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The Role of Gamification in Software Development Lifecycle

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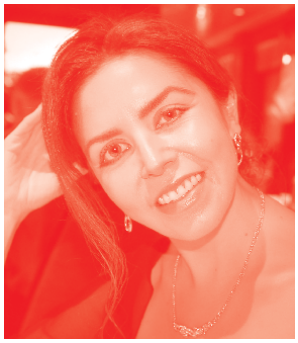

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Meet the editor

Dr. Christos Kalloniatis obtained a Ph.D. in Privacy Requirements Engineering from the Department of Cultural Technology and Communication, University of the Aegean, Greece, a master's degree in Computer Science from the University of Essex, England, and a bachelor's degree in Computer Science from the Department of Informatics, Technological Institute of Athens (now the University of West Attica). He is an associate professor and head of the Department of Cultural Technology and Communication, University of the Aegean, and director of the Privacy Engineering and Social Informatics (PrivaSI) research laboratory. He is a former member of the board of the Hellenic Authority for Communication Security and Privacy. His main research interests are the elicitation, analysis, and modelling of security and privacy requirements in traditional and cloud-based systems, the analysis and modelling of forensic-enabled systems and services, privacy-enhancing technologies, and the design of information system security and privacy in cultural informatics. He has published several refereed papers in international scientific journals and conferences and has served as a visiting professor in many European institutions. Prior to his academic career, he served at various places in the Greek public sector including the North Aegean Region and Ministry of Interior, Decentralisation and e-Governance. He has a close collaboration with the Laboratory of Information & Communication Systems Security, University of the Aegean, and the Systems Security Laboratory, University of Piraeus, Greece. Dr. Kalloniatis has served as a member of various development and research projects.

Contents

Preface

Since the second half of 2010, gamification has been gaining much attention and is being implemented in several sectors to support user engagement as well as provide benefits such as increased user activity, social interaction, and more. While a standard definition of gamification does not yet exist, the official meaning is the use of game elements in non-game contexts to provide a set of benefits to users as well as organizations adopting these types of elements. Indeed, it is true that gamified applications aim to increase users' motivation and awareness towards the use of information and communication technologies (ICTs), and the quality and quantity of the given activities' output. In addition, gamification is based on motivational and behavioral factors. As the aim of gamification is to engage users, developers of gamified services often consider users' needs, various characteristics, interests, and preferences. The introduction of these factors in applications is a challenge because developers must combine psychological principles with software requirements.

Thus, gamification by itself is a complicated concept for software engineers to deal with since it demands a lot of effort to understand and elicit the appropriate requirements that will combine the functionality of the system with the gamified elements and the non-functional requirements (security, privacy, trust, etc.) derived from this combination. This book provides novel contributions and research efforts related to gamification by shedding light on the technical aspects of gamification in various fields. The book consists of six chapters that provide readers, including both experienced and young researchers, the opportunity to engage with this modern and interesting field and identify modern trends and future research opportunities. Chapter authors present their works in a clear and accessible way so that readers are able to understand the meaning of these contributions in relation to the book's objectives.

I would like to thank all authors for their contributions and the editorial team at IntechOpen for their valuable support during the preparation and publication of this book.

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Chapter 1

Gamification: A Necessary Element for Designing Privacy Training Programs

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Abstract

The benefits, deriving from utilizing new Information and Communication Technologies (ICTs), such as Internet of Things or cloud computing, raise at the same time several privacy risks and concerns for users. Despite the fact that users' inability to protect their privacy has been recognized, hence users do not get involved in processes for enhancing their awareness on such issues. However, in order to protect their fundamental right of privacy and to manage it in a practical way when using ICT, privacy literacy is crucial. Users should be trained on privacy issues through appropriate educational programs. Specifically, the development of instructional simulation programs could be of great importance. Relevant methodologies for the development of such services have been recorded in previous literature. Since the concept of training is advanced by creating attractive interaction environments, the educational privacy process could be also more efficient. Towards this, the implementation of game elements serves that purpose, contributing to the design of gameful educational programs. However, despite its benefits, gamification has been noticed to be used more as a tool rather than a concept which could be included in instructional methods. Thus, in this work, gamification features are explained to highlight their importance along with the recorded in the literature educational methods and privacy awareness issues.

Keywords: gamification, game elements, privacy, training program, instructional simulation, educational simulation, method, framework, model

1. Introduction

The established utilization of technologies in various activities, such as the use of cloud systems [1] is an accepted fact [2]. However, several challenges arise concerning privacy protection due to the storage of users' information. Personal information is crucial to be protected while using any type of technology. Thus, privacy should be taken into consideration at the early stages of designing a system. A sequence of methods and steps have been recorded in previous literature and by following them, privacy concepts can be analyzed in systems [3–5] in order for users' privacy to be protected. This analyzation includes the incorporation of privacy requirements in systems [3, 6]. Especially, according to the General Data Protection Regulation – GDPR [7], users' personal data should be protected while using

systems. Except this, individuals have the right to be informed about each process concerns their data. Further to this, each type of organization has to follow specific rules referred in regulations, to ensure that data is protected and to define a person who will be the Data Protection Officer (DPO). Additionally, six principles related to processing of personal data should be considered by each organization [8].

Equally crucial is for the audience to be aware on such issues in order for the privacy protection processes to be accomplished more effectively. For instance, employees should be educated on the rights that they have regarding their data, so as to be able to protect themselves. However, the complexity of such issues signifies that specific educational processes are needed, aiming at training individuals on privacy subjects. This combination could be achieved by introducing several privacy topics in educational methods, in order for a privacy awareness program to be developed. Except this, to maintain users' interest is needed to have attractive interaction environments with elements by which the educational process will be occurred through a more engaging way. Gamification method [9] supports this purpose as the incorporation of game elements in systems creates gameful products, aiming to increase users' engagement on using ICTs. Considering this, by implementing such elements in educational processes on privacy issues, users will have the illusion that they participate into a game but in fact they will be trained.

In spite of the benefits offered by this approach, it has been noticed that developers of instructional models have not emphasize on the consideration of its features during the development phases. Gamification has been mostly used as a tool for the development of applications [10], rather than as an approach which can be considered, so that to design a gamified instructional method. Further to this, the introduction of privacy issues into a such method would be useful for the design of products that purposing on having privacy aware users. Towards this, two main questions arise and will be addressed in this chapter, concerning the offered instructional methods and the mentioned privacy concepts on which users can be educated. The aim is to identify which features and phases have been recommended for the design of educational products and on which privacy topics would be helpful for users to be trained, so that to be able to protect their personal information. Additionally, gamification features are explained to highlight how this method is useful for creating an attractive educational process, especially, when the concept is complex for users, like privacy. These results could be useful for the development of an approach aiming on designing services on privacy awareness within a gameful environment.

To select all this information regarding the two research questions, the PRISMA review method [11] has been followed and implemented. We, first, defined our research questions and the search terms based on each question. According to our search strategy and eligibility criteria, the final results were conducted for each research question which, afterwards, were described. The rest of the paper is organized as follows. In Section 2 gamification features are described. In Section 3, the methods, implemented for the conduction of the results are described. In Section 4, the findings are presented based on the described methods. A discussion of the results is presented in Section 5. Finally, Section 6 concludes the paper.

2. The features of gamification

The provision of attractive ICTs which increase users' engagement is needed while most of users' activities are accomplished through technologies, e.g. e-learning [12]. Such services can be developed through gamification method, as it concerns the implementation of game elements in applications [9]. According

to the literature, several models have been recorded that developers have used to design a gamified system [13–16]. Despite that these methods differ respectively to their processes, their common aim is to show the steps for creating an attractive system to engage users. This approach has been used in various domains [17]. For instance, gamified services in marketing domain aim at raising each company's selling, while customers collect points which can be used for earning gift cards or discounts in products [18]. Furthermore, the use of such services for health issues engages users on protecting their health. For example, they can be notified in order to take their prescription, while they win points or gifts each time they react [19]. Gamified services have been provided in tourism sector as well, in order for the participants to discover several places that may care to visit [20, 21]. Additionally, to increase cultural awareness, such applications are helpful, as it has been recorded in previous literature [22, 23]. Users get familiar with the cultural heritage of various countries through a more interesting process. Thus, several benefits arise by using gamification.

In our previous work, a sequence of game elements has been recorded based on several studies in the literature for the creation of gameful applications [17, 24]. Some of them support the interaction between users, so that they are engaged to participate. These elements are the *communication, challenges, competition* and *collaboration* [25]. The results of each interaction may be presented in *leaderboards*, which engage users on participating in several tasks against or with others. In addition, *alternative activities* [26], such as *quizzes* [12], are provided to users to select *points* and pass *levels*, so that to win *badges* and *rewards* [27]. Users have the ability while creating profiles, to select either a specific role depending on their preferences or an *avatar* for an animated representation [28]. Some of the gamified applications may provide *feedback* to users in order to know their progress or improve their actions [29]. Others include *rules* which have to be followed during the completion of each task or the connection with users' *location* [26]. The last one has mostly noticed in applications regarding tourism domain. Additionally, *notifications* are presented, e.g. for reminding a specific action that should be accomplished [25].

Through these features, gamified applications can be developed in several domains. As described previously, the incorporation of game elements in instructional methods is also crucial, so that the training process to be more interesting and effective, especially, in case the education concerns difficult concepts, such as the protection of users' privacy. However, there is a lack of such models. Two questions arise and addressed in this work, regarding the recorded instructional methods and the privacy awareness topics. These results along with the gamification features could be considered for the creation of a method aiming at training users on privacy issues through gamification.

3. Methods

In this Section, the implemented methodology for the conduction of the review results is described. This research was conducted during September 2020. The review protocol was based on the PRISMA statement [11]. First, the research questions (RQs), presented in **Table 1**, were addressed. The aim of the first research questions is to identify which studies refers to instructional models which can be implemented for developing programs, by using them individuals could be educated on various domains, and to record the steps that each one recommends. According to the second question, the aim is to identify the mentioned privacy topics in literature, which can be taken into consideration while designing training programs for making users to be aware of privacy issues.

Research Question 1	Which instructional simulation models have been recorded?
	Rationale: The aim is to record their steps.
Research Question 2	Which privacy topics have been recorded in literature for increasing users' privacy awareness?
	Rationale: The aim is to identify if there are such topics and to record them.

Table 1.
Research questions.

Based on the above research questions, the next step was to define the search terms. The search string used to collect documents from sources, was constructed using the following terms and the Boolean OR was employed to link them.

- Search terms for RQ1: ("Instructional simulation model" OR "Educational simulation model" OR "Instructional simulation method" OR "Instructional simulation framework" OR "Educational simulation method" OR "Educational simulation framework")

- Search terms for RQ2: ("Privacy educational topics" OR "Privacy awareness topics")

A literature review of works, written in English, indexed in Google Scholar, Scopus, IEEExplore, ACM Digital Library, ScienceDirect and Google was conducted to explore the recorded educational methods and privacy topics. The search was applied to the titles, abstracts and keywords of journal, chapters, workshop and conference papers in order to ensure that their context is the appropriate for the purpose of this work. In addition, studies, identified in non-academic online publications, were collected. The search strategy is outlined in **Table 2**.

Due to the large number of results, returned by a general search and in order to keep the search within reasonable bounds, the number of the results was limited, by selecting publications according to the inclusion and exclusion criteria, presented in **Table 3**. First, academic, journal, conference, workshop studies and sites with

Academic databases searched	• IEEExplore • Scopus • Science Direct • ACM Digital Library
Other data sources	• Google Scholar • Google (only non – academic sources)
Target items	• Journals papers • Workshop papers • Conference papers • Chapters • Non-academic online publications
Search applied to	• Titles • Abstracts • Keywords
Language	• English
Publication period	• From 2005 until today

Table 2.
Search strategy.

	Eligibility Criteria
Inclusion criteria	• Academic journal, conference, workshop papers which include instructional or educational simulation methods • Studies which include privacy awareness topics • Papers written in English • Publication date: since 2005
Exclusion criteria	• Duplicates • Studies without steps • Studies whose full-text is not accessible • Papers available only in the form of abstracts

Table 3.
Inclusion and exclusion criteria.

instructional methods and privacy awareness topics were recorded. The publication date for the studies was defined since 2005, since, according to the literature, most of the studies regarding these methods are published since this year. Thus, it was also preferable to limit the search of the publication period to the last fifteen years. Furthermore, studies which do not include steps would not be considered useful for the purpose of this review. In order for the comprehension of this research to be effective, the studies had to be written in English.

4. Results

In this Section, the conducted results based on the described strategy are presented. Especially, the total number of publications regarding each research question along with specific information about each study are described. It would be interesting to note that many studies were found, but most of them were not appropriate for this research based on the criteria, described in **Table 3**. For the RQ1, 390 studies were identified and after removing duplicates, 336 were screened. The total number of studies included in for this research question is ten, while 326 were excluded according to the inclusion and exclusion criteria. The study selection process is reported and in **Figure 1**, the results are presented based on the PRISMA model.

Specifically, based on the findings in **Table 4**, most of them were identified in ACM digital library and IEEExplore databases, whilst few of the results were found in ScienceDirect database. As presented in **Table 5**, most of the selected studies, which include steps for designing instructional programs, concern journals. On the other side, either workshop papers or non-academic publications meeting the eligibility criteria were not found. Afterwards, the publication year of each work was mentioned and according to **Figure 2**, half of them were published from 2010 to 2015.

For the second research question, our search identified 2.821 studies. After removing duplicates, 1.976 works remained. Many of them, i.e. 1.968, did not pass the inclusion and exclusion criteria. Eight final eligible studies were selected for this research question. These results are presented in **Figure 3**. In **Table 6**, the amount of the identified records is presented, where it is noted that, in contrast to the RQ1, most of them were identified in Scopus and ScienceDirect databases. The included records are eight and most of them were found in non-academic publications, as illustrated in **Table 7**.

Based on the conducted results of this Section, it was noticed that the number of the final studies were included in this review regarding the second research question is greater than this of the RQ1 which concern the educational design

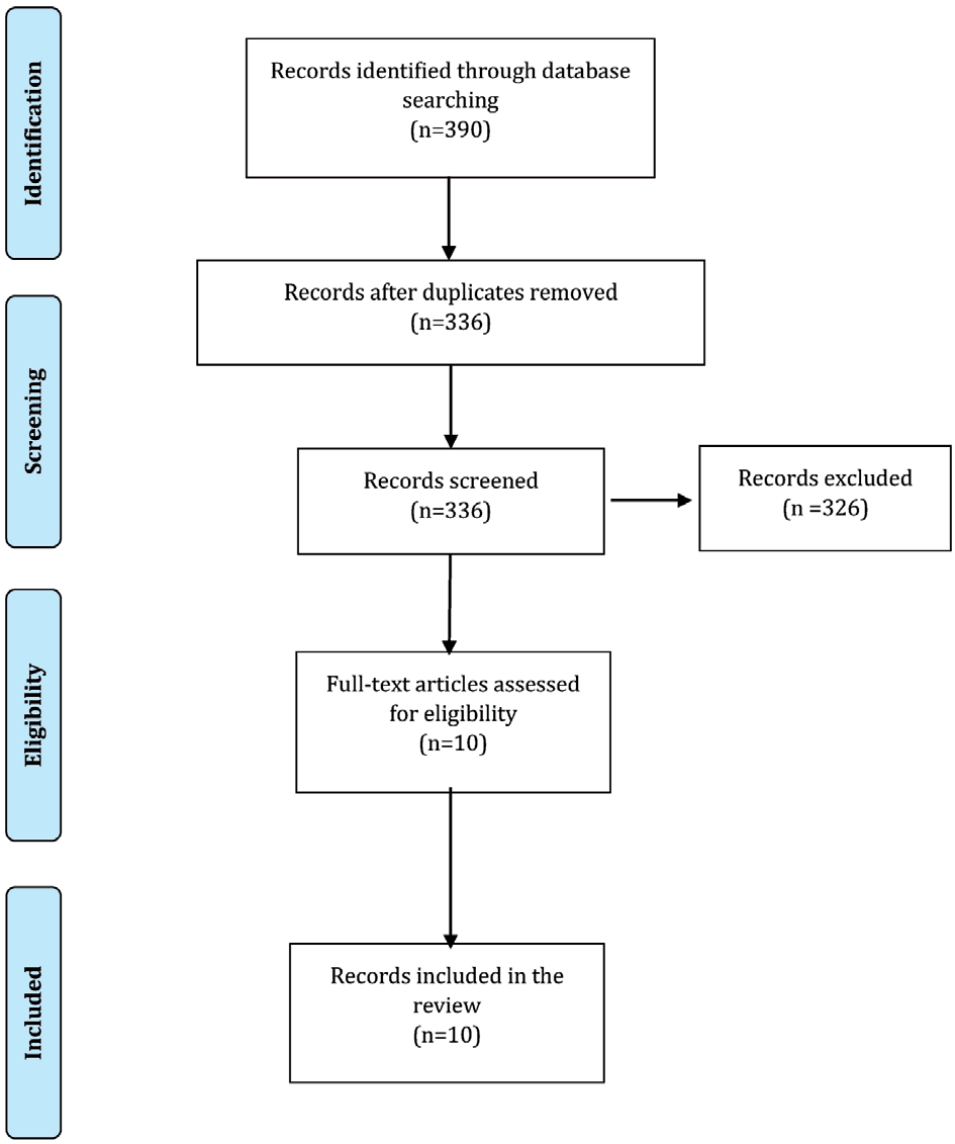

Figure 1.
Flow diagram for RQ1.

Summary of target items – RQ1	
Academic databases searched	
Scopus	16
IEEExplore	134
ACM Digital Library	185
ScienceDirect	15
Other data sources	40
Total	389
Total without duplicates	336

Table 4.
Summary of target items for RQ1.

Summary of search results – RQ1	
Journals papers	6
Workshop papers	—
Conference papers	1
Chapters	1
Books	2
Non-academic online publications	—
Total	10

Table 5.
Summary of search results for RQ1.

