exclusion</i>	<ul style="list-style-type: none"> - Duplicate articles; - If several articles show the evolution of a study, only the most recent article was included; - For different versions of the same article, a summary and another full, the summary was deleted; - Technical reports, abstracts or presentations (gray literature) and secondary education (e.g. systematic reviews of literature and systematic mappings).

Figure 40 shows the frequency of research on group formation in the context of CSCL over time. As can be seen in Figure 3, the formation of groups has been investigated for approximately 20 years. Moreover, the amount of papers on this topic has dramatically increased since 2006. In particular, 2009 and 2011 stand out as the years in which most efforts in this area have been published so far: 16 studies in 2009 and 17 in 2011.

Figure 40 – Frequency of selected primary studies distributed by year of publication

B.1.4 Keywording

This step is centered on classifying and categorizing primary studies. Initially, the abstracts of the primary studies were scanned for keywords that reflect the contributions presented in these studies. Thereafter, the resulting keywords were merged (i.e., terms that were considered synonyms were collapsed into the most commonly occurring term between the two) and analyzed in hopes of gauging the nature of the contributions in this area. We use the keywording to classify the studies according to our framework and answer the RQs that we set out to investigate. Note that primary studies can fall into more than one category in our framework; thereby some of the proposed categories overlap.

B.2 Systematic Mapping Results

In this section, we analyze the results of our systematic mapping. We draw information from the primary studies in order to answer the RQs of our mapping study.

B.2.1 Research Question 1: What are the most investigated characteristics of group formation in the domain of CSCL?

The categories, as mentioned earlier, were created with the purpose of shedding some light on what are the most investigated characteristics of group formation in the domain of CSCL. By characteristics we mean that we applied a keywording strategy to prepare our rating system and characteristics for the selected primary studies. By applying such a strategy, initially summaries were read to find keywords and concepts that reflect the study's contribution. Next, these keywords and concepts were combined to produce a general understanding of the nature and contributions of the research. The classification scheme gradually evolved towards its final version as some characteristics were eliminated, added, merged or split (Durelli et al. 2010). Also, by grouping the primary studies into categories allowed us better to grasp the interrelationships among categories and how efforts in this area overlap. However, it is worth mentioning that the resulting categories do not encompass all characteristics, research themes and contributions in the area. Rather, the categories were devised in hopes of better answering the RQ1.

B.2.1.1 Group Formation Planning

As mentioned, this category groups the primary studies in terms of the sort of planning that was used during group formation. Here we classify as unsystematic group formation approaches within which the formation of groups lacks a set of governing rules and takes places in a seemingly random fashion. In contrast to unsystematic group formation, systematic group formation is based on criteria that govern the size and organization of groups. Figure 5 shows the proposed classification, highlighting the basic difference between systematic and unsystematic

group formation. In 12 of the selected studies, students are grouped in a random fashion. Nevertheless, in only 6 of these studies randomness is the only factor determining group formation. In the other studies, it was also possible to group students based on criteria aimed at achieving the target educational objectives. As an example, in the study conducted by (Mujkanovic and Lowe 2012), initially the groups were unsystematic formed (i.e. by chance), given that not enough information to warrant the application of more complex criteria about the students was collected yet. Later, after the conduction of more activities, the students were evaluated, and the results of the evaluations were then used as a group formation criterion. According to (Mujkanovic and Lowe 2012), this approach could be an alternative to using placement or pre-evaluation questionnaires. One drawback of using questionnaires before collaborative learning activities is that carrying out this sort of evaluation takes a significant amount of time, and it is often seen as tedious for the students taking part in it.

Figure 41 – Classification scheme of the primary studies in accordance with the sort of planning used back up the group formation

Most primary studies, however, report on group formation approaches that are based on some criteria: in 94 studies, criteria are used to support the definition of rules that establish which group each student should be added to. Figure 6 shows the frequency of the criteria for the formation of groups found in primary studies analyzed. The number of criteria present in each study varies according to the objectives of the collaborative activities to be performed or can be based on the kind of computational support employed (e.g. algorithms). Abnar et al. (2012) remark that, in general, when groups are manually created, only one criterion is used. They also point out that the more criteria are used, the more complicated it is to handle the information related to groups.

Nevertheless, Medina and Gómez-Pérez (2013), and Hwang et al. (2008) state that it is unlikely coming up with one criterion that yields good groups. It follows that it is desirable to have multiple criteria, given; the more information is taken into account during group formation, the greater the control over the quality and granularity of the resulting groups. Recent research indicates that sound pedagogical theories should underpin group formation approaches. For instance, the studies carried out in Isotani et al. (2009) and Isotani et al. (2013) provide further

evidence in this regard. Moreover, the approaches proposed in Isotani et al. (2009) and Isotani et al. (2013) benefit from Semantic Web to formalize the knowledge required for creating groups.

The most used criterion for group formation was knowledge level. Knowledge level-based group formation is investigated in 59 primary studies. Skill-based group formation is the second most investigated criterion, investigated in 33 primary studies. Learner roles are the third most investigated criteria, 31 primary studies. As shown in Figure 42, the other criteria that have been explored are group objectives, individual objectives, students genre, cultural aspects (e.g., nationality and language), interaction issues, characteristics extracted from social relationships, psychological characteristics, learning disabilities, schedule compatibility, age, and academic formation. It is worth mentioning that these are only some of the identified criteria, studies might have used other additional criteria. However, these other criteria were not mapped because the studies failed to describe sufficiently them. Usually, these additional criteria are simply mentioned in the primary studies as “other criteria” or “among other things”.

Figure 42 – Frequency of the criteria for the formation of groups found in primary studies analyzed

B.2.1.2 Initiative in Systematic Group Formation

When group formation follows a methodical (viz., systematic) approach to group formation, the initiative for group formation can be handled in two different ways: spontaneous group formation (i.e., when the students are the ones in charge, yielding self-selected groups) and controlled group formation (i.e., when the instructor or underlying approach controls group formation, resulting in instructor-select groups). This distinction is highlighted in Figure 43. We classify as spontaneous the approaches in which students are free to form their own groups. Spontaneous group formation approaches take into account the preferences of the students (e.g., affinity between students, idiosyncrasies, and friendship). Therefore, we classified as controlled group formation (guided) the approaches that take some other elements into account during the formation of groups, apart from students' preferences. We argue that the term controlled better

describe such approaches, given that there is an external element, which can be impervious to the students' preferences, effectuating the rules and controlling how students should be grouped.

Figure 43 – Classification of primary studies in accordance with the initiative of group formation

In 21 of the selected studies, the preference of the studies was taken into account during group formation. Nevertheless, in only four studies this was the only factor taken into consideration. In the other 17 studies, apart from the students' preferences, other criteria could also be used. In these primary studies, the students are polled about their preferences, and the gathered information is then used to devise group formation criteria. The Venn diagram shown in Figure 8 illustrates how the primary studies were categorized in terms of their planning strategy. As mentioned, some primary studies can fall in more than one category since their approaches are flexible enough to allow for more than one planning strategy. By analyzing Figure 44, it can be seen that most group formation approaches (70 primary studies) are exclusively criteria-based approaches.

Figure 44 – Distribution of the primary studies according to the criteria used during the clustering strategy

B.2.1.3 Population Diversity

In the context of this study, diversity has to do with the makeup of groups, which can be heterogeneous or homogeneous as shown in Figure 45. Homogeneous approaches emphasize criteria that result in groups of like-minded students, i.e., students that present similar characteristics. Heterogeneous approaches, conversely, propose the creation of groups that are comprised of members with different backgrounds and characteristics.

Figure 45 – Classification scheme for the audience diversity when forming groups

The most used approach is the formation of heterogeneous groups (84 primary studies). Evidence suggests that heterogeneous groups foster the interaction among group members due to the members have skills that are complementary to the group as a whole (Barkley et al. 2005; Johnson and Johnson 1999). Also, in heterogeneous groups it is normal to have members with characteristics that supplement other individuals in the group. In 36 primary studies relied on the formation of homogeneous groups. Note that in two of these 36 studies the formation of homogeneous groups is the only option, the other 34 studies also propose criteria that yield heterogeneous groups, as shown in Figure 46 . Also, nine papers were not classified in terms of diversity, given that in five of them the formation of groups can be carried out in a random fashion and four in a spontaneous way. Apart from these papers, we also analyzed 17 primary studies that either use or investigate group formation. However, it was not possible to identify the diversity of the groups in these papers.

Figure 46 – Primary studies according to diversity of the population in the groups

Table 31 – Primary studies according to diversity of the population in the groups

Research Type	#
Solution proposal	77
Evaluation	17
Tool	11
Opinion	01

In the study conducted by Chiu and Hsiao (2010), it is argued that randomly assembled groups can result in an acceptable level of heterogeneity with respect to certain characteristics as, for instance, the amount of students of the same gender or with some particular personality traits

(e.g., active students, passive students, leaders, and followers). Moreover, in the study conducted by Ardaiz-Villanueva et al. (2011), problem-based learning (PBL) principles and several support tools were used to support the conduction of collaborative learning activities. Two criteria drive group formation: the first is based on a “creativity score” attributed to each student and the second boils down to computing an “affinity score” that gauges how each student gets along with others. According to the authors, the results seem to suggest that homogeneous group (in terms of creativity) and whose members interact with each other well lead to a better learning experience. Besides, the authors report that in this kind of groups they did not detect freeloaders and there was an increase in students’ engagement during collaborative learning activities.