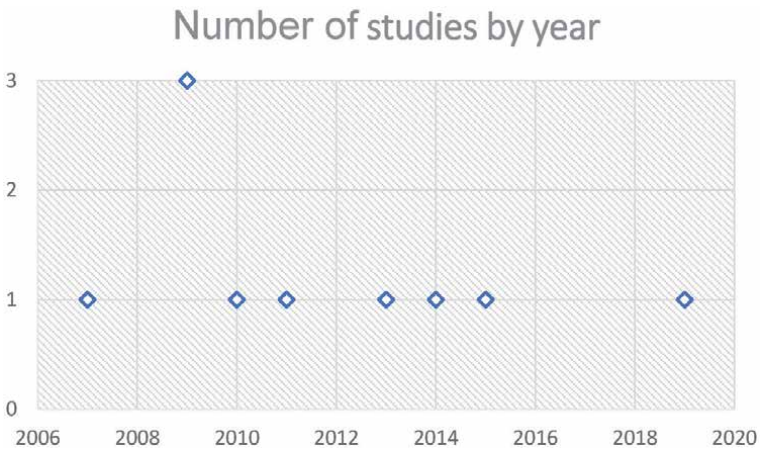

Figure 2.
Number of instructional design studies by year.

approaches. The aim of this review process was to identify the recorded instructional methods and the recommended privacy issues on which users could be educated. Both are presented and described in the next Section.

5. Discussion

The completion of several activities by using technologies may raise several privacy risks, while users' actions and information are recorded. Thus, it is crucial to have aware users on such issues in order to be able to protect their personal information. For instance, many individuals use increasingly various social media, where the creation of a personal account is one of the requirements. Several personal information has to be provided in order to create an account, e.g. the date of birth or an email account. Such information is stored along with users' actions, like communication history and preferences concerning posts or publications. According to this, privacy risks arise while using various social platforms [30].

The development of instructional programs aiming to train the audience on privacy issues would be a useful process to avoid privacy violations. Several instructional design methods have been recorded in the literature and can be implemented for the development of such services. Additionally, privacy awareness topics have been noticed which could be considered during designing them. The aim of this

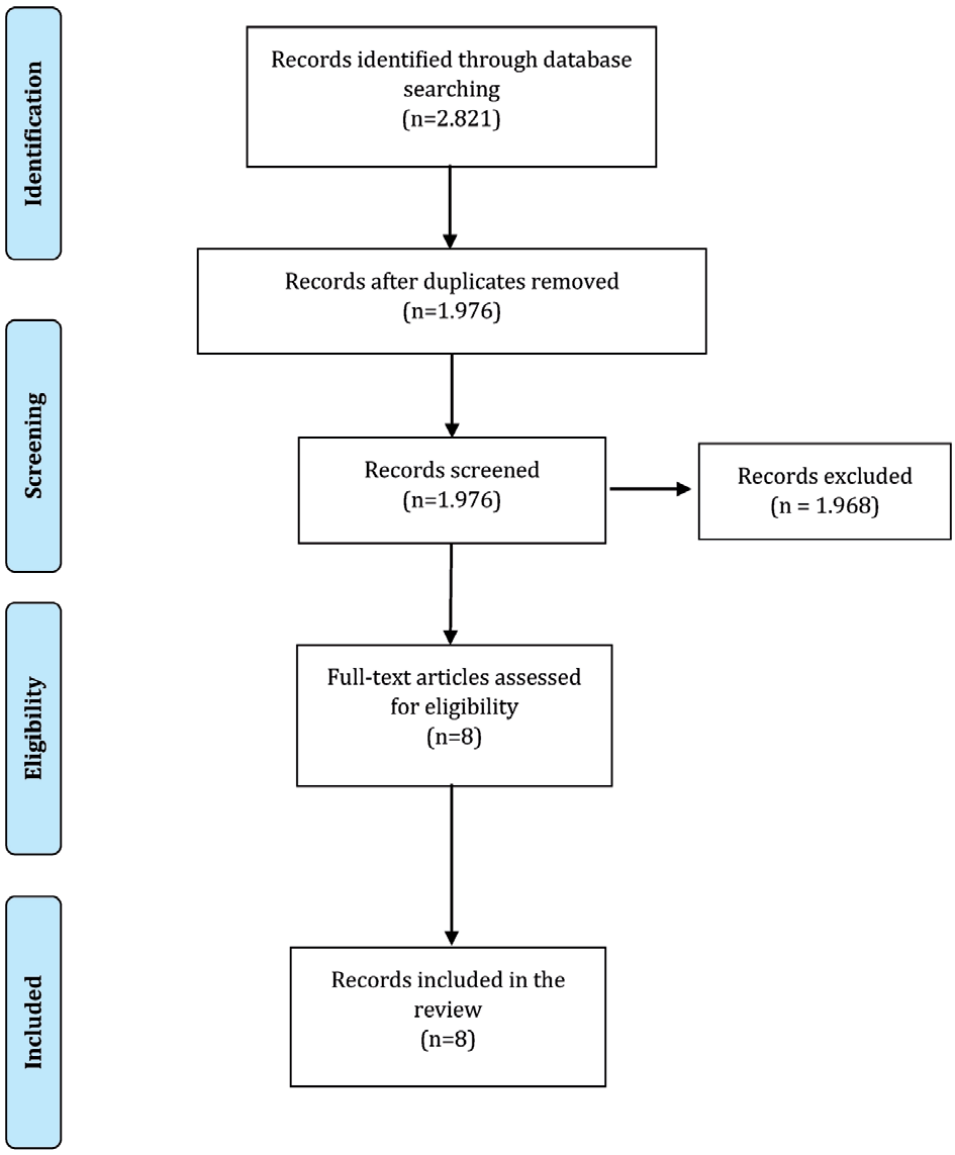

Figure 3.
Flow diagram for RQ2.

Section is to present and discuss the results of both research questions, mentioned above regarding the amount of instructional design approaches and the recommended awareness topics on privacy issues.

5.1 Instructional design approaches

According to the results of the research for the first question, ten educational models have been recorded and presented in **Table 8**. Dissimilar steps and processes are included in each model and two of them consist of a specific concept, e.g. the development of gamified educational programs. Nevertheless, all of them focus on designing applications, whose purpose is to engage users on educating. In [31], the ADDIE approach is described and its name is based on the included steps, i.e. **A**nalyze, **D**esign, **D**evelop, **I**mplement and **E**valuate. In summarily, the aim of each

Summary of target items – RQ2	
Academic databases searched	
Scopus	1000
IEEExplore	79
ACM Digital Library	800
ScienceDirect	910
Other data sources	32
Total	2.821
Total without duplicates	1.976

Table 6.
Summary of target items for RQ2.

Summary of search results – RQ2	
Journals papers	1
Workshop papers	—
Conference papers	—
Chapters	—
Books	—
Non-academic online publications	7
Total	8

Table 7.
Summary of search results for RQ2.

step, respectively, is to a) define the context, the aim of the system and users' needs, b) design the application, c) develop it along with the instruction for the audience, d) implement it after preparing the users, and e) evaluate based on the determined evaluation criteria. Similar to this approach, is the ARCS (Attention, Relevance, Confidence, and Satisfaction) model presented in 2010 [32], which includes the analyzation of the objectives, materials and audience motivation, the selection of tactics and the writing of instructions, the development and implementation of the materials, and the revision of the product in order to detect the expected and unexpected motivational effects.

In 2015, the ARCS+G model [33] was presented, which extends the ARCS model by incorporating gamification principles in order to provide an approach for using gamification in learning. The gamified approach of ARCS model includes the design and implementation stages in which a sequence of steps is described. Especially, the introduction of gamification principles is accomplished by including the definition of motivational design goals, the preparation of a list with the motivational tactics, which help instructors to accomplish the goals, as well as the development of learning environments with motivational elements. All these processes concern the design phase. During the implementation phase, the selection and explanation of gamification mechanisms is described. For instance, in case of implementing the "competition" element, the use of leaderboards will show the leading scorers, so that users to be motivated and compete more with others. For the implementation of each element, the motivational tactic is considered. In the case of competition, the proposed tactic is the provision of the results to engage users.

Instructional Design Approaches					
Publication	**Year**	**Target**	**Context**	**Type of publication**	**Database**
Instructional Design: The ADDIE Approach (Robert Maribe Branch et al.)	2009	Instructional design	1. Analyze 2. Design 3. Develop 4. Implement 5. Evaluate	Book	Google
Backward Design: Targeting Depth of Understanding for All Learners (Childre Amy et al.)	2009	Instructional design	1. Identify learners 2. Identify Curricular Priorities 3. Design Assessment Framework 4. Create learning activities	Journal	Google
First principles of instruction (David Merrill, M.)	2009	Instructional design	1. Activation 2. Demonstration 3. Application 4. Integration	Journal	Google
Motivational Design for Learning and Performance (Keller, John M.)	2010	Instructional design	1. Define 2. Design 3. Develop 4. Pilot	Book	Google
Bloom et al.'s taxonomy of the cognitive domain	2011	Instructional design	1. Knowledge 2. Comprehension 3. Application 4. Analysis 5. Synthesis 6. Evaluation	Journal	Google

Instructional Design Approaches					
Publication	**Year**	**Target**	**Context**	**Type of publication**	**Database**
A model for the systematic design of instruction (Walter Dick et al.)	2013	Instructional design	1. Instructional Goals 2. Instructional Analysis 3. Entry Behaviors and Learner Characteristics 4. Performance Objectives 5. Criterion-Referenced Test Items 6. Instructional Strategy 7. Instructional Materials 8. Formative Evaluation 9. Summative Evaluation	Journal	Google
Enhancement of the ARCS Model for Gamification of Learning (W. M. Amir Fazamin W. Hamzah et al.)	2014	Gamification & Instructional Simulation	1. Design 2. Implementation	Conference	IEEE
Comparative Analysis between System Approach, Kemp, Journal (Ibrahim, Ahmad Abdullahi)	2015	Instructional design	1. instructional program identification, and goal specification of an instructional course 2. examination of learners' characteristics based on the instructional decisions 3. subject content identification with task analysis related to goals and purposes 4. instructional objective specification 5. instructional unit in arranged, in logical sequential order of learning 6. instructional strategies design to meet the mastery of lesson objectives 7. plan and develop instruction 8. evaluate instruments for measuring course objectives, 9. resource selection for instruction and learning activities	Journal	Google

Instructional Design Approaches					
Publication	**Year**	**Target**	**Context**	**Type of publication**	**Database**
An ASSURE-Model Instructional Design Based on Active Learning Strategies and its Effect for 1st Intermediate Student's Higher Order Thinking Skills in Teaching Science Text Book (Sami Hameed Kadhim Al-Khattat et al.)	2019	Instructional design	1. Analyze learners 2. State standards and objectives 3. Select strategies, technology, media and materials 4. Utilize technology, media and materials. 5. Require learner participations 6. Evaluate and revise	Journal	Google
Simulation Models in Education (Hrvoje Stančić et al.)	2007	Simulation Model for e-learning	1. Formulation of the problem 2. Collection of the information and construction of the conceptual model 3. Checking the validity of the conceptual model 4. Model programming 5. Checking the validity of the programmed model 6. Design, conduction and analysis of the simulation Documentation and presentation of the simulation	Chapter	Google
Total number of studies			10		

Table 8.
Instructional design approaches.

Based on [34], the main aim is to identify which the learners are and the priorities of each curriculum. Afterwards, the assessment framework should be developed, which, significantly, includes the selection of tasks, tests and quizzes. The last phase concerns the creation of the learning activities, considering that the context should engage users on educating. The ASSURE model, published in 2019 [35], named after its phases, as the ADDIE model. The described parts are the a) analyzation of learners' characteristics b) definition of objectives, c) selection and design of learning materials and strategies d) employment of technologies and learning media e) implementation of the material and f) the evaluation and revision of the program.

In [36], similar steps with the above models, have been identified. The main difference is identified on the separation of some phases, which previously were presented as the step one. In particular, the identification of needs, the definition and documentation of the objectives, the analyzation of learners and contexts are the four distinct steps in this approach. Similarly, the development of assessment instruments, instructional strategy and materials concern the three next phases. Afterwards, the aim is to evaluate the product in order to revise it, based on the results of the evaluation and finally, to design and re-evaluate the product. The repetition of the assessment process is recommended in order to improve more the final product.

An equivalent approach has been published in 2015 by [37], where the first parts concern the identification of the instructional program, purposes, users' needs and context of program. Next, the already defined program has to be planned and developed in order to be implemented. As it is suggested in most of the instructional models, the evaluation process is needed in order to improve it based on the assessment results. The recommended approach in 2011 [38], is relative to the first one of the above described models. This approach consists of six steps, where at first the same identifications about the users' needs, characteristics, learning objectives and materials are included. Next, the design and application of the material, based on the previous analyzations, are described. The last step is the evaluation of the material based on the recorded feedback. In 2007 [39], Hrvoje Stančić et al. presented general steps, which should be implemented for developing the instructional simulation approaches. In this work, the first step is to identify the scope of the program and therefore, to record the needed information, e.g. development timeframe, in order to design the conceptual model of the program. The design of the program and the examination of each validity are considered as the final steps.

Based on the described models, several steps with similarities are identified. Most of them include the definition of objectives, users' needs, concept of program and instructional materials during the first phases. Afterwards, the design phase is included where the interface and the context of the program is illustrated in order to be developed. The developed programed is implemented, where users interact with it. In order for the system to be improved, it is crucial to record users' feedback. Thus, an evaluation stage is needed, where the evaluation criteria are specifically defined. Few differences have been recorded among the models. For instance, one difference that could be mentioned concerns the model ARCS, which focuses more on motivating users, so as to be educated. Furthermore, one of them, i.e. the ARCS+G model [33], is totally different, since its concept is not only to develop an educational product, but also to gamify it by incorporating game elements during its development.

Such approaches should be enhanced and as it was aforementioned, it could be interesting and useful to be combined with gamification attributes in order for, by implementing them, attractive training programs to be developed. Gamification has

been mostly utilized as a tool for designing gamified educational programs. Various of such programs have been recorded in previous literature [40, 41] offering a more entertaining educational process and users are more engaged to be trained on several issues. Despite the usefulness of gamification in education domain, its report in educational models is missing. A correlation could be defined among these elements and the processes of instructional models, based on the concept of each element and the aim of each process. Thus, game elements will be included in each step of a model and not only in the design phases as it is customary, according to the gamification models.

5.2 Privacy awareness topics

According to the results, recorded during the search for the RQ2, several privacy topics have been identified, which could be considered during designing educational programs for increasing users' awareness on privacy issues. Based on their concept, they were classified into four main categories, as presented in **Table 9**. Landau [42] recommends that users could be educated on privacy social aspects, i.e. privacy regulations and laws, psychology and economics. Specifically, regarding law issues on information privacy, it would be interesting for users to be trained on the existing privacy regulations, on how data has to be protected by each type of organization based on these regulations, and on which rights the privacy policies have been based [42].

Additionally, more technical subjects are suggested, which could be used for example in order to educate software developers on designing tools, which analyze security and privacy concepts in systems or on developing privacy and security aware services [42]. Furthermore, one subject concerns the anonymization tools, e.g. k-anonymity, while others relative to anonymity – one of the privacy requirements –, concern security issues, cryptography technique and privacy techniques. In general, for users is important to be aware on the "Privacy by Design" philosophy, since they will be able to understand either the importance of protecting their privacy or to recognize what is needed to be implemented to ensure privacy protection [43]. Privacy threats is another issue on which users would be educated, as it is useful to be aware on possible threats in order to be able to protect their personal information while using each type of technology.

Besides them, a sequence of questions has been recorded, recommended as possible topics for privacy awareness. First of all, the audience of an educational program would be interested to know what privacy means and its importance, why it should be aware on privacy issues [44] in order to be able to understand more specified issues. Such issues could be the type of data that should be protected, the way of organizing data, the importance of saving and backing up critical data and the protocols of sharing data [45]. Another privacy awareness topic could be to learn how data can be controlled in order to avoid possible attacks [46]. As, frequently, new products are provided by organizations, the education on privacy issues which arise with new services would be useful for users, as they will be able to identify them while using technologies [43].

While many organizations restore data, individuals should be informed about their rights, which data are used, by whom and the reason of each use. In a similar way, organizations should be aware on their responsibilities regarding the collection, processing and sharing of this users' data [47]. Further to this, responsible departments of an organization could be educated on strategies regarding the training of the staff on protecting security and privacy in order the education process to be more effective [48]. Additionally, they could be

Privacy's social aspects
Law
Regulation
Economics
Psychology (including human–computer interaction)
Law issues on information privacy
Development of privacy within the law
Privacy law in commercial practice, health information, and communications
Privacy and data protection, including the international aspects of this
Regulatory frameworks for privacy
Technical issues on information privacy
Cryptography
Anonymity
Security
Privacy techniques
Anonymization tools (pseudonymity, Tor, k-anonymity, and differential privacy) and attacks on and failures of those tools
Privacy threats
General issues
Why privacy?
What are the consequences of not being #PrivacyAware?
Why should I care about privacy if I have nothing to hide?
Wouldn't we all be better off if all information was always recorded and visible?
What data needs to be protected?
How to label data
How to organize data
Protocols on sharing data
How to dispose of data no longer needed
The importance of backing up critical data
Differences between privacy and security
Rights that individuals have regarding their personal data
Organization's responsibilities when collecting and processing personal data
The responsibilities organizations have when sharing data internally, externally, and across borders
Trust
Minimize What Data You Collect and Release
Controlling Data Access
Understand the "Privacy by Design" philosophy
How to identify the privacy issues that can arise with new products or services
What are the best tactics for educating staff about their roles in and the importance of privacy and data security?
What should organizations look out for to make sure their vendors and partners are privacy aware?

Table 9.
Privacy awareness topics.

trained on how to recognize that employees are aware on the taught material [48]. By satisfying such issues, trust among users and organizations can be increased. Trust would be also an important subject within educational programs in order to highlight the importance of creating a straightforward relation between entities [47].

Concluding various privacy topics could be considered while designing an educational programs. This process would be useful for individuals due to the difficulty of understanding in depth the importance of privacy and the way of protecting personal data. For instance, a combination between the results of these research questions could concern the model ARCS+G and the consequences of not being privacy-aware. The provision of an attractive interaction environment in relation to the provision of privacy violation examples could be an interesting educational process for users. Such combinations could be achieved, considering the above described results, in order to have privacy-aware users who will be able to protect themselves. Various instructional methods are offered and in their processes the identification of objectives and users' needs are included. The protection of users' privacy consists a crucial objective to be considered during designing such services. Concluding, these findings could be useful for experts of designing educational methods. Specifically, the provision of an instructional model whose purpose is to create privacy awareness training programs would be helpful to increase users' awareness on such issues.