B.2.1.4 Distribution Approaches

We categorized the studies according to the way the students were distributed in groups. As mentioned, groups can be homogeneous or heterogeneous groups according to the criterion (or criteria) used. In terms of distribution, we classified the studies whose approaches result in either homogeneous or heterogeneous groups (despite how many criteria were used) as simple distribution. By the other hand, we also found studies in which a subset of criteria was used to cluster the students in homogeneous groups, while at the same time; another subset of criteria was used to cluster them in heterogeneous groups. This second type of approach was classified as hybrid distribution, and the classification scheme is shown in Figure 47.

Figure 47 – Simple distribution results in homogeneous OR heterogeneous groups, while in hybrid distribution, groups are concomitantly homogeneous AND heterogeneous according to each subset of criteria

B.2.1.5 Computational support

Although the domain of computer-supported collaborative learning contains the words "computer-supported", not always the group formation occurs with technological support. Based on these observations, we devise the category shown in Figure 48, to classify the primary studies according the computational support.

We observed that a few primary studies (13) did not provide enough information clarifying neither the use nor the extension of the computational support, getting this restricted to the other stages of collaborative learning (i.e. collaborative tasks to be performed). In the remaining 83 studies analyzed, various technological solutions have been used. Although the extent and the

Figure 48 – Classification of the primary studies according to the computational support

way these technologies were employed are relevant, they are beyond the scope of this paper and will not be detailed. Figure 49 presents an overview of the related major computational resources identified in the studies analyzed, and Figure 50 presents the main types of algorithms described in the primary studies.

Figure 49 – Major technologies used to support group formation in the primary studies investigated

Technology cited	Source
Algorithms	(Abnar et al. 2012; Agustín-Blas et al. 2011; Ardaiz-Villanueva et al. 2011; Balmaceda 2014; Bekele and McPherson 2011; Brauer et al. 2013; Challico et al. 2014; Craig et al. 2010; Dascalu et al. 2014; de Oliveira Fontes et al. 2011; Duque et al. 2014; Eberspacher and Joab 2006; Gouardères and Gouardères 2011; Graf and Bekele 2006; Haaake et al. 2003; Ho et al. 2009; Huang and Wu 2011; Hwang et al. 2008; Inaba et al. 2003; S. S. Isotani et al. 2013; Jong et al. 2006; Khandaker and Soh 2010; Khandaker and Soh 2011; Li and Zhao 2008; S. Liu et al. 2009; Malzahn et al. 2007; Medina and Gómez-Pérez 2013; Mehta et al. 2012; Messeguer et al. 2010; Moreno et al. 2012; Mujkanovic and Lowe 2012; Pollalis and Mavrommatis 2009; Razmerita and Brun 2011; Read et al. 2006; Redmond 2001; Rubens et al. 2009; Suebnukarn and Haddawy 2006; Sun and Shen 2014; Virvou and Sidiropoulos 2012; Yannibelli and Amandi 2012; Zheng and Pinkwart 2014; Zhou et al. 2009)
Multi-user game	(Sancho-Thomas et al. 2009)
Wireless devices	(Adán-Coello et al. 2011)
Web System	(Pérez-Sanagustín et al. 2009)
Framework	(Boticki et al. 2013; Erdem 2009; Jong et al. 2006; A. Liu 2009; Read et al. 2006)
Learning Management System	(Eberspacher and Joab 2006; Hernández-Leo and Nieves 2011)
Ontology and Semantic Web	(Dascalu et al. 2014; Inaba et al. 2003; S. S. Isotani et al. 2013; S. Isotani et al. 2009; Luan and Li 2004; Malzahn et al. 2007; Ounnas et al. 2009)
3D system	(Ellis et al. 2008)
Ubiquitous computing	(Balestrini et al. 2014; Huang and Wu 2011; Kanev et al. 2009)

B.2.1.6 Rationale Behind the Strategy for Group Formation

The primary studies were also classified in terms of how the authors back up their approach for group formation. We found three types of studies: (i) studies that do not present any arguments that back up their approaches, (ii) studies whose group formation approach is borne out by empirical evidence, (iii) and studies that draw on assumptions from pedagogical theories (Figure 51).

Only 37 of the 106 analyzed studies are based on sound pedagogical or instructional theories, which back up the selection criteria employed during group formation. We also found that 46 studies do not report whether any pedagogical theory was used to support the group formation criteria. These 46 studies mention, however, that the chosen criteria are based on

Figure 50 – Major algorithms used to support group formation in the primary studies investigated.

Algorithm (as described in the primary study)	Source
Adaptive group formation	(Read et al. 2006)
Algorithm (not specified)	(Eberspacher and Joab 2006; Gouardères and Gouardères 2011; Haake et al. 2003; Huang and Wu 2011; S. Isotani et al. 2009; A. Liu 2009; S. Liu et al. 2009; Malzahn et al. 2007; Pollalis and Mavrommatis 2009)
Ant Colony Optimization	(Graf and Bekele 2006)
Bayesian network	(Messeguer et al. 2010; Suebnukarn and Haddawy 2006)
Bayesian Performance prediction mode	(Bekele and McPherson 2011)
Best-first search	(Henry 2013)
Choco toolkit	(Balmaceda 2014)
Clustering	(Mujkanovic and Lowe 2012)
Context walk algorithm	(Brauer et al. 2013)
Data mining	(Duque et al. 2014; Medina and Gómez-Pérez 2013; Rubens et al. 2009)
Deterministic crowding evolutionary algorithm	(Yannibelli and Amandi 2012)
Discrete Particle Swarm Optimization	(Zheng and Pinkwart 2014)
Evolutionary	(Craig et al. 2010)
Fuzzy C Mean	(Li and Zhao 2008)
Genetic	(Abnar et al. 2012; Agustín-Blas et al. 2011; Hwang et al. 2008; Moreno et al. 2012; Sun and Shen 2014)
Greedy search	(Redmond 2001)
Hete-A	(Khandaker and Soh 2011)
Hierarchical Task Network	(Challco et al. 2014)
Instance-based learning (IBL)	(Messeguer et al. 2010)
K-means	(Razmerita and Brun 2011)
Network- flow-based matching algorithm	(Mehta et al. 2012)
Optimization	(Jong et al. 2006)
Particle Swarm Optimization (PSO)	(Dascalu et al. 2014; Ho et al. 2009)
Simulated Annealing	(Tourtoglou and Virvou 2012)
VALCAM	(Khandaker and Soh 2010; Khandaker et al. 2006; Khandaker and Soh 2011)

Figure 51 – Classification of the primary studies regard the kind of rationale found in the primary studies explaining the group formation approach

empirical evidence. Apart from these primary studies, 23 studies do not elaborate on what theories ground their criteria. Table 32 shows an overview of the rationales behind the examined group formation approaches.

Table 32 – Regard the kind of rationale found in the primary studies explaining the group formation approach

Rationale	#	Theories, best practices
Uncommented	23	-
Empirical evidences	46	Data mining techniques; Genetic algorithms; Pair-Programming Techniques. Blended Learning; Project Based Learning; Learning by (Observation, self-expression, teaching, being taught, apprenticeship, practice, diagnosing, guiding, reflection and discussion);
Learning theories, instructional theories and best practices.	37	Peer-reviewed; Collaborative Learning Flow Patterns (CLFP); Learning as belonging/ Wenger Social Learning theory; Experiential learning theory (ELT); Zone of Proximal Development (ZPD).

B.2.1.7 The answer for RQ1

RQ1: What are the most investigated characteristics of group formation in the domain of CSCL?

ARQ1:: The majority of the primary studies (101 out of 106) report on approaches for planned group formation, i.e., the formation of groups is based on pre-established criteria. The most widely used criterion is the level of knowledge of the students, which is used in 46 of the selected studies. Controlled group formation is used in 90 primary studies. In terms of distribution, most primary studies rely on heterogeneous groups: 84 studies propose the formation of heterogeneous groups. Nevertheless, only in 50 out of these 84 studies simple heterogeneous groups are the only possible outcome. According to our results, 82 studies capitalize on some sort of technology to automate and support group formation. Only 37 studies exploit educational or pedagogical theories to justify their rationale for the group formation approach.

B.2.2 Research Question 2: In what educational level (or learning activities) group formation has been most investigated and applied to?

In order to answer RQ2, we classified the selected studies in terms of their target population. In the context of this paper, target population refers to the stage (or level) at which educational activities take place or the type of educational activities. As shown in Figure 52, the group formation approaches proposed in most studies (56) emphasize tertiary education (viz., undergrad students). Few studies focus on applying group formation approaches to other educational levels (or stages). For instance, our results would seem to suggest that there has been scant research on the impact of group formation when applied to early childhood education (1), graduate students (1), e-Health students (1), language-learning activities (1), primary education students (3), and secondary education students (6). 36 primary studies fail to specify the target population of their proposed approach. Also, these studies present theoretical models that represent solutions that have not been implemented or fully tested yet.

Figure 52 – Distribution of primary studies according to the level/type of educational activity.

B.2.2.1 The answer for RQ2

RQ2: In what educational level (or learning activities) group formation has been most investigated and applied to?

ARQ2:: Most research on group formation applied to CSCL has been geared towards undergrad students: approximately 52% (56 primary studies) of the studies tackle group formation at this educational stage (level).

B.2.3 Research Question 3: What type of research is the most common in the field?