6. Conclusions

The education of users on privacy issues is crucial in order for them to be able to protect their personal information by several possible threats. Thus, privacy awareness programs need to be developed. As privacy is a complex concept for users, attractive environments would support a more effective educational process. This could be achieved by incorporating game elements into instructional methods for privacy issues. However, it has been noticed that gamification has been used more as tool for creating gamified applications on several domains than as a concept included in such methods. Thus, in this work, the gamification features are explained to highlight its importance of considering them in these methods. Further to this, all the offered instructional models recorded in previous literature are presented. Additionally, privacy awareness topics were summarized and explained. For the presentation of these results, a literature review was conducted based on two research questions. The implemented methods are explained in detail and as it is already mentioned, the PRISMA method was used. According to the search terms, many publications were resulted, but considering the eligibility criteria, many of them were excluded. Several educational frameworks were recorded with many similarities, such as the design or the evaluation phase, but some of them differ, since their concept focuses on a specific research area. For instance, one of them incorporates the gamification method in order to develop a gamified instructional model. Similarly, a sequence of privacy issues was mentioned and described, e.g. the importance of protecting personal data and be a privacy-aware user. These results could be considered either for the development of a method, whose aim is to create gamified privacy training programs or for extending one of these methods incorporating gamification features and including a privacy awareness topic. In each case, the provision of such programs is important and useful, so that users to be able to protect themselves through a more effective and engaging way, as many technologies are used for the completion of various tasks.

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Conflict of interest

The authors declare no conflict of interest.

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References

[1] T. Dillon, C. Wu, and E. Chang, "Cloud computing: Issues and challenges," Proceedings-International Conference on Advanced Information Networking and Applications, AINA, pp. 27-33, 2010, doi:10.1109/AINA.2010.187.

[2] A. Valentín, P. M. Mateos, M. M. González-Tablas, L. Pérez, E. López, and I. García, "Motivation and learning strategies in the use of ICTs among university students," *Computers and Education*, vol. 61, no. 1, pp. 52-58, 2013, doi:10.1016/j.compedu.2012.09.008.

[3] C. Kalloniatis, P. Belsis, and S. Gritzalis, "A soft computing approach for privacy requirements engineering: The Pri S framework," *Applied Soft Computing Journal*, vol. 11, no. 7, pp. 4341-4348, 2011, doi:10.1016/j.asoc.2010.10.012.

[4] C. Kalloniatis, "Incorporating privacy in the design of cloud-based systems: A conceptual meta-model," *Information and Computer Security*, vol. 25, no. 5, pp. 614-633, 2017, doi: 10.1108/ICS-06-2016-0044.

[5] A. Pattakou and C. Kalloniatis, "Security and Privacy Requirements Engineering Methods for Traditional and Cloud-Based Systems: A Review," *Cloud Computing*, no. c, p. 7, 2017.

[6] L. Liu, E. Yu, and J. Mylopoulos, "Security and privacy requirements analysis within a social setting," *Proceedings of the IEEE International Conference on Requirements Engineering*, vol. 2003-Janua, pp. 151-161, 2003, doi: 10.1109/ICRE.2003.1232746.

[7] G. Danezis *et al.*, *Privacy and Data Protection by Design - from policy to engineering*, no. December. 2015.

[8] W. S. Blackmer, "EU general data protection regulation," *American Fuel and Petrochemical Manufacturers, AFPM - Labor Relations/Human Resources Conference 2018*, vol. 2014, no. April, pp. 45-62, 2018.

[9] S. Deterding, Dan Dixon, Rilla Khaled, and L. E. Nacke, "From Game Design Elements to Gamefulness: Defining 'Gamification,'" *Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments, MindTrek 2011*, pp. 9-15, 2011.

[10] C. R. Nevin *et al.*, "Gamification as a tool for enhancing graduate medical education," *Postgraduate Medical Journal*, vol. 90, no. 1070, pp. 685-693, 2014, doi: 10.1136/postgradmedj-2013-132486.

[11] D. Moher, A. Liberati, J. Tetzlaff, and D. G. Altman, "Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement," *International Journal of Surgery*, vol. 8, no. 5, pp. 336-341, 2010, doi: 10.1016/j.ijsu.2010.02.007.

[12] M. M. Gåsland, "Game mechanic based e-learning: a case study," *Science And Technology, Master Thesis (June 2011). ...*, no. June, p. 77, 2011.

[13] B. Morschheuser, L. Hassan, K. Werder, and J. Hamari, "How to design gamification? A method for engineering gamified software," *Information and Software Technology*, vol. 95, pp. 219-237, Mar. 2018, doi: 10.1016/j.infsof.2017.10.015.

[14] K. Yonemura, K. Yajima, R. Komura, J. Sato, and Y. Takeichi, "Practical security education on operational technology using gamification method," in *2017 7th IEEE International Conference on Control System, Computing and Engineering (ICCSCE)*, Penang, Nov. 2017, pp. 284-288, doi: 10.1109/ICCSCE.2017.8284420.

[15] K. Werbach and D. Hunter, *For the win: how game thinking can revolutionize your business*. Philadelphia: Wharton Digital Press, 2012.

[16] O. Pedreira, F. García, N. Brisaboa, and M. Piattini, "Gamification in software engineering – A systematic mapping," *Information and Software Technology*, vol. 57, pp. 157-168, Jan. 2015, doi: 10.1016/j.infsof.2014.08.007.

[17] A. G. Mavroeidi, A. Kitsiou, C. Kalloniatis, and S. Gritzalis, "Gamification vs. privacy: Identifying and analysing the major concerns," *Future Internet*, vol. 11, no. 3, 2019, doi: 10.3390/fi11030067.

[18] K. Huotari, "Defining Gamification - A Service Marketing Perspective," pp. 17-22, 2012.

[19] D. Johnson, S. Deterding, K. A. Kuhn, A. Staneva, S. Stoyanov, and L. Hides, "Gamification for health and wellbeing: A systematic review of the literature," *Internet Interventions*, vol. 6, pp. 89-106, 2016, doi: 10.1016/j.invent.2016.10.002.

[20] N. S. Sever, G. N. Sever, and S. Kuhzady, "The Evaluation of Potentials of Gamification in Tourism Marketing Communication," *IJARBSS*, vol. 5, no. 10, p. Pages 188-202, Oct. 2015, doi: 10.6007/IJARBSS/v5-i10/1867.

[21] A. Mehrbod, N. Mehrbod, A. Grilo, C. Vasconcelos, and J. L. Silva, "Gamification in supported geocaching tours," in *2017 International Conference on Engineering, Technology and Innovation (ICE/ITMC)*, Funchal, Jun. 2017, pp. 1419-1423, doi: 10.1109/ICE.2017.8280049.

[22] Y. Heryadi, A. Z. Robbany, and H. Sudarma, "User experience evaluation of virtual reality-based cultural gamification using GameFlow approach," in *2016 1st International Conference on Game, Game Art, and Gamification (ICGGAG)*, Jakarta, Indonesia, Dec. 2016, pp. 1-5, doi: 10.1109/ICGGAG.2016.8052644.

[23] A. Döpker, T. Brockmann, and S. Stieglitz, "Use Cases for Gamification in Virtual Museums," p. 14.

[24] A.-G. Mavroeidi, A. Kitsiou, and C. Kalloniatis, "The Interrelation of Game Elements and Privacy Requirements for the Design of a System: A Metamodel," in *Trust, Privacy and Security in Digital Business*, vol. 11711, S. Gritzalis, E. R. Weippl, S. K. Katsikas, G. Anderst-Kotsis, A. M. Tjoa, and I. Khalil, Eds. Cham: Springer International Publishing, 2019, pp. 110-125.

[25] K. Seaborn and D. I. Fels, "Gamification in theory and action: A survey," *International Journal of Human Computer Studies*, vol. 74, pp. 14-31, 2015, doi: 10.1016/j.ijhcs.2014.09.006.

[26] Z. H. Morford, B. N. Witts, K. J. Killingsworth, and M. P. Alavosius, "Gamification: The intersection between behavior analysis and game design technologies," *Behavior Analyst*, vol. 37, no. 1, pp. 25-40, 2014, doi: 10.1007/s40614-014-0006-1.

[27] A. Ahtinen *et al.*, "Mobile mental wellness training for stress management: Feasibility and design implications based on a one-month field study," *Journal of Medical Internet Research*, vol. 15, no. 7, pp. 1-13, 2013, doi: 10.2196/mhealth.2596.

[28] M. Andrew, *Game Thinking*. 2015.

[29] B. Morschheuser, L. Hassan, K. Werder, and J. Hamari, "How to design gamification? A method for engineering gamified software," *Information and Software Technology*, vol. 95, no. January, pp. 219-237, 2018, doi: 10.1016/j.infsof.2017.10.015.

[30] G. Beigi and H. Liu, "Privacy in social media: identification, mitigation

and applications," *arXiv*, vol. 9, no. 4, pp. 1-36, 2018.

[31] R. M. Branch, *Approach, Instructional Design: The ADDIE*, vol. 53, no. 9. 2009.

[32] J. M. Keller, *Motivational Design for Learning and Performance*. 2010.

[33] T. Ramadani Arjo, R. Yulius, and M. Fajri Amirul Nasrullah, "Enhancing learning engagement on minangkabau traditional food through gamified mobile quiz," *Journal of Physics: Conference Series*, vol. 1196, no. 1, 2019, doi: 10.1088/1742-6596/1196/1/012027.

[34] A. Childre, J. Sands, and S. T. Pope, "Backward Design: Targeting Depth of Understanding for All Learners," *TEACHING Exceptional Children*, vol. 41, no. 5, pp. 6-14, 2009, doi: 10.1177/004005990904100501.

[35] S. H. K. Al-Khattat, R. R. Habeeb, and A. R. Mohammed, "An ASSURE-Model Instructional Design Based on Active Learning Strategies and its Effect for 1st Intermediate Student's Higher Order Thinking Skills in Teaching ...," *Psihologija*, no. March, 2019.

[36] W. Dick, "A model for the systematic design of instruction," *Instructional Design: International Perspectives: Theory, Research, and Models*, vol. 1, pp. 361-370, 2013.

[37] A. A. Ibrahim, "Comparative Analysis between System Approach, Kemp, Journal," vol. 3, no. 12, pp. 261-270, 2015.

[38] W. Huitt, "Bloom et al.'s taxonomy of the cognitive domain," *Educational Psychology Interactive*, 2011.

[39] *M. David* Merrill, "First principles of instruction," *Instructional-Design Theories and Models*, vol. 3, no. 3, pp. 41-56, 2009, doi: 10.4324/9780203872130.

[40] C. Cheong and J. Filippou, "Quick Quiz : A Gamified Approach for Enhancing Learning," 2013.

[41] L. Feldbusch, F. Winterer, J. Gramsch, L. Feiten, and B. Becker, "SMILE Goes Gaming : Gamification in a Classroom Response System for Academic Teaching," no. Csedu, pp. 268-277, 2019, doi: 10.5220/0007695102680277.

[42] S. Landau, "Educating engineers: Teaching privacy in a world of open doors," *IEEE Security and Privacy*, vol. 12, no. 3, pp. 66-70, 2014, doi: 10.1109/MSP.2014.43.

[43] TeachPrivacy, "Privacy Awareness Training-Privacy by Design." https://teachprivacy.com/training-privacy-by-design/.

[44] Cipher, "Integrate These 10 Topics into Your Data Protection Training," 2020. https://cipher.com/blog/integrate-these-10-topics-into-your-data-protection-training/.

[45] Jordan Stokes, "9 Topics to Cover in Your Privacy Awareness Training Program," *MediaPRO*, 2019. https://www.mediapro.com/blog/9-topics-privacy-awareness-training-program/.

[46] S. Morrow, "5 Methods for Data Privacy Enhancement," 2017.

[47] TeachPrivacy, "Global Privacy and Data Protection," 2020. https://teachprivacy.com/training-program-global-privacy-data-protection/.

[48] CSIAC, "Data Privacy Day – Fostering a Culture of Privacy Awareness at Work." https://www.csiac.org/data-privacy-day-fostering-a-culture-of-privacy-awareness-at-work/.

Chapter 2

Threats Arising from Software Gamification

Lucio Gros and Cécile van de Leemput

Abstract

The appearance of gamification dates back about a decade and since this tool has been increasingly used not only in the entertainment sector but also in the industry, army, education, health and others. Studies suggest that this approach may provide added value outcomes, in particular in the users' motivational and engagement areas, in a wide range of fields such as customer relations, skills learning, physical exercises, health management, etc. On the other hand, the consequences and potential risks related to its use remain insufficiently understood and have started to become the object of research in the last years. This chapter aims at exploring and deepening the understanding of the possible threats resulting from the use of software gamification at both the individual and collective levels. To do so, an integrative literature review was carried out on studies examining the negatives effects and challenges of this tool so as to identify the possible adverse impacts arising from them. Overall, results would show that an inadequate gamification design and implementation and its implications in terms of a flawed rewarding system and ethical issues may entail perils such as demotivating users, engendering mistrust, health issues and tarnishing the gamification credibility as well as that of the management in charge of it.

Keywords: gamification, engagement, motivation, risks, threats

1. Introduction

The impressive growth of the gaming sector in the last decades [1] constitutes one of the major elements to understand the rational of gamification. Indeed, the massive use of video games has triggered the interest of scientists and several industrial sectors to know what renders this cyberactivity motivating [2]. Fundamentally the objective being to identify and use the engaging components of video games in other activities with other purposes than gaming so as to increase the participation of the users concerned (customers, employees, students, etc.) [3].

Since 2010s gamification has been growing as both a subject of study and as a tool for stimulating users' activities [1, 4]. In particular, it is usually designed and used for promoting and supporting users' motivation and engagement and it has been applied in a quite wide range of areas such as entertainment, business, health, education, military, etc. [5].

The increasing use of gamification in the last decade attracted the attention of researchers and thus led to a growing number of studies in this field. However, it could be stated that despite its rapid development the academic attention to this

field is rather recent [6]. According to the available papers in research databases (see section Approach), it seems that the efforts to understand the dimensions and characteristics related to this tool and its use have been unequally distributed. Indeed, theorising on the gamification concept and studying its main advantages through concrete applications are the most explored areas. Studies on the effectiveness of this approach relative to its goals in different contexts are also rather frequent, although to a lesser extent. On the other hand, despite the production of useful and interesting literature review studies on detecting and grasping the limitations, negative consequences, unintended side effects, challenges and risks of gamification, this topic appears to be one of the least covered areas so far and probably insufficiently understood [7–9]. Since the information systems do influence users' behaviour [10], it is meaningful to examine the possible harms caused by gamification, which overall remain under addressed and represent an area needing further research.

Within this frame, this chapter aims at exploring the following question: What are the possible threats arising from the use of gamification at both the individual and collective levels?

An integrative literature review [11] was chosen as a means to seek answers and to develop insights into the mentioned research question that constitutes the scope of this study. The rest of this chapter is organised as described hereafter:

The next section concerns the notional part of this chapter, that is the grasping of gamification as a concept, with examples of definitions and differentiation with similar concepts as well as the semantic mapping on the main notions arising from this subject. Then, the research approach and the protocol employed to operate the analysis are presented. The following section displays and describes the results from the integrative literature review. Finally, the last section includes the discussion on the results, their implications, ideas on possible future research, conclusions and limitations of this study.

Through this integrative literature review, this paper contributes to discern perils that may result from gamification and suggests to take them into consideration during both the design and the outcome evaluation phases of this tool.

2. Grasping gamification

Understanding the nature, the purpose and the components of gamification is probably the pre-requisite to explore the potential threats that may result from the use of this approach. Precising the content of the gamification concept and its boundaries has been the object of studies [6]. As a result, the theorization work on gamification produced several definitions on this subject. For instance, Zicherman and Cunningham [12] define this concept as " *…changing the way of thinking and using some gaming rules in order to increase the interest of learners and to solve problems*".

Huotari and Hamari [13] share many concepts of the previously cited definition by referring to gamification as "*the process of enhancing services with motivational affordance for gameful experiences*". Seaborn and Fels [14] define it as "the intentional use of game elements for a gameful experience of non-games tasks and context".

Detering et al. [6] describe this concept as " *…the use of game design elements in non-game contexts*". This definition is quite generic, comprehensive and implicitly involves the motivational and useful aspects of this tool.

Beyond the degree of explicitness in citing the major components of gamification in the definitions, the leading thread of resorting to game elements and

applying them in non-game like activities consists in the attempt to combining the pleasant to the useful.

The obvious tie between the terms *gamification* and *game* deserves to be clarified. Whilst game refers to an activity whose main purpose is entertaining, gamification uses games principles in a non-game activity aiming at changing attitudes and behaviours [15].

It is probably also useful to make the distinction between gamification and game-based learning. In the latter participants embark in their learning process through game playing, whereas in the former the learning takes place in a non-game context and requires the endeavour, knowledge and skills of participants to reach their goals [16].

The concept of *serious games* could also be regarded as quite close to that *of gamification*, yet their differences lie in the fact that the former is a complete game setting for non-recreational purposes on a serious subjects whereas, as mentioned previously, the latter adopts game elements in other non-game systems contexts [6].

Another concept that probably needs to be addressed is that of *play*. Games imply a set of norms and regulations to reach an objective usually through competition, unlike *play* which rather involves a free improvising behaviour with a sense of enjoyment [17]. However, gamification has also been described by resorting to aspects of *play*: "Gamification is the application of gameful or playful layers to motivate involvement within a specific context" [18]. The distinction between these two concepts is based on the previous analysis made on the specificities of *paidia* (i.e. play) and *ludus* (i.e. games) [19]. In other words, games would result from the formalisation of *play* through the establishment of rules, norms and explicit objectives. For its part, gamification relates to games, which in turn has ties with *play*, and aims at benefiting from the stimulating features of these two concepts [20]. These are all definitions that suggest a possible lack of consensus concerning the explicit inclusion of the notion *play* when defining gamification. Yet, some industrial sectors criticise the insufficient components of *play* in the gamification design and consider that, if included, they could probably render the gamified solution more engaging [6].