Our answer is based on the classification proposed in (WIERINGA *et al.*, 2005), which comprises the following research types. Validation Research, studies that fall into this category describe a novel technique, approach, or strategy and have not been implemented in practice, but its effectiveness has been evaluated to some degree through laboratory studies. Evaluation Research, this category contains studies that empirically evaluate a technique, approach, or strategy in practice or real settings. Position Papers, these studies report the authors' point of view. Research in this category does not contain evidence that backs up the authors' opinion. Philosophical Papers, studies that present a new of perceiving things or new guidance for a domain, often using taxonomies and conceptual frameworks. Solution Proposals, Studies in this category are usually not present in-depth validation of the described technical solution but tend to describe a proof of concept by way of example or a sound prototype running. Experience papers, these studies are concerned with reporting the author's experience during the implantation of a new approach. As some selected primary studies did not fit well into the categories above, we extended the classification scheme, by adding a research type category namely Tools. In this category are the studies whose main contribution is the developed tool, often in the form of a research prototype.

After reading the primary studies, we identified four research methods. As indicated in

Table 33, the research methods in the primary studies fall into one of the following categories: (i) Solution proposals, (ii) Evaluation, (iii) Opinion, and (iv) Tools. Solution proposals are by far the most common research method, including 77 studies, 17 primary studies are concerned with some evaluation, and only one study falls into the opinion category. Moreover, the main contribution presented by 11 studies boils down to the implementation of a tool to automate and support group formation, falling into the tools category.

Table 33 – Distribution of primary studies by research type.

Research Type	#
Solution proposal	77
Evaluation	17
Tool	11
Opinion	01

B.2.3.1 The answer for RQ3

RQ2: What type of research is the most common in the field?

A_{RQ3}:: The research method used in the majority of the primary papers is solution proposal: 77 studies present group formation approaches that can be applied to CSCL environments. Conversely, the least explored category is opinion. Only one study describes the author's view about group formation applied to CSCL environments and the implications thereof.

B.2.4 Research Question 4: What are the main venues in which research in this area has been published?

As shown in Figure 53, most primary studies are indexed in IEEE (IEEE Xplore) and Elsevier (26 and 24 papers, respectively). ACM Digital Library indexes 19 of the selected papers, 14 papers were retrieved from Scopus, and Springer and Web of Knowledge (WoK) had six papers each. The electronic database with the least amount of selected papers was Engineering Village (5 papers). It is worth mentioning that Springer, WoK, and Engineering Village were the last electronic databases we went through; consequently many of the papers returned by these sources had already been retrieved and selected from other databases. Apart from these studies, 6 selected journal papers were retrieved from SciVerse Hub.

The selected papers were published in a variety of venues that range from conferences, workshops, to journals. Figure 54 shows an overview of the distribution of primary studies according to their types over the years. By analyzing Figure 54, we can see that most efforts in the area were published from 2006 on. Since then, it seems that the topic has gained momentum. As indicated in Figure 16, there was a marked increase in the amount of journal publications in 2011.

Figure 53 – Frequency of selected primary studies according to the consulted electronic databases

Figure 54 – Frequency of selected studies according to the year and the publication of the forum

As shown in Table 34, 12 venues has contributed with at least two studies that represent 48 publications, while the rest of the studies are spread in 58 different venues (with one publication each).

Table 34 – Main venues in which research about group formation has been published.

Name	#
Computers & Education	10
Computers in Human Behavior	6
Proceedings of the Conference on Innovation and Technology in Computer Science Education	6
Educational Technology & Society	5
IEEE Transactions on Learning Technologies	4
Expert Systems with Applications	3
Proceedings of the ACM international Conference on Supporting Group Work	3
Proceedings of the Conference on Computer Supported Collaborative Learning	3
British Journal of Educational Technology	2
Educational Technology Research and Development	2
Intelligent Tutoring Systems	2
User Modeling and User-Adapted Interaction	2
Total	48

B.2.4.1 The answer for RQ4

RQ4: What are the main venues in which research in this area has been published?

A_{RQ4}: Most primary studies were published in journals. Computers & Education is the venue with the highest number of selected studies (10), followed by another journal, Computers in Human Behavior and for the proceedings of the Conference on Innovation and Technology in Computer Science Education (ITiCSE), both with six studies.

B.3 List of the selected primary studies N=106

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RATIONALE: SYSTEMATIC MAPPING ON GAMIFICATION APPLIED TO EDUCATION

In this study, we are focusing on providing an overview of the research on gamification applied to education. Furthermore, it is worth mentioning that this mapping study is part of an ongoing project whose purpose is to investigate gamification and Computer Supported Collaborative Learning (CSCL). Thus, as a secondary objective of this systematic mapping, we also aim to identify the existence of initiatives that use gamification in CSCL environments.