The connexions of '*gamification*' with '*games*' and '*play*', constitute a web of major concepts related to one another of this research topic. In fact, each one of these terms is polysemic, thus in each of them coexist several meanings. In addition to the thorough and articulated definitions on *gamification, games* and *play* provided by the authors mentioned previously, a semantic mapping [21] of these concepts as well as with of those related to main purpose of gamification (i.e., '*engaging*' and '*motivating*' users) is developed here below to have a synthetic overview on how these notions tie with one another, on the meanings they share or that differentiate them.

2.1 Semantic mapping of gamification, game, play, motivation and engage

2.1.1 Goal

The aim of this section is providing a holistic scheme so as to visually display the concepts semantically related to the main terms of this study (gamification, game, play, engage, motivation) independently of their specialised definitions mentioned previously. Based on the distinctions and sameness between the meanings arising from these main words, it is intended to highlight the notions that would match the purpose of gamification and those that would diverge from it and could represent potential threats.

2.1.2 Method

We looked for the dictionary definitions [22] of the main concepts to grasp this tool (i.e., *gamification*, *game*, *play*, *motivation*, *engage*). The key words (terms directly related to this research topic) defining each of these concepts were included in the semantic net around the word they are related to. For example, the definition of gamification was: *Transformation of a product/story into a game.* The association between the gamification definition and the term *game* as a key concept on which this definition is based, is represented with the arrow linking *gamification* with *game.* In turn, the key word *game* was subject to a new cycle of search definition whose key words were also included in this semantic net with the corresponding

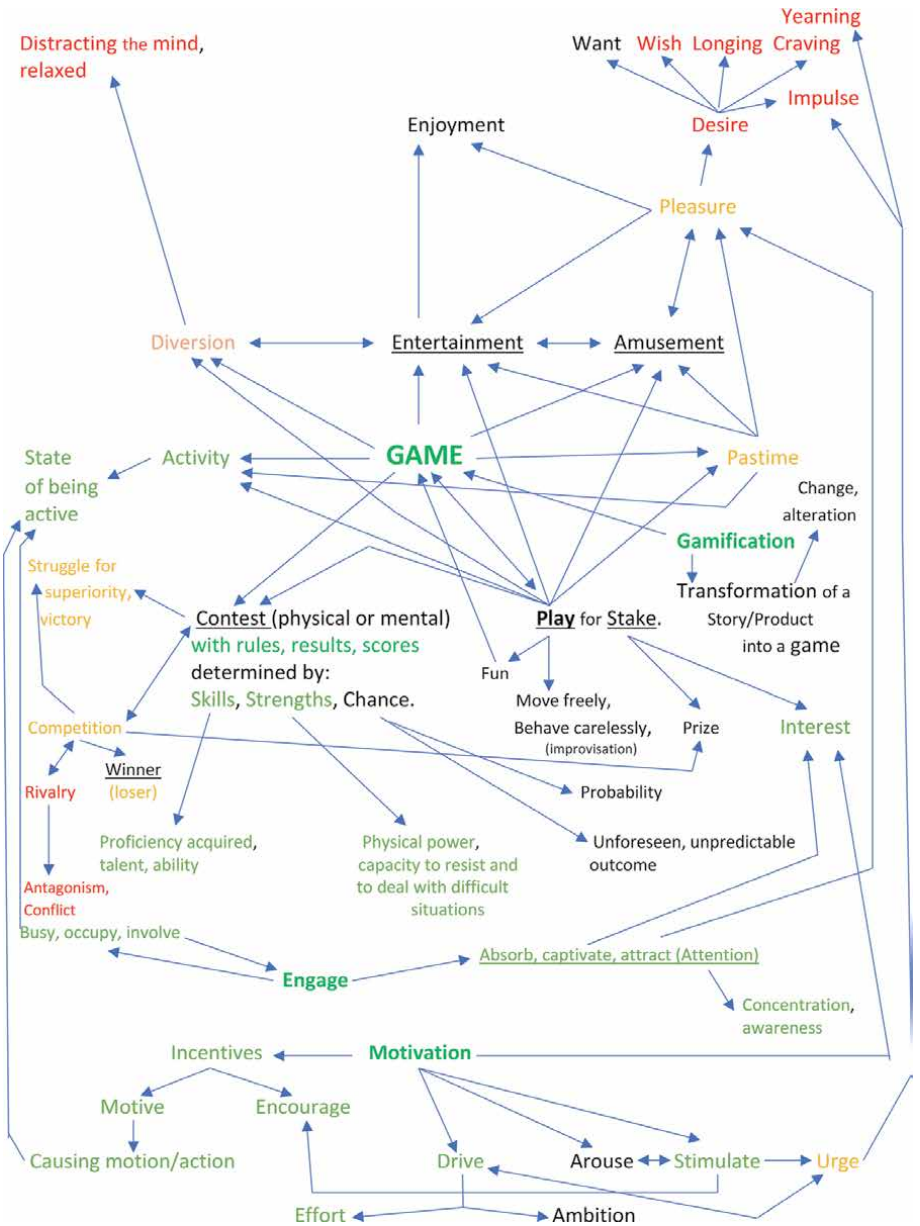

Figure 1.
Semantic net graphic of Gamification, Game, Play, Engage and Motivation.

arrows tying *game* with to each of the key words sustaining its meaning. Then, each of these key words went through the definition search. The same proceeding was applied over again until the key words of the new definition were the same ones as those previously found or were out of the scope of this research. This process was undertaken for the five mentioned words in one integrated mapping. Finally, the meaning-based connections between the identified terms were underlined or coloured according to their degree of compatibility with the gamification purpose as described in 2.1.3.

2.1.3 Results of the sematic mapping

The graphic illustrates the results of the semantic mapping (**Figure 1**) which shows the obvious and expected link between *gamification* and *game*. In turn, *game* shares an important common ground with *play*. Although often gamification definitions do not resort to the notion of *play,* this conceptual intersection between *play* and *game* might raise the question as whether these two concepts could be separated from each other.

In principle, the areas in green are affordances, psychological and behavioural outcomes that gamification is meant to promote [7], whereas the words in red represent those that the tool is not supposed to foster and may designate risky areas [7, 9]. The words in black and underlined would be affordances, psychological and behavioural outcomes that gamification would use and aim at in moderation.

On the other hand, the orange coloured text would highlight those indicating a possible risk for the gamification approach to deviate from its purpose.

We are aware that there is not always a clear cut between these notions and that much can be debated about how these concepts relate with gamification. The last section of this chapter deepens and expands the analysis on these issues.

3. Research approach

To investigate the possible threats resulting from gamification, an integrative literature review approach was implemented [11, 23]. This approach intends to gather relevant observations and findings of existing literature review studies enabling to deepen insights into the issues and trends likely to provide elements of answer to the research question. In particular the aim is identifying the unintended side effects, challenges and limitations of gamification detected and analysed in the included studies from which may be inferred the possible perils arising from gamification, and thus compensating the shortage of papers studying specifically the threats resulting from this tool.

The mentioned approach consists in three phases:

1. The choice of words for the search of studies was intended to be as broad as possible given the previously mentioned dearth of papers covering specifically the threats of gamification. Consequently, several words were used to refer to the possible adverse impacts of gamification. The terms chosen to search the studies in all used databases were: *literature review, gamification, risks, disadvantages, threats, negative impacts, unintended side effects*.

The four inclusion criteria were: 1) Published peer reviewed papers 2) Literature review studies 3) Written in English 4) Papers that examine, at least partially, the negative consequences and/or threats of gamification. Were excluded: 1) Posters

2) Non-published studies 3) Studies written in other languages than English. Literature review papers on empirical studies about gamification implementation pros and cons were privileged so as to increase the chances to identify frequent trends about the research question of this chapter.

2. To check the relevance of the literature review studies a closed question was used: *Does the study provide explicit information on the negative outcomes of gamification (limitations, side effects, risks, threats, challenges)?* In practical terms, the title of all the studies detected was analysed to verify whether it referred explicitly or implicitly to the research question. If yes, the abstract and key words were in turn analysed to corroborate that the mentioned gamification issues were covered by the study. Then the paper was scrutinised to further reassert that it provides an explicit description/ synthesis of the challenges, unwanted effects, negative impacts of gamification solutions so as to ensure the match of the study with the purpose of this chapter and finalise the selection process. Due to the scarcity of literature review papers on this specific research question identified through the databases, other literature review studies matching the inclusion criteria were found via references.

3. A manual content analysis was carried out to detect the items or paragraphs related to the mentioned gamification's issues linked to the search words. The leading thread to conduct this content analysis was the question "what challenges/risks/threats/negative impacts were encountered when implementing gamification?". The identified items/texts from the selected studies are summarised and described in Section 4. Besides, all the identified items/texts are listed in **Table 1** and constitute the measures of this phase. Since, as expected, some items were the same or very similar across the included studies, based on their commonalities they were grouped in homogeneous categories (gamification issues) and the frequency of items per category relative to the total number of identified items was calculated (**Table 2**). In turn, these categories went through two processes. First, they were grouped in clusters according to their ties with the functions or fields of gamification, with the purpose of reaching a more synthetic overview and detecting the areas of gamification where dysfunctions were observed or reported. Secondly, for each of the categories the open question was posed: *"What are the potential adverse impacts of these items*?" [24], so as to explore and infer the possible threats that may arise from them at both the individual and collective/organisational levels. This second process led to the identification of perils that could result from the mentioned categories. The result of this analysis with all the mentioned components is described and synthesised in 4.2 and **Table 3** respectively.

4. Results

The search was carried out by employing the key words mentioned earlier in the following databases through the University of Maastricht: Clarivate Analytics, JSTOR (filters used: science & engineering, journal articles), PubMed, MEDLine (Ovid SP), Clarivate Analytics (filters used: medicine, health & life science), EBSCO host APA PsycArticles (filters used: psychology & neuroscience, journal articles), Google Scholar and Maastricht University online library.

	Included Literature Review Studies	Identified Items/texts on Limitations, Challenges and Negative Unintended Side Effects of Gamification
1.	"Does gamification work? A literature review of empirical studies on gamification". J. Hamari, J. Koivisto and H. Sarsa (2014). [25]* Number of examined studies included in this review: 24	• Gamification might not be effective in utilitarian contexts • Results of gamification may not be long term • Some users did not find gamification engaging
2.	"The dark side of gamification: How we should stop worrying and study also the negative impacts of bringing game design elements to everyone". S. Hyrynsalmi, J. Smed and K. Kimppa (2017) [9]* Number of examined studies included in this review: 26	• Users might be optimising the end-result game (ex. Position in leader boards) and not the task at hand • Some gamified solutions may be simplistic, childish and therefore demotivating • Some gamified solutions may encourage users to perform behaviour only when rewarded. • Gamified solutions may distract users from the main purpose • Risks of replacing intrinsic motivation with pursuit of extrinsic rewards • Ethical issues: ex. taking advantages of users, infringing their autonomy. • Lucrative gaming elements for one user can be detrimental to teamwork
3.	"A systematic review of gamification in e-Health". L. Sardi, A. Idri and JL Fernandez-Aleman. Journal of Biomedical Informatics, 17 (2017), [26]* Number of examined studies included in this review: 46	• Effectiveness of the gamification solutions can lessen when relying on only one game element. • There is no unified framework for evaluating gamification principles and outcomes. • Users might feel motivated and excited about the gamification elements, but the interest declines over time • Gamification elements are sometimes perceived to be meaningless and not helpful in terms of the system's healthcare purposes • Gamification solutions are not users-centred as they overlook the traits and demographics characteristics of potential users. • Some rewards were judged to be irrelevant or exaggerated • Gamified health solutions do not integrate health professionals in their development • Cheating may increase as users might work to achieve higher levels solely for their sake of rewards • There is a significant lack of control between the elements of gamification and thus various elements were viewed as a single one
4.	"Gamification of enterprise systems – A synthesis of mechanics, dynamics and risks". M. Schmidt-Kraepelin, S. Lins, S. Thiebes S. and Sunyaev A. (2019), [27]* Number of examined studies included in this review: 62	• Quality of tasks might suffer if gamified elements distract from the main purpose of the activity • Low implementation quality of mechanics and dynamics which might lead to dysfunctional reward system or interaction concepts and may result in users' demotivation. • If underlying rules are not clearly defined, it enables cheating, which can lead to rejection of implemented game elements by other employees

	Included Literature Review Studies	Identified Items/texts on Limitations, Challenges and Negative Unintended Side Effects of Gamification
		• Monitoring and surveillance of both the performed activity and the performing employee are likely to breach privacy rights • An overemphasis of competition might lead to decreasing participation and not appeal to employee. Competition might undermine cooperation, which is needed in business contexts • A decreased effectiveness can occur once the novelty of gamification has worn off. • By excessively granting extrinsic rewards, the underlying intrinsic motivation can be undermined
5.	"Gamification in health behaviour change support systems – A synthesis of unintended side effects". M. Schmidt-Kraepelin, S. Thiebes, S. Stepanovic, T. Mettler and A. Sunyaev (2019), [7]* Number of examined studies included in this review: 33	• Undermining intrinsic motivation • Motivation decreases over time • Unfulfilled expectations (generated by gamification solutions) • Distraction from health purpose • Trivialising the health context • Reduced usability: confusing/too complex interface • Cheating the self • Incorrect reward • Execution overuse due to wrong rewards • Cheating others • Overemphasised peer pressure (competition) • Exaggerated punishment • Feeling of manipulation • Discouragement due to failure in competitions • Privacy infringements • Fostering behaviour that harms third parties
	. Total included Literature Review Studies: 5 . Total studies on gamification reviewed by the five included Literature Reviews: 187	Total: 42 identified items

Table 1.
Included literature review papers, number of studies on gamification examined by them and the 42 identified items/texts on limitations, unintended negative side effects, risks and challenges of gamification. () numbers in brackets allud to the bibliographic references.*

All databases together, the search conducted beginning of September 2020 produced 1696 hits from which 2 literature review studies were selected. Due to the considerable dearth of literature review papers about our research topics, 3 other studies that met the inclusion criteria were found via references. Consequently, altogether 5 literature review papers were selected and included, which in total analysed 187 studies on gamification and identified 42 negative unintended side effects, limitations, risks and challenges about its implementation, all of them listed in **Table 1**.

Although the methods and the examined gamification contexts somewhat vary across the five selected literature review studies, they yielded to an important extent common and/or converging gamification issues as described here below.

For instance, in their literature review Hamari et al. [25] aimed at measuring the effectiveness of gamification by examining 24 peer reviewed empirical studies on gamification in different contexts. In particular, the areas explored referred to the

used *motivational affordances*, and their impact in terms of *psychological* and *behavioural* outcomes. In terms of gamification issues, the results of this study would indicate that gamification may be less compatible with utilitarian contexts, with some profile of users and would only have a short-term impact. Methodologically though, it is noteworthy remarking that 17 (out of the 24-peer reviewed empirical studies) utilised qualitative users' perception measurements only without using control groups. Moreover, most of their experiment timeframes were quite short and consequently the novelty effect might have impacted users' perceptions. In addition, the motivational affordances as well as the psychological/behavioural outcomes varied between the studies.

Hyrynsalmi et al. [9] tackled more straightforwardly the issues arising from this tool from a researcher perspective. Indeed, their research question aimed at exploring *"how researchers have perceived the negative side effects of applying gamification?"*. To do so, authors carried out a systematic literature review (SLR) that included 26 literature review studies about gamification on which they implemented a content analysis that led to the definition of two categories of negative consequences: 1) Limitations of gamification (i.e., moderate or less optimal outcomes of gamified system), which could be demotivating, detrimental to teamwork or distracting users from their core activity. 2) Harmful consequences (i.e., gamified solution producing users' questionable and potentially unethical behaviours), that may lead to problem of ethical nature. It is important underlining that this SLR relied on secondary studies and thus lacks the detailed information on specific issues that primary studies may provide.

Sardi et al. [26] also run a SLR, but they focused their study to explore the advantages and shortcomings of gamification in e-health. Several research questions were addressed, among which the one that relates to our integrative review: "Which challenges are most frequently encountered during gamification?". In total the authors included 46 studies that were examined via structured questionnaire to extract data from them to answer the research questions. The challenges identified were also around the decline of users' interest over time, the poor design of gamified solutions and the ethical issues. Besides, other important issues were detected, namely the inadequacy of rewards, the poor tailoring of the gamified solutions and the lack of united framework for evaluating gamification principles and outcomes. This SLR provides a more holistic analysis of the challenges associated with gamification, but it specifically examined the e-health sector only.

Schmidt-Kraepelin et al. [27], studied the use of gamification in Enterprise Systems (ES). Apart from exploring how gamification could increase ES end-user acceptance, the authors raised and examined the research question that is quite linked to our integrative review: What risks are related to applying gamification in ES contexts? Altogether, 62 studies (quantitative and qualitative) on gamification were selected and analysed. The focus of this literature review was centred on gamification's mechanics, dynamics (Zichermann and Cunningham 2011) and risks. In total 339 mechanics and dynamics were identified (172 empirically confirmed). The negative consequences of gamified Enterprise Systems (perceived risks) amounted 59 risks, which were categorised in seven master-risks. The found risks relate to areas similar to those identified in the previous studies, in particular the ethical issues, the declining impact of gamification over time, the grabbing of users' attention at the expenses of the main purpose and the dysfunctional rewards. Concerning the last point, the authors state how a moderate quality of gamification mechanics and dynamics adversely impacts the rewarding system, which in turn leads to users' demotivation. On the other hand, the interaction between the mechanics and dynamics is not analysed in this study.

Finally, Schmidt-Kraepelin et al. [7] examined the consequences of gamification as a means to support behavioural change in the health domain. The authors run a literature review with the aim of exploring the research question "*what unintended side effects may occur when implementing gamification in the health behaviour change support systems*?". In this literature review 33 studies were included; peer reviewed papers were prioritised. Data was processed through manual content analysis and by using an open coding approach, which yielded 16 potential unintended side effects linked with motivational issues (undermining intrinsic motivation, motivation decreasing over time), rewarding system inadequacies, distraction from the core purpose of the activity, ethical matters, poor match with the context and low-quality system interface. The moderate running-in of this tool is worthy of note and thus requires cautiousness about its impact evaluation.

The detailed information about this phase is presented in **Table 1**, which lists the titles of the included literature review studies and describes the 42 unintended negative side effects, risks and challenges of gamification identified by them.