C.1 The Systematic Mapping Process

We carried out our study by following the process described by (PETERSEN *et al.*, 2008). According to them, systematic mappings are a fivefold process: (i) definition of research questions, (ii) performing the search for relevant primary studies, (iii) screening of papers, (iv) keywording of abstracts, and (v) data extraction and mapping. Research questions have to incorporate the study purpose. Thus, since we set out to ascertain what aspect of gamification applied to education has been most investigated by researchers, our three research questions (RQs) reflect this purpose as the following:

- RQ1: In what educational contexts and levels has gamification been most investigated?
- RQ2: What types of studies have been most investigated in terms of gamification and education?
- RQ3: What gamification approaches have been most investigated in the field of computer-supported collaborative learning (CSCL)?

Based on these questions we defined inclusion and exclusion criteria. These criteria are important to identify relevant primary studies that answer the RQs. We devised the following inclusion criteria:

- If several papers reported the same study, only the most recent paper was selected;
- If the paper describes more than one study, each study was item assessed individually.

And the following exclusion criteria:

- Papers that do not present studies relating to education;
- Papers in languages other than English;
- Technical reports and documents that are available in the form of summaries or presentations (gray literature) and secondary studies (i.e., systematic literature reviews and mapping studies).

At first, we ran some searches using a combination of candidate keywords. These trial searches combined the keyword gamification with some synonyms related to education and learning. Due to the small number of papers returned from the resulting strings, we decided that only the keyword gamification should be used. This decision allowed us to analyze a greater number of papers, lowering the odds of leaving relevant studies out of our final set. Using gamification as keyword, we performed searches on electronic databases that are known to cover relevant scientific journals and articles from a wide variety of domains such as Computer Science, Education and Educational Research, Science, Engineering, Medicine and Psychology.

Initially, we retrieved 357 primary papers. However, only 48 candidate papers were obtained after applying the inclusion and exclusion criteria based upon title and abstract. Finally, after going over introductions and conclusions, we ended up with a final set of 26 primary papers as shown in Table 35.

Table 35 – Distribution of primary studies by electronic database

Database	Quantity
ACM Digital Library	144
Elsevier (Science Direct)	32
IEEE Xplore	31
Scopus	95
Springer	55
Total	357
Candidates	48
Final Selection	26

We read all 26 papers in full and applied a keywording strategy to devise our classification scheme and categories for the selected primary studies. At first, abstracts were read in order

to find keywords and concepts that reflect the contribution of the studies. After reading the papers, the keywords and concepts were combined to synthesize the nature of the selected contributions. Finally, the final set of keywords was used to define representative categories. As a result, the following categories were defined to better understand and classify the primary studies: Mastering Skills: in this category we included all studies that propose the use of gamified systems as a means to improve students' ability to perform activities considered complex or repetitive.

- Challenging: this category includes studies whose authors claim that gamified systems that implement challenging activities can contribute to the improvement of learning.
- Guidelines: this category includes studies whose authors consider how gamification can be applied in educational settings. These studies, however, do not provide empirical evidence that backs up the authors' claims. Usually, these papers are built on results of other researchers.
- Engagement: studies in this category describe approaches or strategies to arouse and maintain students' interest in learning a given subject.
- Improving Learning: this category includes studies that propose gamified solutions to enhance the way students learn, maximizing the results of the learning process.
- Behavioral change: this category includes studies that propose using gamified systems in order to foster behavioral changes in students.
- Socialization: studies in this category discuss that learning can take place under more favorable conditions when supported by gamified social tools.

The final set of processed papers ($N = 26$). The numbers in parenthesis represent the number of papers in the category, while the numbers in square brackets are the papers' references. 24 of the 26 studies have Engagement among students as their main objective. Only two studies do not directly approach such an objective, discussing motivation in a higher abstraction level. Contributing to further improvement in how students socialize is mentioned by 13 studies (Socialization). Nevertheless, only eight primary studies report practical solutions to achieving such an objective, four encourage group activities, and one highlights the importance of this sort of activity.

C.2 Research Questions Revisited

According to our results:

- RQ1: In what educational contexts and levels has gamification been most investigated? Most studies were published in conferences and have focused on Higher Education (RQ1 – see Table 4)
- RQ2: What types of studies have been most investigated in item gamification and education? Solution proposals to foster the engagement of students through learning activities that build on gamification concepts (RQ2 – see Figure 11).
- RQ3: What gamification approaches have been most investigated in the field of computer-supported collaborative learning (CSCL)? There is a lack of approaches that combine gamification and CSCL.