4.1 Classifying the 42 identified items on limitations, risks, challenges and unintended side effects of gamification

Despite the different methods used and the variety of gamification contexts examined in these studies there are clear similarities among the 42 identified items on the risks, challenges, limitations and side effects of gamification. Consequently, items sharing analogue meanings or belonging to the same gamification area/function were set in the same cluster. In other words, the listed 42 items in **Table 1** went through a grouping process and based on their commonalities and semantic consistencies a total of 11 categories were constituted.

For instance, the four items referring the short-term impact of gamification and its decline over time were grouped in the same category (Short-term impact of gamification on users' motivation).

The same goes for the two items related to the poor users-centred gamified solutions and the absence of integration of health professionals' input in gamification development (None or insufficient tailoring in the gamification design and development).

The three items alluding to gamified solutions not fitting the demands of the environment constituted the category 'Mismatch between gamification and its context'.

The item stating the absence of united framework for evaluating gamification principles and outcomes is related to the two previous categories albeit as a cause of them rather than as part of them, hence its status as one item category (Lack of evaluation tool).

The four items associated with gamified elements deviating users' attention from their core duties and activities were grouped under the category 'Possible over-emphasis on hedonic elements at the expenses of the utilitarian purpose'.

The four items related to users taking unfair advantage of gamified systems were placed in the 'Cheating' category.

The four items linked with the possible misuse of gamification (surveillance, manipulation, exploitation and infringing privacy and autonomy of users) formed the category 'Moral and Legal Principles Matters'.

The six items referring to the impact of poorly designed gamified solutions on users' motivation and engagement were set in the category 'Usability of gamified solutions and users' motivation'.

The seven items stating the inconsistent rewards generating demotivation or misbehaviour constitute the category 'Unsound encouraging/punishing'.

Categories of gamification issues	Items x Category	Frequency
Possible over-emphasis on hedonic elements at the expenses of the utilitarian purpose	• Quality of tasks might suffer if gamified elements distract from the main purpose of the activity [27] • Gamified solutions may distract users from the main purpose [9] • Users might be optimising the end-result game (ex. Position in leader boards) and not the task at hand [9] • Distraction from health purpose [7]	4/42
Short term impact of gamification on users' motivation	• A decreased effectiveness can occur once the novelty of gamification has worn off. [27] • Users might feel motivated and excited about the gamification elements but the interest declines over time [26] • Results of gamification may not be long term [25] • Motivation decreases over time [7]	4/42
None or insufficient tailoring in the gamification design and development	• Gamification solutions are not users-centred as they overlook the traits and demographics characteristics of potential users [26] • Gamified health solutions do not integrate health professionals in their development [26]	2/42
Lack of evaluation tool	• There is no unified framework for evaluating gamification principles and outcomes. [26]	1/42
Mismatch between gamification and its context	• Gamification elements are sometimes perceived to be meaningless and not helpful in terms of the system's healthcare purposes [26] • Gamification might not be effective in utilitarian contexts [25] • Trivialising the health context [7]	3/42
Cheating	• If underlying rules are not clearly defined, it enables cheating, which can lead to rejection of implemented game elements by other employees [27] • Cheating may increase as users might work to achieve higher levels solely for their sake of rewards [26] • Cheating the self [7] • Cheating others [7]	4/42
Moral and Legal Principles Matters	• Monitoring and surveillance of both the performed activity and the performing employee are likely to breach privacy rights [27] • Taking advantage of users, infringing their autonomy. [9] • Feeling of manipulation [7] • Privacy infringements [7]	4/42
Usability issues of gamified solutions and users' motivation	• Effectiveness of the gamification solutions can lessen when relying on only one game element. [26] • There is a significant lack of control between the elements of gamification and thus various elements were viewed as a single one. [26] • Some gamified solutions may be simplistic, childish and therefore demotivating [9] • Some users did not find gamification engaging [25]	6/42

Categories of gamification issues	Items x Category	Frequency
	• Reduced usability: confusing/too complex interface [7] • Low implementation quality of mechanics and dynamics which might lead to dysfunctional reward system or interaction concepts and may result in users' demotivation [27]	
Unsound encouraging/punishing (explicit or implicit)	• Some rewards were judged to be irrelevant or exaggerated [26] • Some gamified solutions may encourage users to perform behaviour only when rewarded [9] • Exaggerated punishment [7] • Execution overuse due to wrong rewards [7] • Incorrect reward [7] • Unfulfilled expectations (generated by gamification solutions) [7] • Fostering behaviour that harms third parties (doc 3)	7/42
Weakening cooperation, teamwork	• An overemphasis of competition might lead to decreasing participation and not appeal to employee. [27] • Lucrative gaming elements for one user can be detrimental to teamwork [9] • Overemphasised peer pressure (competition) [7] • Discouragement due to failure in competitions [7]	4/42
Overemphasis on extrinsic motivational elements and users' intrinsic motivation	• By excessively granting extrinsic rewards, the underlying intrinsic motivation can be undermined [27] • Risks of replacing intrinsic motivation with pursuit of extrinsic rewards [9] • Undermining intrinsic motivation [7]	3/42

Table 2.
Categories of gamification issues, the identified items (unintended side effects, limitations, risks and challenges of gamification) per category with the bibliographic reference number in brackets of the study that originally detected them, the frequency of the mentioned items per category relative to the total number of items.

The four items indicating that competition-like gamified solutions may take place at the expenses of cooperation were grouped under the cluster 'Weakening cooperation, teamwork'.

Finally, the three items showing the negative impact of gamified solutions linked with extrinsic rewards on intrinsic motivation of users formed the category 'Overemphasis on extrinsic motivational elements and users' intrinsic motivation'.

These categories are presented with their corresponding items and the frequency of the mentioned items per category relative to the total number of items (**Table 2**).

4.2 Threats of gamification

In turn, these eleven categories with their respective items went through a double processing whose aim is to facilitate the identification of threats and their localisation in relation to the organisational areas/functions of gamification. That is: 1) Grouping them according to the major areas/functions of the gamification system where these limitations and unintended side effects have been observed or

reported. 2) Inferring the threats that could arise from them by exploring the potential adverse impacts of their items.

The content analysis suggests that the design and development phase of the gamification system, its rewarding system and the ethical sphere are the gamification areas/functions associated with the detected issues. Although it could be stated that most identified negative impacts of gamification result from insufficiencies in the design and development phase, some of them are associated more specifically to particular domains of gamification, hence the formation of two other areas/functions of gamification (i.e., Flawed Rewarding System and Ethical Issues). As for the threats, some areas and/or mismanagement of this tool could lead to perils, namely a loss of gamification/management credibility, low productivity, users' demotivation, an atmosphere of mistrust tied with health and ethical issues. Each of these areas/functions of gamification with their respective categories are described below, along with the possible threats that arise from them.

4.2.1 Inadequate gamification design and development phase

This area of gamification is composed of several categories. The category "None or insufficient tailoring in the gamification design and development" that leads to a "Mismatch between gamification solution and its context". Moreover, design deficiencies result in "Usability issues of gamified solutions" as well as in two other categories "Gamified elements distracting from the main purpose" and "Cheating". This scenario may be worsened by the "Lack of evaluation tool" which would prevent from ensuring the learning process required to adjust and improve the gamification system. At the organisational level, an inadequate design and development of gamification, would, through its implementation dysfunctions, impact adversely the credibility of both the gamified system and that of Management [26, 27]. It would also imply a productivity loss and thus a low cost-effectiveness as well as a low implementation quality of mechanics and dynamics that would engender problematic interactions and an inefficient reward system [27].

Moreover, from a user stand point, "Gamified elements distracting from the main purpose" would suggest, at least partially, the engaging effect of flow [9]. Whilst this emotional state may serve the purpose of gamification (engaging and motivating), it may also put at risk users with gaming addiction history [9] and with attention deficit disorders (ADD) [28]. The nature of this category, due to its health-related impact, may be regarded as an extension of the "Ethical issues". Finally, although the "Usability issues of gamified solutions" are not elements of the rewarding system per se, they would also have a demotivation impact on users like a flawed rewarding system does [9].

4.2.2 Flawed rewarding system

As a function, the rewarding system is probably the gist of the gamification process. The observed "Unsound encouraging/punishing" measures produce unintended effects such as "Some gamified solutions may encourage users to perform behaviour only when rewarded", "Users' Motivation declines over time", "Execution overuse due to wrong rewards" or even "Fostering behaviour that harms third parties" which can have ethical consequences [7]. Besides, the over use of competition as a means to increase users' engagement might weaken "cooperation and teamwork" [9, 25], with the risk of deteriorating the interactions and the atmosphere among users [7]. Furthermore, the gamified solution that "overemphasise the extrinsic motivation" could eventually hinder users' motivation [8, 9, 18].

Areas/ functions of gamification	Categories of gamification issues	Items (limitations, unintended side effects, challenges of gamification) x category	Possible Threats	Frequency of items x Areas/ functions of gamification
Inadequate gamification design and development	None or insufficient tailoring in the gamification design and development	• Gamification solutions are not users-centred as they overlook the traits and demographics characteristics of potential users • Gamified health solutions do not integrate health professionals in their development	• Hindering the credibility of the gamified system as well as that of management [7, 26]	20/42 (47.6%)
	Mismatch between gamification and its context	• Gamification elements are sometimes perceived to be meaningless and not helpful in terms of the system's healthcare purposes • Gamification might not be effective in utilitarian contexts • Trivialising the health context	• Productivity loss [27] • Low cost-effectiveness	
	Lack of evaluation tool	• There is no unified framework for evaluating gamification principles and outcomes		
	Usability issues of gamified solutions	• Effectiveness of the gamification solutions can lessen when relying on only one game element. • There is a significant lack of control between the elements of gamification and thus various elements were viewed as a single one • Low implementation quality of mechanics and dynamics which might lead to dysfunctional reward system or interaction concepts and may result in users' demotivation • Some gamified solutions may be simplistic, childish and therefore demotivating	• Demotivating users [8, 9, 27]	

Areas/ functions of gamification	Categories of gamification issues	Items (limitations, unintended side effects, challenges of gamification) x category	Possible Threats	Frequency of items x Areas/ functions of gamification
		• Some users did not find gamification engaging • Reduced usability: confusing / too complex interface		
	Cheating	• If underlying rules are not clearly defined, it enables cheating, which can lead to rejection of implemented game elements by other employees • Cheating may increase as users might work to achieve higher levels solely for their sake of rewards • Cheating the self • Cheating others	• Demotivating users [8, 9] with possible ethical implications	
	Possible over-emphasis on hedonic elements at the expenses of the utilitarian purpose	• Quality of tasks might suffer if gamified elements distract from the main purpose of the activity • Gamified solutions may distract users from the main purpose • Users might be optimising the end-result game (ex. Position in leaderboards) and not the task at hand • Distraction from health purpose	• Decreased productivity • Health Matters [9, 28]: Possible flow generating gamified solutions that could put at risk users prone to addiction or with ADD	
Flawed Rewarding System	Unsound encouraging/ punishing	• Some rewards were judged to be irrelevant or exaggerated • Some gamified solutions may encourage users to perform behaviour only when rewarded • Exaggerated punishment • Execution overuse due to wrong rewards • Incorrect reward • Unfulfilled expectations (generated by	• Hampering users' motivation, frustrating users, undermining cooperation, thus obtaining the opposite effects relative to the gamification's goals [8, 27]	18/42 (42.8%)

Areas/ functions of gamification	Categories of gamification issues	Items (limitations, unintended side effects, challenges of gamification) x category	Possible Threats	Frequency of items x Areas/ functions of gamification
		gamification solutions) • Fostering behaviour that harms third parties *		
	Overemphasis on extrinsic motivational elements rather than on intrinsic ones	• By excessively granting extrinsic rewards, the underlying intrinsic motivation can be undermined • Risks of replacing intrinsic motivation with pursuit of extrinsic rewards • Undermining intrinsic motivation		
	Weakening cooperation, teamwork	• An overemphasis of competition might lead to decreasing participation and not appeal to employee. • Lucrative gaming elements for one user can be detrimental to teamwork • Overemphasised peer pressure (competition) • Discouragement due to failure in competitions		
	Short term impact of gamification on users' motivation	• A decreased effectiveness can occur once the novelty of gamification has worn off. • Users might feel motivated and excited about the gamification elements but the interest declines over time • Results of gamification may not be long term • Motivation decreases over time		
Ethical Issues	Moral principles matters	• Monitoring and surveillance of both the performed activity and the performing employee are likely to breach privacy rights	• Generating an atmosphere of mistrust [27]	4/42 (9.5%)

Areas/ functions of gamification	Categories of gamification issues	Items (limitations, unintended side effects, challenges of gamification) x category	Possible Threats	Frequency of items x Areas/ functions of gamification
		• Taking advantage of users, infringing their autonomy • Feeling of manipulation • Privacy infringements		

Table 3.
The areas/functions of gamification with their corresponding categories of gamification issues, items x category (limitations, risks, challenges and unintended side effects of gamification), possible threats arising from gamification (with the bibliographic reference number in brackets) and frequency of items per areas/function of gamification relative to the total amount of items expressed in fractions and percentage.

Overall, the failures concerning the rewarding system are a threat at both the individual and collective level insofar as they may hamper users' motivation or lead to users' frustration [7, 27], and thus obtaining the opposite results relative to those targeted by the gamification system [9].

4.2.3 Ethical issues

This sort of critical matters usually results from the two previous areas/functions of gamification (an Inadequate Gamification Design and Development phase, and a Flawed Rewarding system). It could relate to a moderate quality of gamified solutions, in which underlying rules are not clearly defined and enable "cheating". Ethical issues might also arise from the way in which the gamification system handles users' data, defines and implements the users' role ("Privacy and autonomy infringements", "feeling of manipulation") [27, 29]. Besides, as mentioned earlier, rewards that "Foster behaviour that harms third parties" could have also ethical consequences [7]. These issues may generate a sense of mistrust and thus demotivate users, which in turn would weaken the adherence to the system [7].

The synthetic overview of the possible threats arising from areas and functions of gamification are summarised in the **Table 3**.

In short, an inadequate gamification design and development (partially due to the lack of framework to evaluate this tool) would lead to several negative consequences [26]. That is, the usability issues of the gamified solutions together with the flawed rewarding system might adversely impact the motivation of users [27], thus obtaining the opposite outcome of the gamification purpose [9]. Moreover, rewards that foster behaviours that may harm third parties would have ethical consequences [7]. Besides, the moral/legal matters [7, 27] as well as the hedonic emphasis of some gamified solutions could generate ethical and health-related issues [9], thus risking to cause mistrust, which in turn might aggravate the already weakened engagement and motivation of users due to the dysfunctional rewarding system. Then, the users' demotivation and the mistrust may threaten and jeopardise the credibility of both the gamification approach and that of the management in charge of it with the negative impact it may have on productivity, cost-effectiveness, etc. [7, 26, 27]. Finally, this credibility loss, in turn, would worsen both users' demotivation and mistrust [27].

5. Discussion

Overall, this integrative review on gamification suggests that an inadequate design and development phase together with the flawed rewarding system and the moral/legal negative issues arising from it, may be sources of threats for both organisations and individuals, and could possibly jeopardise the management and approach credibility, demotivate users, generate ethical and health issues leading to mistrust [7, 9, 25–27]. Unsound rewards and poor usability of gamified solutions are the categories of gamification issues with the highest number of reported items.

The included studies, among other matters, explored the gamification side effects in several areas (i.e., Education, Health, Business, etc.), yet many negative outcomes seem to occur across sectors. Although the reviewed literature highlights the relevance of the mentioned potential adverse impacts and threats, it is noteworthy wondering how gamification specific they are. Gamification presents similarities with previous information systems (IS) (i.e. intrinsically motivating IS, Persuasive IS, Hedonic IS) whose goals also aim at motivating and engaging users [30]. Moreover, gamification may be regarded as an attempt to improve and/or facilitate pre-existing managerial practices aiming at increasing users' engagement under the assumption that it will have a positive effect on performance [18, 31]. In line with these statements, frustrating and/or demotivating workers/users through childish tasks or over complex processes, or by over encouraging competition at the expenses of cooperation is not a particularity of gamification since the same phenomenon could be produced with other means. The same goes for ill-managed policies resulting in the risk of losing management credibility, obtaining production loss and decreased cost-effectiveness. Designing flow-generating cyber game-like activities with its potential health effects it has for those with a history of gaming addictions [9, 32] is not a distinctive trait of gamification either. Thus, considering that most gamification risks and perils can be found in already pre-existing concepts and practices, it could be stated that at least the mentioned threats may occur in a gamified approach although they do not constitute per se a feature of gamification uniqueness.

It could be posited that gamification would suffer from its design dilemma. That is, since highly stimulating tasks do not require boosting the motivation via other means, it supposes that gamification is meant to target activities which may be important and/or necessary (ex. Commercial, educational, health related tasks etc.) but less stimulating or even somewhat unpleasant [9]. It is assumed that rendering these less attractive tasks more stimulating by introducing the engaging components of games would possibly increase users' participation and thus the performance level [33].

Now, as described below, gamification could rely on gameful or playful components to fulfil its purpose [18]. Although, (video) games are structured around a set rules and competition, they do provide also to some extent with some the room for improvising and enjoying like play does. Indeed, it has been observed the massive use of video games would be explained by motives that could match the targets of certain gamified solutions (skills development, competition, socialising), but also by other reasons that could hinder the gamification purpose (designed to achieving serious goals) like evading one-self, moving into a fantasy world and relaxing [34], which probably derive from the main emotional states associated with play (joy, lightness and flow) and are correlated with opioids release as well as with the activation of ancient brain structures such as the para-fascicular and posterior thalamic nuclei [35].

Ethologically, understanding the functions of play may contribute to assessing the feasibility or the impossibility of transposing some of its engaging components to gamification (applied in serious contexts). Play would serve social purposes

(bonding, cooperation, competition) as well as individual aims associated with survival and social interests (learning physical skills, innovation, tool use), and would exercise the production and mastering of affective behaviours, as a possible waking alter ego of dreaming which processes affective states during the rapid eyes movements cycles while sleeping [35]. It is noteworthy remarking that the cholinergic system (involved in memory, emotional processing and selective attention) [36] is associated with both playing and dreaming [35]. Besides, among mammals and due to their extended childhood and adolescence, humans experience the longest playing time [35], which would imply that this innate activity with its hedonic components is quite anchored in memory and probably rather dissociated from serious contexts.

The mentioned distinctive emotional features of *play* (joy, lightness and flow) suggest that a safe environment is required for the ludic activity to occur, as observed in animal models where rodents set in a new environment adopt an exploratory behaviour to familiarise with it before being in the mood for playing [35]. A supplementary index supporting this view is that laughter, in young humans. as an innate emotional action linked with the activation of ancient brain systems, is strongly associated with play [35] and also suggests enjoying time within a secure context.

Along these lines, fear and hunger (among other states like rage, anger and separation distress) stop playing [35]. Whilst hunger is quite unlikely to happen in a gamification scenario, it might not be always the case for fear. For instance, some competition-like gamified solutions whose results are related to important personal goals (ex. Being promoted, being positively judged, etc.), could trigger fear in users, particularly in anxious ones, and render them reluctant to engage lest gamified solutions would prevent them to achieve their objectives. The same would go for anger resulting from a gamified solution perceived as unfair, or for separation distress produced by providing open access to comparative performance displays (leader boards), which could engender in poor performers the fear of being disregarded by others or of losing their jobs.

This foundation of gamification would argue in favour of a safe context as a prerequisite for gamification and raises several challenges that, if inappropriately managed, may have adverse impacts on both organisations and individuals. For instance, one challenge would be how to render the unattractive task more engaging through game elements generating joy and lightness without trivialising the gamified solution [37] and/or the entire gamification policy, with all the risky consequences this approach might have in terms of management credibility and of users' adherence to the gamified approach [7]. The fact that gamification is usually applied in serious contexts [29] makes this issue even more relevant and raises the question of whether this approach is the most suitable for this sort of settings. Moreover, when the users end up mastering the process by which they obtain the gamification rewards (points, badges, etc.) their involvement level in the gamified solution is reduced [18], which compromises the purpose of the gamification policy [9].

It is likely that the adverse impacts that gamification may have on users are of the same nature as those arising from games [9]. In this line, when playing competition-like video games, the level of dopamine (DA) released in the ventral striatum (a brain area mediating reward, cognition, reinforcement and motivation) is quite comparable to that produced by psycho-stimulant drugs [38, 39]. Enhancing the attractiveness of an activity by introducing flow-generating elements in it could also be a matter of concern. In effect, it has been observed that flow recruits the brain circuits associated with cognitive synchronisation of the attentional function together with those of the brain rewarding system and consequently places the

individual in a "here and now" mode, sometimes engendering distorted perception of place and time [40]. Moreover, excessive exposure to video game has been associated with attention deficit, impulsivity and reduced proactive cognitive control [28, 41, 42]. This grabbing of the entire attentional resources may lead the individual to focus on one particular aspect of the gamified solution at the detriment of broader and more important matters [7, 9, 27].

Besides, over-emphasising the hedonic traits of gamified solutions not only could diminish the users' awareness of the utilitarian purpose of this approach but also may put at risk certain users. Indeed, gaming cues may increase craving in those with gaming disorders [43], which would represent a perilous situation for users with a history of game addiction [9]. Examples of gamification in large organisations showed that an important proportion of users perceive the process as addicting, or they may encounter difficulties prioritising the serious purpose of gamification due to the compulsion they feel to seek rewards [29]. Physiologically, this could be the result of an over DA release at the expenses of serotonin (5HT) since both neurotransmitters share the same amino acid transporter, which leads to an unbalance in the DA-5HT interaction preventing the serotoninergic system to display its inhibitory function to moderate the over activation of the dopaminergic system [44] and consequently increases the likelihood to worsening the mentioned addictive disorder [45]. Moreover, in this sort afflictions, flow may disrupt the perception of individuals [32, 46] that could result in somewhat distorted insights into their emotional states associated with their addictive behaviours [45, 47].

The impact of gamification on this kind of disorders probably deserves much attention. It is noteworthy remarking though, that the link between experiencing flow and this sort of disorders may not be as direct as it seems. In effect, neither all addict video gamers experience flow, nor experiencing flow leads inevitably to addiction, but experiencing flow would boost the chances of becoming addict [32], hence the necessity to take care of the impact that a gamified solution might have on individuals with this type afflictions.

In short, these mentioned adverse impacts pledge for considering and assessing the possible health related consequences of gamification.

Gamified solutions based on competition would be a double edge tool whose impact would vary according to the kind of user profile. In effect, it would be suitable for performance, competitive mind and affective driven individuals [31], but it may not be appealing to users without those personal characteristics. In addition, assuming that the booming of video games based on competition could be transposed to gamification might be a misleading idea insofar as contests in flow generating activities like games are usually perceived as non-self-judgemental [48] and does not entail any responsibility, unlike competitions in gamified solutions especially in work and education environments where displaying the ranking about users' performance may be regarded as humiliating [29] and where results could give rise to criticism from hierarchy. This distinction is in line with what differentiates *play* from *a gamified solution*: playing supposes the lightness of free movements, improvisation and careless fun [35] (Semantic Mapping), whereas through gamification it is expected to obtain results that may be scrutinised by others. It is noteworthy remarking that both perils resulting from over-emphasising competition and hedonic traits of gamified solutions coincide with the critical zones detected through the semantic mapping.

The identified ethical issues (Monitoring and surveillance of users, infringing autonomy and privacy, taking advantage of users, fostering behaviours that may harm third parties, etc.) [29] may reveal various aspects of gamification. It could imply an exploitative purpose and a morally questionable influence on users' behaviour when the gamification approach is only designed to produce value for the

tool provider [49, 50]. It may also result from the speed gap between the very fast pace of gamification technical development relative to the delayed and slower progress of norms definitions required to set ethical boundaries for the design and implementation of the mentioned technical approach [29]. These reasons might not exclude each other.

The consequences of these ethical issues may create a deleterious atmosphere of mistrust among users and vis a vis the gamification provider, which in turn could feed the demotivation engendered by a flawed rewarding system, thus worsening the credibility level of the gamification system and that of the management in charge of it.

6. Conclusion

Overall, the potential threats previously mentioned are all areas of concern that could lead the gamification approach achieving, if not the opposite, diverging results to those for which it was initially designed.

Moreover, it would seem as if gamification is context and user dependent, that is, it would rather suit safe and less serious environments, short/medium term goals and users with competitive and affective characteristics [25, 31].

Perhaps, one of the main challenges of gamification is overcoming the quandary posed by the relationship between the hedonic intensity of gamified solutions and the unengaging tasks. That is, a less stimulating task will remain unengaging if the gamified solutions are not motivating enough; on the other hand, if the emphasis is mainly put on the hedonic gamified components around the task it might increase the likelihood of engendering a trivialisation of the context, a biased attention and a possible demotivation of users over time, unethical issues, unhealthy behaviours [9] and a gamification policy loss of trustworthiness. May be, a gamified solution that bridges the end of its process with the real-world matters could be a possible way forward [8, 18], as a manner to, at least, moderate the over-focus on the hedonic experience seeking loop engendered by flow which would disconnect the user from the outside world [32].

In sum, putting gamification at the service of work and serious contexts is an idea that would be tantamount to combining the useful with the pleasant, yet it involves an attempt to merge two worlds that, a priori, do not mix easily [29]. This suggests that gamification represents a demanding, laborious and somewhat troublesome conception work, to the extent that, according to estimations, gamified applications are destined to have a very high rate of failure [37].

6.1 Limitations

Several limitations for this study are to be mentioned. Due to the novelty of gamification as a research topic, there is a clear shortage of literature review on the threats that may arise from it [8, 9]. In effect, a rather reduced number of studies met the inclusion criteria and were selected in this integrative literature review. In addition, despite the careful approach adopted during the selection phase, one is not immune to having missed out on papers that meet the inclusion criteria. The same goes for the text analysis of the selected and included literature review studies in spite of the detailed checking and examining of information related to negative impacts and possible threats that could result from gamification. Besides, it cannot be excluded that other studies covered this research subject by using another wording and therefore went unnoticed. For example, studies designed to emphasise the potential benefits and added value of gamification that were excluded in this

research might also contain information about the possible adverse impact of this tool. Consequently, it should be stated that this is a non-exhaustive integrative literature review. Furthermore, since the gamification contexts (Health Care, Enterprise, etc.) and the methodologies vary between the selected studies, caution is required when comparing their results and when reaching conclusions about them. This last point argues in favour of deploying future research endeavours to define and design a united framework so as to evaluate gamification outcomes [26].

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References

[1] Lopez Carrillo D., Calonge Garcia A, Rodriguez Laguna T., Ros Magan G. and Lebron Moreno A. "Using gamification in a teaching innovation project at the University of Alcala: A new approach to experimental science practices". Electronic Journal of e-Learning v17 n2 p93–106 (2019).

[2] Leclerq Th., Hammedi W. and Poncin I. "The boundaries of gamification for engaging customers: effects of losing a contest in on-line co-creation communities". Journal of Interactive Marketing 44, Elsevier (2018).

[3] McCarthy I., Kietzmann J., Robson K., Plangger K., and Pitt L. "Understanding gamification of customer experiences", in NA-Advances in Consumers Research, vol 42, eds. June Cotte and Stacey Wood, Duluth MN: Association for Consumer Research. Pages 352–356 (2014).

[4] Dymek M. "Expanding the magic circle – Gamification as a market place icon". Journal Consumption Markets and Culture, vol. 21, issue 6 (2018).

[5] Singh SP." Gamification: a strategic tool for organizational effectiveness". International Journal of Management, (2012).

[6] Deterding S., Dixon D., Khaled R. and Nacke L. "From game design elements to gamefulness: defining gamification". In Proceedings of the 15th International Academic MindTrek Conference: Envisioning Future Media Environments (2011).

[7] Schmidt-Kraepelin M., Thiebes S., Stepanovic S., Mettler T. and Sunyaev A. "Gamification in Health Behaviour Support Systems – A Synthesis of Unintended Side Effects". Proceedings of the International Congress Wirtschaftsinformatik (2019).

[8] Dieffenbach S. and Müssig A. "Counterproductive effects of gamification: An analysis on the example of the gamified task manager Habitica". International Journal of Human-Computer Studies, (2019).

[9] Hyrynsalmi S., Smed J. and Kimppa K. "The dark side of gamification: How we should stop worrying and study also the negative impact of bringing game design elements to everywhere" GamiFIN (2017).

[10] Oinas-Kukkonen H. "A foundation for the study of behaviour change support systems". Personal and Ubiquitous Computing, 17 (2013).

[11] Torraco R. "Writing Integrative Reviews of the Literature: Methods and Purposes". International Journal of Adult Vocational Education and Technology, vol. 7, issue 3, (2016).

[12] Zichermann G. and Cunningham C. "Gamification by design: Implementing game mechanics in web and mobile apps". 1rst edition, Sebastopol, California: O'Reilly Media (2011).

[13] Huotari K. and Hamari J. "Defining gamification: a service marketing perspective". Proceeding of the 16th International Academic MindTrek Conference pp.17-22ACM, Tapere, Finland (2012).

[14] Seaborn K. and Fels D.I. "Gamification in theory and action: A survey". International Journal pf Human-Computer Studies, vol.74 (2015).

[15] Bruder P. "Game on: gamification in the classroom". The Education Digest, vol.80, N°7 (2015).

[16] Kim B., Park H. and Baek Y. "Not just fun, but serious strategies: Using

meta cognitive strategies in game-based learning". Computers & Education, vol. 52, Issue 4 (2009).

[17] Lucero A., Karapanos E., Arrasvuori J. and Korhonen H. "Playful or Gameful? Creating delightful users experiences". Interactions (2014).

[18] Nicholson S. "Exploring the endgame of gamification" https://mediarep.org/bitstream/handle/doc/2960/Rethinking_Gamification_289-303_Nicholson_Endgame.pdf?sequence=1

[19] Caillois R. "Man, Play and Games". University of Illinois Press, Urbana, Chicago (2001)

[20] Dale S. "Gamification: Making work fun or making fun of work? Business Information Review, vol. 31 (2014).

[21] Sowa J. http://www.jfsowa.com/pubs/semnet.pdf

[22] Collins Dictionary https://dictionnaire.reverso.net

[23] Synder H. "Literature review as a research methodology: An overview and guidelines". Journal of Business Research, 104 (2019).

[24] Virtue T. and Rainey J. "Information Risk Assessment". HCISPP Study Guide, chapter 6 pp. 131–166, Science Direct (2015).

[25] Hamari J., Koivisto J. and Sarsa H. "Does gamification work? A literature review of empirical studies on gamification", International Conference on System Science (2014).

[26] Sardi L., Idri A. and Fernandez-Aleman J.L. "A systematic Review of gamification in e-Health", Journal of Biomedical Informatics (2017).

[27] Schmidt-Kraepelin M., Lins S. Thiebes S. and Sunyaev A. "Gamification of enterprise systems – A Synthesis of Mechanics, Dynamics and Risks", https://arxiv.org/abs/1906.01577

[28] Dunckley V. https://www.psychologytoday.com/gb/blog/mental-wealth/201402/why-can-my-inattentive-child-pay-attention-video-games

[29] Kim T.W. and Werbach K. "More than just a game: Ethical issues in gamification". Ethics and Information Technology, 18 (2016).

[30] Bui A., Veit D. and Webster J. "Gamification – A novel phenomenon or a new wrapping for existing concepts?"36th International Conference on Information Systems (2015).

[31] Cardador M.T., Northcraft G. and Whicker J. "A theory of gamification: something old, something new, something borrowed, something cool?". Human Resource Management Review 27 (2017).

[32] Hull D., William G.A. and Griffiths M.D. Video games characteristics, happiness and flow as predictors of addiction among video game players: a pilot study. Journal Behav. Addictions (2013).

[33] Robson K., Plangger K., Kietzmann J., McCarthy I. and Pitt L. "Game on: engaging customers and employees through gamification" Science Direct (2015).

[34] Demetrovics., Urban R., Nagygyörgy K., Farkas J. et al. "Why do you play? The development of the motives for online gaming questionnaire (MOGQ)". Behav Res (2011).

[35] Panksepp J. "Affective Neuroscience – The Foundations of Human and Animal Emotions". Oxford University Press (1998).

[36] Jackson C.E. Cholinergic System. In: Kreutzer J.S., DeLuca J., Caplan B. (eds)

Encyclopedia of Clinical Neuropsychology (2011)

[37] Dale S. "Gamification: Making work fun or making fun of work?" Business Information Review vol. 31 (2014).

[38] Koepp M.J., Gunn R.N., Lawrence A.D. et al. "Evidence from striatal dopamine release during video game. Nature 393, 266–268 (1998).

[39] Yau Y., Crowley M., Mayes L. and Potenza M. "Are internet use and video game play addictive behaviours? Biological, clinical and public health implications for youths and adults." Minerva Psichiatrica 53 (2012).

[40] Weber R., Tamborini R., Westcott-Baker A. and Kantor B. "Theorizing flow and media enjoyment as a cognitive synchronization of attentional and rewards networks". Communication Theory, vol. 19, issue 4 (2009).

[41] Swing E., Gentile D. Anderson C. and Walsh D. "Television and video game exposure and the development of attention problems". Pediatrics (2010).

[42] Bailey K., West R., Anderson C.A. A negative association between video game experience and proactive cognitive control. Psychophysiology, 47 (2010).

[43] Dong G., Wang L., Du X. and Potenza M. "Gaming increases craving to gaming-related stimuli in individuals with Internet gaming disorders". Biological Psychiatry: Cognitive Neuroscience and Neuroimaging. Science Direct (2017).

[44] Esposito E., Di Matteo V. and Di Giovanni G. "Serotonin-dopamine interaction: an overview". Prog. Brain Res. (2008).

[45] Lustig R. "The hacking of the American Mind". New York, NY: Avery (2017).

[46] Chou T. and Ting C.H. The role of flow experience in cyber game addiction. Cyber Psychol. Behah. (2003).

[47] Gros L., Debue N., Lete J. and van de Leemput C. "Video game addiction and emotional states: possible confusion between pleasure and happiness?" Frontiers in Psych. (2020)

[48] Csikszentmihalyi M. Flow: the psychology of optimal experience. Harper Perennial (1990).

[49] Bogost I. "Gamification is bullshit" Bogost.com. August 8. (2011) http://bogost.com/writing/blog/gamification_is_bullshit/

[50] Patella-Rey PJ. "Gamification, Playbor and Exploitation", Cyborgology (2012) https://thesocietypages.org/cyborgology/2012/10/15/gamification-playbor-exploitation-2/

Chapter 3

About Operational Game Scenario Modeling

Vasiliy Shevchenko

Abstract

An original generalizing class of game-theoretic models (operational games or KOSH games) is presented, using which many micro-and macro - economic interactions are naturally modeled. Basic concepts of the theory of operational games and classification of such games, equations of dynamics of operational game interactions, and procedures for modeling scenarios of such interactions are described. Examples of operational games and some practical results of using this theory are given. The possibilities of fundamental and applied development of the considered direction of game-theoretic research are analyzed. The importance of this research is due to the fact that the original idea of the founders of game theory, which is to create an adequate accurate language for describing economic processes, has not been implemented to this day. In this paper, an attempt is made to implement this by accurately defining the concept of "operation" using static games of a well-defined type and considering dynamic ensembles of such static games.

Keywords: game theory, operations research, microeconomics, macroeconomics, scenario modeling, information and analytical system, digital platform

1. Introduction

In the fundamental work [1], a super-task was set to build an adequate accurate language for a complete and interrelated description of economic (in the broad sense) processes. This work is associated with the emergence of mathematical game theory. At the same time, its authors (J. von Neumann and O. Morgenstern) were very skeptical about the use of differential equations to describe economic processes (considering, that this mathematics adequately describes physical processes is not suitable for Economics, that some other mathematics is necessary here) and called for starting with building a description of the simplest facts of economic life that meets the standards of scientific rigor. Game theory, which began with the consideration of antagonistic (zero-sum) matrix games, which are a natural formalization of the well-known salon games, has now branched out into a number of powerful directions and confidently claims to become a generalizing standard in the accurate description of economic (social) processes [2–6]. At the same time, the description of any game always contains a finite set of players, a set of choices, and the principle of optimality for each player.

Games are divided into static (in which players make their choice once, at a designated point in discrete time, but before choosing, they can think, count, and exchange information) and dynamic (with multiple consecutive choices, possibly in continuous time). Dynamic games can be repetitive (played in discrete time,

past draws do not affect the current one), multi-step (also in discrete time, but past draws affect the current one), differential (a controlled differential dynamic system is considered, in which control is divided between players with different goals). There is also a class of cooperative games that have a large number of players with simple behavior.