C.3 List of the selected primary studies N=26

1. Baker, P.M.A., Bujak, K.R., DeMillo, R.: The Evolving University: Disruptive Change and Institutional Innovation. In: *Procedia Computer Science* 14. pp. 330–335. Elsevier (2012).
2. Bell, J., Sheth, S., Kaiser, G.: Secret ninja testing with HALO software engineering. In: *SSE '11 Proceedings of the 4th international workshop on Social software engineering*. p. 43. ACM Press, New York, New York, USA (2011).
3. Bierre, K.: Implementing a game design course as a multiplayer game. In: *4th International IEEE Consumer Electronic Society - Games Innovation Conference, IGiC 2012*. pp. 1–4. IEEE Comput. Soc (2012).
4. Charles, T., Bustard, D., Black, M.: Experiences of Promoting Student Engagement Through Game-Enhanced Learning. In: Ma, M., Oikonomou, A., and Jain, L.C. (eds.) *Serious Games and Edutainment Applications*. pp. 425–445. Springer-Verlag, London (2011).
5. Domínguez, A., Saenz-de-navarrete, J., Fernández-Sanz, L., Pagés, C., De-Marcos, L., Martínez-Herráiz, J.-J.: Gamifying learning experiences: Practical implications and outcomes. *Comput. Educ.* 63, 380–392 (2013).
6. Erenli, K.: The impact of gamification: A recommendation of scenarios for education. In: *15th International Conference on Interactive Collaborative Learning, ICL 2012*. pp. 1–8. IEEE Comput. Soc (2012).
7. Farhangi, S.: Reality is broken to be rebuilt: how a gamer's mindset can show science educators new ways of contribution to science and world? *Cult. Stud. Sci. Educ.* 7, 1037–1044 (2012).
8. Fitz-Walter, Z., Tjondronegoro, D., Wyeth, P.: A gamified mobile application for engaging new students at university orientation. In: *24th Australian Computer-Human Interaction Conference, OzCHI 2012*. pp. 138–141. ACM Press (2012).
9. Foster, J.A., Sheridan, P.K., Irish, R., Frost, G.S.: Gamification as a strategy for promoting deeper investigation in a reverse engineering activity. In: *2012 ASEE - American Society for Engineering Education Annual Conference*. American Society for Engineering Education (2012).

10. Freitas, S. De, Liarokapis, F.: Serious Games: A New Paradigm for Education? In: Serious Games and Edutainment Applications. pp. 9–23 (2011).
11. Goldhaber, T.: Using Theories of Intrinsic Motivation to Support ICT Learning for the Ageing Population. In: Proceedings of the 2012 ACM international conference on Intelligent User Interfaces - IUI '12. pp. 359–362. ACM Press, New York, New York, USA (2012).
12. Hernández Ibáñez, L. a., Barneche Naya, V.: Joint spaces between schools and museums via virtual worlds. In: Proceedings of the 2012 ACM workshop on User experience in e-learning and augmented technologies in education - UXeLATE '12. pp. 19–24. ACM Press, Nara, Japan (2012).
13. Johnson, M.W., Okimoto, T., Barnes, T.: Leveraging Game Design to Promote Effective User Behavior of Intelligent Tutoring Systems. *Intell. Tutoring Syst. Lect. Notes Comput. Sci.* 7315, 597–599 (2012).
14. Kim, J.T., Lee, W.-H.: Dynamical Model for Gamification: Optimization of Four Primary Factors of Learning Games for Educational Effectiveness. *Commun. Comput. Inf. Sci.* 351, 24–32 (2012).
15. Kim, S., Ko, F.I.S.: Toward Gamified Classroom: Classification of Engineering Students Based on The Bartle's Player Types Model. *Int. J. Digit. Content Technol. its Appl.* 7, 25–31 (2013).
16. Landers, R.N., Callan, R.C.: Casual Social Games as Serious Games: The Psychology of Gamification in Undergraduate Education and Employee Training. In: Ma, M., Oikonomou, A., and Jain, L.C. (eds.) Serious Games and Edutainment Applications. pp. 399–423. Springer-Verlag (2011).
17. Li, W., Grossman, T., Fitzmaurice, G.: GamiCAD: A gamified tutorial system for first time AutoCAD users. In: UIST'12 - Proceedings of the 25th Annual ACM Symposium on User Interface Software and Technology. pp. 103–112. ACM Press (2012).
18. Malamed, C.: The Gamification of Learning and Instruction: Game-Based Methods and Strategies For Training And Education, (2012).
19. Mazur, M., Rzepka, R., Araki, K.: Proposal for a conversational English tutoring system that encourages user engagement. In: Proceedings of the 19th International Conference on Computers in Education, ICCE 2011. pp. 10–12. Elsevier (2011).
20. Raymer, R.: Gamification - Using Game Mechanics to Enhance eLearning, (2011).
21. Schuster, E.: Mobile Learning and the Visual Web, Oh My! Nutrition Education in the 21st Century. *J. Ext.* 50, (2012).
22. Simões, J., Redondo, R.D., Vilas, A.F.: A social gamification framework for a K-6 learning platform. *Comput. Human Behav.* 29, 345–353 (2013).
23. Singer, L., Schneider, K.: It was a bit of a race: Gamification of version control. In: 2nd International Workshop on Games and Software Engineering (GAS), 2012. pp. 5–8. IEEE Comput. Soc, Zurich, Switzerland (2012).
24. Spence, M., Foster, J.A., Irish, R., Sheridan, P.K., Frost, G.S.: “Gamifying” a library ori-

entation tutorial for improved motivation and learning. In: 2012 ASEE - American Society for Engineering Education Annual Conference. Elsevier (2012).

25. Tabata, H., Hashimoto, H.: WBL for technical skill of MONODZUKURI — With target selection at any time method and sequential presentation of achievement method. In: Proceedings of SICE Annual Conference (SICE), 2011. pp. 2514–2517. SICE, Tokyo, Japan (2011).

26. Vassileva, J.: Motivating participation in social computing applications: A user modeling perspective. *User Model. User-Adapted Interact.* 22, 177–201 (2012).

GAMEFUL DESIGN, SERIOUS GAMES, VIDEO GAMES, AND GAMIFICATION

For means of clarification, in this section we present some concepts usually related to the term *game*. The following discussion is not comprehensive, and it is only intended to clarify and narrow down our definition of gamification. A more comprehensive and deep discussion can be found in [DETERDING *et al.*](#).

- Gamification is not Playful design or gameful design:

Playful design is using game-based aesthetics or limited usability based on game elements in non-game contexts with the purpose of drawing the user's attention ([FERRI, 2016](#)). These elements are used to amuse users and cause an emotional response. One successful example is Twitter's page known as "Fail Whale" (Figure 55). Whenever there is an overload on the servers, instead of a boring page with some standard error message, users are presented with a drawing of a dozen birds, twitters, trying to lift a whale ([KALBACH, 2016](#)).

Figure 55 – The (now retired) "Fail Whale" was used to illustrate Twitter's service outage.

- Gamification is not Serious games:

Serious games are games designed for non-recreational environments, however with learning and game objectives in focus (BLANCHARD; FRASSON C. ANDLAJOIE, 2011). The term “serious” is employed because these games can focus on areas as diverse as economics, education, health, industry, military, engineering, and politics. In environments created by applying serious game concepts, it is possible to simulate real-world situations without incurring in eventual costs and risks. The main goal of this sort of training-environment is to convey information to the user. The Virtual Incident Management Training System (Figure 56) is a multiplayer training environment designed for training professionals that need to act swiftly in case of accident on highways, such as paramedics and policemen (Center for Advanced Transportation Technology Laboratory, 2017).

Figure 56 – The Virtual Incident Management Training System initial screen. Source: (Center for Advanced Transportation Technology Laboratory, 2017)

- Gamification is not video games or digital games:

Video Games or Digital Games are systems in which users are engaged in resolving abstract conflicts and challenges, under predetermined rules (FULLERTON, 2008). In this scenario the game continuously offers interactivity and feedback to the user, which often result in an emotional reaction. Figure 1-d shows a screenshot of the game New Super Mario Bros. Wii© whose main character, Mario, is considered one of the most iconic video game characters.

Figure 57 – New Super Mario Bros. wii a game developed and published by Nintendo

EFFECT SIZE AND CONFIDENCE INTERVAL IMPLICATIONS

Figure 58 – Compilation of effect sizes usually found in the literature.

Table 5.1 Effect sizes commonly used for null hypothesis significance testing and their values considered small, medium, and large effect sizes. This table was created based on existing literature (Cohen 1998; Field 2009; Mizumoto and Takeuchi 2008)

Statistical methods	Effect size	Small	Medium	Large
t-test	Cohen's d	0.2	0.5	0.8
ANOVA	η^2 and η_p^2	0.01	0.06	0.14
Non-parametric tests	R	0.1	0.3	0.5
Correlation	R	0.1	0.3	0.5

Source: Robertson and Kaptein (2016).

Figure 59 – Combinations of effect size and confidence interval, and theoretical implications.

Table 5.2 Implications with eight possible combinations of effect sizes (ES) and confidence intervals (CI)

CI includes 0	ES absolute value	CI range	Implication
No	Small	Small	The effect apparently exists, but the effect is small
	Small	Large	(This is unlikely to happen)
	Large	Small	The effect apparently exists, and we are sure that the effect is large
	Large	Large	The effect apparently exists and may be large, but we are not sure about its actual size
Yes	Small	Small	We are sure that the effect is small, but not sure whether the effect really exists
	Small	Large	We are not sure whether the effect exists. We thus need more data
	Large	Small	(This is unlikely to happen)
	Large	Large	We are not sure whether the effect exists. We thus need more data

Source: [Robertson and Kaptein \(2016\)](#).