You can name thousands of scientific papers in the field of game theory. Many of them are informative and interesting. Which of these works to rely on is up to each researcher. This research is based on the fundamental works [2–6] of one of the leading schools of game theory, the school of Yu.B. Hermeyer and N. N. Moiseev, which are relevant to this work. In [2], games with non-opposite interests are proposed for consideration, analyzed, and developed. This class of static and multistep games differs from antagonistic games (zero-sum games) in part, that mutually beneficial cooperation, coalition interaction, and agreements are possible between players. As a basic principle of optimality that formalizes the interests and behavior of players, the principle of guaranteed results is considered, in which players expect the worst from other players and nature and, based on this, maximize their winnings. But other principles of optimality are also considered. A class of static hierarchical Hermeyer games is defined, which differ among themselves in the scheme of information interaction between the center player and players at the lower level of the hierarchy.

In [3], a class of games with a hierarchical vector of interests is proposed, which considers a set of zero-level players (individuals) who are United in coalitions that are first-level players. Players of the first level, in turn, unite in coalitions that are second-level players. And so on. The interests of each zero-level player are described as a convolution (linear, minimal, or otherwise) of their winning function as a zero-level player, multiplied by the so-called altruism coefficients of the winning functions of those first-level players (coalitions) that they belong to, and so on. The zero-level player determines the importance of the interests of all players of other levels, in which he participates directly or through a chain of coalitions, by his system of altruism coefficients. For a particular type of games in which each zero-level player distributes the resources available to him (the resource vector) among coalitions, Nash equilibria are constructively defined for convolution in the form of a minimum. Further, in the works of N. S. Kukushkin, strong equilibria were determined for both minimum convolution and linear convolution.

In [4], the original coalition principle of optimality (compromise with a metagoal) is proposed and considered, in which, along with their own interests (goals), players have a common interest – a metagoal. A Pareto set is constructed for a multi-criteria problem, in which the criteria are the players 'own interests, and then the maximum point for the metagoal is determined on this set.

In [5, 6], various issues related to multi-step games are investigated, and the applied possibilities of using the considered game models are analyzed.

A generalizing field closely related to game theory is the theory of operations research [7–10]. Due to the importance of this area in the context of this work, the main points of formation of the basic concepts of operations research will be discussed in the Section 2 devoted to this issue.

The term "operation" is very General and universal. Arithmetic or algebraic operation. Surgery. Military operation. Economic operation. Financial operation. Political or geopolitical operation. We can draw a natural conclusion that there is something in common in all this. But what is it, exactly?

Until the beginning of the 20th century, rather complex operations were studied only at a qualitative, descriptive level. Only mathematical and algebraic operations were studied at the level of strict definitions (at the level of established requirements for the concept of strictness).

Yu. B. Hermeyer proposed a very General qualitative definition of an operation as "a set of purposeful actions" [7]. It was assumed that operations are performed by intelligent and goal-setting entities (players, agents) alone or together, and that each of them wants to move towards achieving a particular goal when performing each operation. The goal can be formulated as a single-criteria (one specific indicator is maximized) or multi-criteria (the desire to increase several indicators) principle of optimality of the player (agent). Unfortunately, Yu.B. Hermeyer failed to increase the level of strictness of the definition of an operation by presenting mathematical definitions of the concepts "action" and "a set of".

In [7], a methodology for operations research is also proposed, in which the decision-maker (the operating side (OS), the first player, the LPR) and the operations researcher who helps the OS make decisions are distinguished.

When you carefully consider the definition of operation proposed by Yu. B. Hermeyer, it becomes clear that it contains everything that is designated by the word "operation". Indeed, the surgeon and assistants perform a set of purposeful actions, wanting to achieve a very specific result. Conducting a military operation is a set of purposeful actions to complete the task. The salesman wants to do his job by performing actions to move and deliver packages to recipients, minimizing his own costs. And so on.

The theories of non-antagonistic games and hierarchical games of Hermeyer [2], and the theory of games with a hierarchical vector of interests of Vatel-Hermeyer [3] are also associated with the name of Yu.b. Hermeyer. We can say that game theory and operations research theory merged for him, as well as for his friend and colleague N. N. Moiseev, into one whole, which requires the development of a single universal mathematical basis. This is quite consistent with the aspirations and attitudes of the founders of game theory [1]. But how do you find such a unified mathematical basis? Students and followers of Y. B. Hermeyer and N. N. Moiseev worked in the direction of its search.

Significant progress has been made in the study of issues related to uncertainty, aggregation, related constraints, and awareness in hierarchical games, and a decision support methodology based on the idea of "compromise with metacel" has been developed [4–6]. Based largely on the models of V. V. Leontiev to identify production functions and utility functions of the agents under consideration, the differential-difference direction of modeling macroeconomic processes was developed [11].

The theory of active systems was born in IPC RAS (V. N. Burkov) and actively developed in the theoretical and applied directions [12]. the idea of this theory is to generalize the theory of automatic regulation (TAR) in order to accurately describe socio-economic processes by assuming that some elements of TAR systems can be active, act expediently, and have expressions of will. In the works of one of V. N. Burkov's students D. A. Novikov and his colleagues, an attempt is made to organically synthesize the theory of active systems and mathematical game theory.

Analytical research of rather complex game-theoretic models, at the current level of "quickness of mind " of researchers, is very difficult. In this regard, it is very relevant to simulate the processes of interaction of many people.

The most advanced school of simulation modeling (not only in Russia) can be called the school of one of the students of N. N. Moiseev Yu.N. Pavlovsky [13]. This school was successfully conducted simulation SDI (it has been shown that the implementation of the so-called strategic defense initiative is impossible due to the fact that to control the entire surface of the planet would take more than a hundred thousand satellites), the Peloponnesian wars, geopolitical interaction between the three political-military alliances (the West, the Soviet Union with the allies, all the rest). A number of simulation models were built and successfully used by The F. I.

Ereshko school. A fruitful attempt to generalize the simulation methodology is presented in [14].

These achievements determined the possibility of generalizing the concept of accurate descriptions of social processes, the unifying formalism of game theory, the idea of the operation as the " a set of purposeful actions," the developments of simulation and of the theory of active systems, other achievements of the human mind in the exact modeling of complex, large-scale systems. As a candidate for such generalization, representatives of the Hermeyer-Moiseev school (in the process of solving of practical problems of scenario forecasting and decision support in industrial corporations, complexes, and industries) formed the theory of operational games and the related methodology of operational game scenario modeling [15–24].

Structurally, the work is structured as follows:

Section 2 analyzes the history of the formation of closely related game theory and operations research theory. The Central points of formation of basic representations of these theories are marked. The novelty of the proposed approach, which naturally grows out of these basic concepts, is indicated.

Section 3 presents the proposed precise definitions of the concepts "action", "operation", and other definitions necessary to describe operational games. The equations of dynamics of operational game processes are written out and analyzed. The classification of operating games and the principles of their use for solving applied problems are considered.

Section 4 uses simple examples to illustrate the methodology for constructing various scenarios for operational game interaction.

Section 5 outlines the prospects for fundamental and applied research of this class of game models.

2. Formation of the theory of operations research

The emergence of operations research as a field of precise research is rightly associated with the names of Mikhail Pavlovich Osipov and Frederick William Lanchester (1868–1946), who were the first to analyze military operations using differential Equations [8]. Almost simultaneously (M. P. Osipov was ahead of F. W. Lanchester after publishing their work "The Influence of the number of fighting parties on their losses" in the magazine "Military collection" in 1915), they proposed to consider and use the differential equation of Osipov-Lanchester, describing a military operation with a confrontation between two opponents. The status of each of the opponents in each moment of the confrontation was described by a number of troops and destructive power of weapons defined by the product quality on the number of weapons. Further, the study of operations using mathematical relations in the form of equations (including difference and differential equations) and restrictions (not only in the form of inequalities) has been widely extended to other areas of human activity.

In the second half of the 20th century, the scientific term "operations research" becomes generally accepted. This is due to the work of Russell Lincoln Ackoff (1919–2009), published in the 1960s [9]. R. L. Ackoff defines operations research as "the application of the scientific method by complex research teams to solve problems related to the management of organized (human-machine) systems in order to obtain solutions that best meet the goals of the entire organization." This definition can be considered a preliminary qualitative (descriptive) definition on the way to formalizing the social Sciences, which, of course, was based on other founders of the theory of operations research, including Yuri Borisovich Hermeyer (1918–1975) and Elena Sergeevna Wentzel, who worked in the same defense

research organization. Hermeyer, a researcher and mathematician from God, a child who survived clinical death during a famine in the Volga region, winner of the first mathematical Olympiad in the USSR, was responsible for the development of torpedo control systems. Having started working at the invitation of his classmate in Moscow state University, N. N. Moiseev, at the legendary Computing center of the USSR Academy of Sciences (later named after its founder A. A. Dorodnitsyn), Yuri Borisovich creatively rethought and generalized the existing achievements of game theory and operations research [2, 3, 7]. Operation was defined by him as "a set of purposeful actions". In game theory, he became the founder of the theories of hierarchical Hermeyer games and games with a hierarchical vector of interests of Vatel-Hermeyer. The works of one of his closest associates, E. S. Wentzel, are also widely known [10].

To date, the definition of an operation Y. B. Germeyer can be called conventional. But it also needs to be clarified, since it lacks precise mathematical definitions of the concept of "action" and the operation of combining actions in the aggregate. The strictness of the definition of purposefulness by Hermeyer and his followers generally meets the "standards of scientific rigor". Purposefulness is linked to the concept of the "optimality principle", which is generally understood as several functions of variables describing the state of the game process (at the current moment or, in General, throughout the game process up to the current moment), maximized by a purposefully acting player (agent). The concepts of a decision maker (DM) and an operations researcher (OR) conducting research in the interests of the DM are introduced. In the case of a multi-criteria optimality principle, the OR task is to construct a Pareto set, and the DM task is to choose from this set. The followers of Yu. B. Hermeyer and N. N. Moiseev thoroughly investigated the issues of information exchange in hierarchical game interactions of a non-antagonistic nature, the issues of studying games with uncertainties and associated restrictions, the issues of bluffing and aggregation of information, the issues of finding equilibria and using the principle of guaranteed results in such games.

Other areas of work in game theory and operations research are also interesting. But it is hardly possible to do anything useful without going past what the founders did. It is possible that someone will offer a completely different view of the formalization of the Sciences of social interactions. But this, so far, is not visible.

The novelty of what is proposed by the author and his colleagues [15–24] can be represented as follows:

To date, we have considered multi-step games in which all players at each step (during each clock cycle of discrete time) play one common static game. When considering real game interactions, it is impossible to formulate or analyze such a game that adequately describes what is happening in reality. In this connection, we propose to assume that at each step, many (ensemble) static games are played that formalize real operations. If we talk about Economics, this corresponds to the wishes of the founders of game theory [1] to build accurate descriptions of "the simplest facts of economic life" that correspond to the "norms of scientific rigor". The game as a whole can be called a dynamic ensemble of static games (in the next step, the same static games are played again in new conditions).

Due to the fact that there are a lot of static games (operations) being played at any moment, they may conflict with each other (requesting the same resources, which are not enough for all requests, for example). This introduces the concept of a "regulatory rule", which in one way or another adjusts the operation requests so that there is no conflict.

In reality, actions not only implement certain technologies, but also improve them. In this regard, actions are divided into simple and operator actions.

Operator actions change parameters and functions that describe available actions and operations.

All this will be discussed later.

3. A basic concept of the operational games theory

Mathematically precise definition of the concept of "operation" is not known to this day (at least, for the author). To suggest such a definition is very relevant, since it would be the key to formalizing both Economics and many other qualitative social Sciences. In this case, it is necessary to take as a basis one or another qualitative definition of the concept of operation. Which one is the researcher's choice. Next will be made based on the definition of Y. B. Germeyer [7].

Let us make the definition of an operation proposed by Yu.b. Hermeyer ("a set of purposeful actions") more strict, starting with the question of what we will understand by "action". At the level of "subtle matters", even a magic spell can be considered as an action. May be one day this understanding will become normal. But this is a matter for the future. In the present time, it is reasonable to limit ourselves to the consideration of processes in which motion is observed in a particular finite-dimensional space, and the values of a finite number of numerical variables change (in discrete or continuous time). Then it is natural to consider any movement in a given space as an action (of players or/and natural factors). At the same time, formalizing real processes, it is natural to assume that each action (possibly representable as a set of simpler actions) is performed by a well-defined finite number of persons (players, agents), including nature. These players can participate in the Commission of an action either independently of each other, or by agreeing on something, having developed a common decision. In General, by agreeing on something. Any agreement is reached within the framework of a certain procedure of game interaction. The result of any agreement is a solution that can be formally represented as a vector of non-necessarily numeric variables. This vector will determine how exactly (on what scale, on which of the possible options) this action will be performed. From these considerations, a more precise definition of the operation appears below, in which the set of participants is called the set of LPR, the procedure for reaching an agreement is called the convolution function, and the decision made by the participants is called the vector of operation controls. However, in addition to moving actions in the finite-dimensional space of game interaction, we also consider operator actions that change the attributes of the description of operations (parameters of the convolution function and other functions describing the operation).

Strictly formally stated above, in the case of discrete time consideration of game interaction) is described as follows:

Let there be N players (one of which can be nature) interacting on a discrete time interval, whose phase state is denoted by the vectors $x_i, i = 1,\ldots,N$ $x_i \in G_{x_i} \subseteq R^{n_i}$. The dimensions of the vectors $n_1,\ldots,n_N$. We assume that their interaction is realized by performing simultaneous operations, during which the position of the game process changes in its phase space (which is the Cartesian product of the players 'phase spaces $G = G_{x_1} \times \ldots \times G_{x_N}$ $G \subseteq R^{n_1+\ldots+n_N}$) and parameters of the operations themselves. When describing the operation, we will set

- a subset of the set of players $I_j \in \{1,,\ldots,,N\}$ (the set of LPR operations) that take part in making decisions on its implementation, in determining the vectors u_j of controls of the j-th operation during its implementation;

- function (vector-function) of convolution of the operation $f_j\left(\gamma_k^j\left(k \in I_j\right), \xi_j\right)$, which is an algorithm for determining the control vector of the operation by selecting players from the set of LPR operations γ_k^j (from their sets of choices for this operation H_k^j) and by realizations of uncertainties associated with this operation $\xi_j \in \Xi_j$;

- sets of simple PR_j and operator PR_j^o actions of this operation that are implemented during the operation and change the position of the game process in the phase space (simple actions) and the parameters of the operations themselves (operator actions).

The set of operations of the operating game is denoted by $OP = \{op_1, \ldots, op_M\}$.

We will consider the sets of simple and operator actions *PR* and PR^o to be uniform (common) for all operations. These sets belong to the sets of operations actions. The numbers of actions in the sets PR and PR^o are denoted by Q and Q^o, the numbers of actions of the *j*-th operation are Q_j and Q_j^o. We will also assume that the control vector of operations is unified for a given dimension *L*, which is common for all operations (some of its components may not be used in each specific operation). Each *l*-th simple or operator action of the *j*-th operation is generally associated with several sum functions of this action, depending on the control vector: $S_{jl1}, \ldots, S_{jl\alpha_{jl}}$ for a simple action or $S_{jl1}^o, \ldots, S_{jl\beta_{jl}}^o$ for the operator. These amounts (positive, negative, zero) are changed by the implementation of the action associated with this sum, the coordinate of the phase space *G* or the associated parameter of the action or operation.

At each moment of time of game interaction, the choices made by the players and the implementation of uncertainties determine some of the following operations: movement in the space $R^{n_1+\ldots+n_N}$ But this move may take the process out of the allowed G area. In this regard, in each operating game, a regulatory rule must be defined that corrects the management of operations so that this does not happen. In the simplest and most common case of resource constraints, these rules can be proportional cuts to the resources requested by operations, operation priority systems, and others. We assume that such a rule is defined and the control vectors defined by the operation convolution functions become arguments of the transaction sum functions after correction by the control rule. The corrected control vectors will be marked with a wave ($\tilde{u}_j$).

Each sum S_{jlm} of a simple action of an operation is associated with a certain coordinate of the game interaction space $R^{n_1+\ldots+n_N}$ x_{ir} $i \in \{1, \ldots, N\}, r \in \{1, \ldots, n_i\}$, which this sum changes. Let us denote the δ_{jlm}^{ir} indicator equal to one if S_{jlm} is associated with x_{ir}, and zero otherwise. Then the system of equations for the dynamics of phase variables in the operational game interaction in discrete time is written as.

$$x_{ir}(t+1) = x_{ir}(t) + \sum_{j=1}^{M}\sum_{l=1}^{Q_j}\sum_{m=1}^{\alpha_{jl}} \delta_{jlm}^{ir} \cdot S_{jlm}\left(\tilde{u}_j(t)\right) \quad i = 1, \ldots, N;$$

$$r = 1, \ldots, n_i \tag{1}$$

Similarly, (1) is written and the system of equations of dynamics of those parameters of actions and operations that can change the operator actions. If there

are K such parameters and they are ordered, we denote them $\pi_1,\ldots,\pi_K$. The system of equations of their dynamics is written as

$$\pi_q(t+1)=\pi_q(t)+\sum_{j=1}^{M}\sum_{l=1}^{Q_j}\sum_{m=1}^{\beta_{jl}}\delta_{jlm}^{oq}\cdot S_{jlm}^{o}\left(\tilde{u}_j(t)\right)\ q=1,\ldots,K; \qquad (2)$$

Systems (1–2) together with the regulatory rule allow you to play (simulate) any operational game interaction of this operating game, if you know the players 'choices and the implementation of uncertainties at each moment of the discrete time interval of this interaction. Players 'choices are determined by their principles of optimality and their adopted behavior strategies (in the form of a program or synthesis), which can be very different. Uncertainties may or may not be described by certain probability distributions.

A very flexible language for describing legal and other restrictions, player obligations, assumptions about the behavior of other players, and the implementation of uncertainties is records of the form

$$\text{IF}\langle\text{condition}\rangle\text{THAT}\langle\text{action}\rangle\text{OTHERWISE}\langle\text{sanction}\rangle, \qquad (3)$$

in which < condition> has the format of a logical sentence, the terms of which can be any simple statements about the values (or intervals of values) of phase variables, player elections, implementations of uncertainties, the presence and fulfillment of certain obligations, the players 'awareness from the beginning of the game to the current moment; <action> and < sanction> have an imperative format for regulating (possibly interval) player elections at the current time.

To define the information structure of an operational game, you need to determine which subset of the complete information about the course of the game interaction each player has at each moment of this interaction. Full information is understood as accurate knowledge of the dynamics of phase variables, choices, implementations of uncertainties, sets of obligations, restrictions, and selected strategies for player behavior.

The dynamics of players 'States is described as the dynamics of turnover and balance (or only balance) of their base accounts (variables of the space for developing game interaction) that arise as a result of various operations performed by players (production, investment, credit, purchase and sale of products and services, R & d, innovation and modernization, and others). The dynamics of arbitrarily complex indicators is represented as the dynamics of turnover and balance of analytical accounts, which are generally any computable functions of turnover and balance of basic and other analytical accounts.

Operations are described by the corresponding sets of LPR (players involved in making decisions about how, with which controls, these operations will be performed); sets of actions (transactions on basic accounts), the amounts of which are certain functions of the operation controls; convolution functions that determine the operation controls depending on the choices of players involved in the operation, and the implementation of uncertain factors.

Systems (1)–(2) have quite clear content meaning. In any operational interaction, there are many potentially possible operations that can be performed by participants. For each such operation, the technology of its implementation is known, including

- the number of possible participants, possibly different with a limit on the maximum number of participants;

- a list of actions that are performed during the operation, each of which can be implemented in different ways, with different implementation parameters;

- procedure for participants to agree on parameters for implementing actions.

At any given moment, some operations are performed, some are not. Some actions may be modernization in nature and change the technology of operations themselves.

In order to determine what happened at the current moment in discrete time, you need to go through the entire set of possible operations, for each of which you find out whether it was performed or not at the moment and determine how exactly it was performed, if so. During each operation, there is a swing (as the participants wanted to do it) and a blow (as it really happened), which is why the control vectors with the wave appear (the regulatory rule corrects the swing). The system (1) calculates the final movement in the interaction space, and the system (2) calculates the final change in the operation technologies themselves.

In the case of a surgical operation, actions are known practiced movements of the scalpel and other tools, in economic operations, economic facts related to production, purchase and sale, lending, investment, taxation, modernization, R & d, training, consumption, health care, etc. If we consider only production, exchange (purchase and sale of products, services, labor), investment, credit, tax and consumer transactions, writing out the system (1) will naturally lead to the well-known and used equations of the material and financial balance.

The universal nature of systems (1)–(2) opens up very interesting prospects. In particular, it is possible to raise and solve the issue of creating a software environment (platform) for generating in the menu regime a wide range of program systems for supporting micro - and macroeconomic decision-making.

In [16], we consider not only operational games with continuous accounts (variables) and discrete time, which are referred to as RD-games. Equations of dynamics of operational game processes can also be written for cases of continuous accounts and continuous time (RC-games), discrete accounts and discrete time (ZD-games), discrete accounts and continuous time (ZC-games). Differential games can be represented as RC games. The chess, checkers, and other finite games played by moves can be represented as ZD games. In the form of ZC games-game processes in continuous time, in which only a finite space of possible States of game interaction is essential.

4. Methodology for creating scenarios of operational game interactions

After formalization by the operational games theory some real-world game interaction (in salon game, in production and economic activities of enterprises and corporations, industrial complexes and sectors of the economy, in macroeconomic and geopolitical processes) you can start to study various possible scenarios of game interactions. It is necessary for the formation of the strategies of the operational side (of the player in whose interests research is conducted), optimal or rational in any sense, in various scenarios. This requires a methodology.

In a particular operational RD-game, a set of players is defined; a discrete time clock; a set of considered accounts (variables of the game's configuration space), actions, and operations. Operational gameplay refers to the game interaction of all or part of the players for a given period of time, during which players make choices during operations, accept and fulfill (or fail to fulfill) obligations, exchange

information between them, and natural uncertainties are realized. What do you need to know in order to play analytically or imitatively a particular operational game process?

First, you need to know the initial balances (values) of accounts (variables) at the beginning of the considered segment of game interaction. Second – the initial characteristics of actions and operations: the parameters of the convolution functions and the sum functions of actions, which, if there are operator actions, can change during the game interaction, as well as the account balance. Third, it is necessary to use one or another hypothesis of the implementation of uncertainties in the course of game interaction, determined and modeled by probability distributions or otherwise. Fourth – for each player other than the operating party (the first player), it is necessary to make an assumption about his awareness and formulate a hypothesis about his strategy of behavior with such awareness, given in the General case in the form of synthesis. Knowing all this, we can conduct a simulation game simulation of this process, developing an optimal, in one sense or another, strategy for the behavior of the operating party.

This defines the methodology for modeling scenarios of operational game interactions. Operational game scenario modeling uses the concepts of "scenario condition", "full scenario condition", "scenario", and "scenario plan".

A scenario condition is any finite sequence of entries of the form (3), each of which can relate to any of the players or to the implementation of an undefined factor.

A full scenario condition is a scenario condition that determines the implementation of an indeterminate factor and the election of all players except one (the operating side).

A scenario is a combination of a complete scenario condition and the "optimal" (rational) strategy of the operating side when this condition is met.

A scenario plan is a set of scenarios of one of the players that describes all possible or practically interesting implementations of game interaction for this player.

Let us look at examples of creating scenarios for fairly simple operational game interactions.

Salon games, in most cases, are held in discrete time (by moves) and in a finite space of possible States of game interaction, and therefore are adequately modeled as ZD games. But in the case of, for example, poker, in which arbitrary money bets can be made, it is more correct to use the RC games considered in this paper.

In this case, the accounts (variables that describe the state of the game) will be:

- accounts of players 'available funds;
- money at stake;
- the state of the deck (at the beginning of each draw-one of 54! possible locations of cards in the deck, then – one of the factorial of the number of remaining cards in the deck);
- the state of the card sets in the players 'hands and the binary States of the players themselves (in-game or out-of-game).

Possible actions include:

- moving money from players to the pot at stake (an action with one sum equal to the amount of money being moved);

- moving money from the Bank to players (also a single-sum action);
- player exits from the current game;
- move cards from the deck to players during the initial distribution of cards to players in the draw;
- players taking a certain number of cards from the deck determined by the rules;
- players discard a certain number of cards from their own set of cards.

Possible operations include:

- individual operations of players related to depositing money in the Bank, replacing cards with cards from the deck, and withdrawing from the current draw;
- shuffle the deck before drawing;
- distribution of cards to players at the beginning of the draw;
- issuance of the Bank based on the results of the draw.

Multitudes of decision-makers, functions, convolution, vector controls, sets of action operations are defined the obvious way. Uncertainty is present in one operation – in the shuffle of the deck before the start of the draw. This operation itself can be modeled as having an empty set of LPR and consisting in an indefinite choice of one of 54! variants of the deck state under the influence of natural factors. But it can also be modeled differently, both by the operations researcher and by the players themselves, based on certain (possibly mystical) ideas about this process.

Players 'awareness is determined by the rules of the game (which are different for different types of poker).

To form a complete scenario condition in each draw of such a game for one or another player means to make certain assumptions about how the deck was laid and what other players have in their hands, what amounts other players have and what strategies their behavior in the game is. These assumptions can include (and usually do include) probability distributions. Developing their own strategy of behavior, the player can strive to maximize the mathematical expectation of their own winnings.

When modeling the game interaction between a seller and a buyer in the market (for example, several types of fruits and vegetables), we will have to consider as accounts the wallets of the buyer and seller and the availability of all types of goods sold by both of them. You also need invoices describing the quality of each product. Players 'interests can be described in one or multiple criteria. The seller is usually better informed about the quality of the goods than the buyer. During the bidding process, information is exchanged about the prices offered by participants, the availability and quality of goods.

In more complex game interactions associated, for example, with the production and economic activities of enterprises and corporations, industrial complexes and industries, the set of players, accounts, actions, and operations is significantly expanded. The variety of options for awareness and strategies of player behavior, risks and uncertainties, of course, becomes much richer. But the proposed formalism for describing operational game processes can withstand this as well.

5. Opportunities for development and application of operational games theory

The class of operating game models is original. Its novelty is due to the fact that

- the original formal definition of the operation is used, specifying the definition proposed by Yu. b. Hermeyer: "a set of targeted actions";
- unlike traditional multi-step games, in which one static game is played at each step, in which all players participate, in operational games, an "ensemble of static games" is played at each step;
- possible resource conflicts between static ensemble games are resolved using the "regulatory rule".

The proposed concept of operation is very flexible. The vast majority of actions that we do, in fact, either change some variables that formally describe the external world, or teach us something, improve the technologies at our disposal. This is how operations are defined above.

It is quite clear at the qualitative level that such operations can naturally be enlarged and detailed. In this connection, the question arises about the formal definition of the consolidation and detailing of operations, as well as about the formal definitions of the Union and decomposition of the players themselves. There are also many other fundamental questions related to equilibria and the analysis of the information structure in operational games.

At the first stage of testing operational game scenario modeling on solving applied problems, both micro-and macro-economic problems were considered. In terms of decision support for the management of production and economic activities and the development of enterprises and corporations, operational game models were developed and used that allow for What If analysis of a wide variety of scenarios for managing these activities with different implementations of exogenous factors [15, 16, 20, 21]. In the process of modeling the functioning of the Moscow industrial complex, scenario forecasting of the dynamics of the main indicators of the development of this complex and its branches was carried out [16, 18, 19]. We also built operational game models of a macroeconomic nature designed for What If analysis of national economic development management and modeling of geopolitical processes.

Developing this area of research, it is advisable to adjust the existing paradigm of economic and mathematical modeling. It is reasonable to replace the monetarist description of rational behavior of agents (players) as the desire to maximize profits with the natural desire of existing micro - and macro-agents to maximize total assets, including net assets and reasonable estimates of available human (taking into account the levels of health, skills, education) and natural resources. In legal terms, it is advisable to restrict operations that reduce the total assets of the planet as a whole.

6. Conclusions

The theory of operational games and the methodology of operational game scenario modeling based on this theory have proved to be a workable tool for adequate modeling of both micro-and macro-economic processes, collective and social interactions of a wide range. In this connection, there are very promising areas of

fundamental and applied research. This tool allows us to talk about creating a new generation of platforms for generating information and analytical decision support systems.

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References

[1] Neyman J., Morgenstern, O., Theory of games and economic behavior, translated from English. Moscow, Russia: Nauka, 1970, – 707 p.

[2] Hermeyer Yu. B., Games with non-contradictory interests. Moscow: Nauka, 1976, 328 p.

[3] Germeyer, Yu. B., Vatel I.A., Games with a hierarchical vector of interests // Moscow,Technical Cybernetics, 1974, №3. pp. 54-69.

[4] Ereshko F. I., Hierarchical compromises in General relations and parallel threats. Moscow: CC of the USSR Academy of Sciences, 1984, – 18 p.

[5] Kononenko A. F., On multistep conflicts with information exchange / / Journal of computational mathematics and mathematical physics, 1977, Vol. 17, No. 4, pp. 922-931.

[6] Gorelik V. A., Gorelov M. A., Kononenko A. F., Analysis of conflict situations in control systems. Moscow: Radio and communications, 1991, 288 p.

[7] Hermeyer Yu. B., Introduction to the theory of operations research. Moscow: Nauka. 1971-384 p.

[8] Sergeev S. V., Dolgov E. I., Osipov Mikhail Pavlovich / / Military topographers of the Russian army. - Moscow: "SD-Press", 2001.

[9] Akof R., Sasieni M., Fundamentals of operations research. - M: Mir, 1971. - 533 p.

[10] Wentzel E. S., Operations Research: problems, principles, methodology, Moscow: Nauka, Main editorial office of physical and mathematical literature, 1980.

[11] Petrov A. A., On Economics in the language of mathematics. Moscow: FAZIS, CC RAS, 2003, 112 p.

[12] Burkov V. N., Theory of active systems and improvement of economic mechanism. Moscow: Nauka, 1984.

[13] Pavlovsky Yu. N., The simulation model and the system. Moscow: FAZIS, CC RAS, 2000, 134 p.

[14] Brodsky Yu. I., Distributed simulation of complex systems. Moscow: CC RAS, 2010, 156 p.

[15] Kononenko A. F., Shevchenko V. V., Problems of management of production corporations and operational games. Moscow: CC RAS, 2004, – 42 p.

[16] Kononenko A. F., Shevchenko V. V., Operational games. Theory and applications. Moscow: CC RAS, 2013, – 136 p.

[17] Ereshko F. I., Shevchenko V. V., Principles and procedures of operational game scenario modeling // Materials from VSPU-2014. Moscow, Russia: IPC RAS, 2014, pp. 5364-5374.

[18] Matveeva L. K., Kovalev A.M., Kononenko A. F., Kosenkova S. T., Shevchenko V. V., Application of the operational game modeling apparatus for developing a scenario plan for the development of industrial activities. Moscow: Scientific and technical collection "Questions of defense technology", series 3, issue 1 (338), 2007, pp. 19-27.

[19] Kononenko A. F., Shevchenko V. V., Methodology of scenario game operational modeling of socio-economic processes, presented on the example of scenario forecasting of the development of the industrial complex of Moscow. Moscow.: Scientific and technical collection "Questions of defense technology", series 3, issue 2 (339), 2007, pp. 44-53.

[20] Chursin A.A., Shevchenko V.V., About the possibilities of operational

gaming scenario modeling activities of enterprises and corporations. IEEE Xplore Digital Library. Tenth International Conference Management of Large-Scale System Development (MLSD), Moscow, Russia, 2017. http://ieeexplore.ieee.org/document /8109609/

[21] Ostrovskaya A.A., Shevchenko V.V. About the possibilities of classic and operational gaming modeling in support of decision-making on the management of enterprises and corporations. IEEE Xplore Digital Library. Tenth International Conference Management of Large-Scale System Development (MLSD), Moscow, Russia, 2017. http://ieeexplore.ieee.org/document/8109666/

[22] Shevchenko V.V., About the possibilities of the operational gaming simulation of the processes of logistic interactions // 12th Int. Conf. Management of Large-Scale System Development (MLSD), Moscow, Russia, 2019. DOI: 10.1109/MLSD.2019.8911114

[23] Shevchenko, Vasiliy V.; Kokuytseva, Tatiana V., Ovchinnikova, Oksana P., Competitiveness of the Enterprises of the Eurasian Economic Union:Assessment Methodology. Revista ESPACIOS. ISSN 0798 1015 Vol. 40 (N° 37) Year 2019, pp. 15-22.

[24] Shevchenko V.V., On the construction and analysis of macroeconomic operating game models. IEEE Xplore Digital Library. Eleventh International Conference Management of Large-Scale System Development (MLSD), Moscow, Russia, 2018. DOI: 10.1109/MLSD.2018.8551764

Chapter 4

Supporting Named Entity Recognition and Document Classification for Effective Text Retrieval

Philippe Tamla, Florian Freund and Matthias Hemmje

Abstract

In this research paper, we present a system for named entity recognition and automatic document classification in an innovative knowledge management system for Applied Gaming. The objective of this project is to facilitate the management of machine learning-based named entity recognition models, that can be used for both: extracting different types of named entities and classifying text documents from different sources on the Web. We present real-world use case scenarios and derive features for training and managing NER models with the Stanford NLP machine learning API. Then, the integration of our developed NER system with an expert rule-based system is presented, which allows an automatic classification of text documents into different taxonomy categories available in the knowledge management system. Finally, we present the results of two evaluations. First, a functional evaluation that demonstrates the portability of our NER system using a standard text corpus in the medical area. Second, a qualitative evaluation that was conducted to optimize the overall user interface of our system and enable a suitable integration into the target environment.

Keywords: named entity recognition, document classification, rule-based expert system, social network, applied gaming, knowledge management system

1. Introduction

The European research project Realizing and Applied Gaming Ecosystem (RAGE) is an innovative online portal and service-oriented platform for accessing and retrieving reusable software components and other related textual documents from the Web, such as research publications, source code repositories, issues, and online discussions. RAGE is used to support software reuse in the domain of applied gaming. Applied games (AG) or serious games (SG) aim at training, educating and motivating players, instead of pure entertainment [1]. RAGE supports the integration with various social networks like Stack Exchange ("Hot questions"), or GitHub ("Build software better"). For instance, RAGE includes facilities to connect with the Stack Exchange REST API which enables an easy import of online discussions into its ecosystem. RAGE users can easily import multiple discussions from, for instance, the Stack Overflow social site,

describe them with further meta information, classify them using an integrated taxonomy management system, and then finally retrieve useful information with faceted search that enables drilling down large set of documents. Currently, the classification of text documents into existing taxonomies in RAGE is done manually. The user has to, first, analyze the content of each document manually to understand the context in which this document is used. This is done by consulting the title and description of each imported document, as well as, analyzing all related meta-information (like keywords and tags), which are associated with this document. Once done, the user has to search for taxonomies that may be used to classify the imported document based on its content and metadata. This process can be very hard and requires the full attention of the user because he or she needs to consult the document and taxonomy each time manually. With a large number of documents and multiple hierarchical taxonomies, it can be very time-consuming to classify documents in RAGE.

To solve this problem, *Named Entity Recognition (NER)* is generally applied because it can extract various knowledge contents (like named entities) from natural language texts [2]. The extracted knowledge content can then be used to automate the process of classifying text documents from various domains on the Web, using, for instance, an expert rule-based system. NER has been widely used to recognize named entities in medical reports [3], news articles [4], and software web documents [5, 6]. Techniques for NER vary from rule-based, over machine learning (ML), to hybrid methods. But, ML-based NER methods are more efficient on Web contents, because they include statistical models that can automatically recognize and classify named entities from very large and heterogeneous contents on the Web. The training of a machine learning-based NER model is however very challenging. It requires, besides very good programming knowledge, dealing with different technologies and pipelines for text analysis, natural language processing (NLP), machine learning and rule-based operations [7]. Errors in the initial stages of the pipeline can have snowballing effects on the pipeline's end performance. Therefore, facilitating the development, management, and execution of all necessary NER related tasks and pipelines will, not only reduce the effort to train new NER models but also contribute to optimizing the performance of the whole system.

The goal of this research project is to develop and integrate a named entity recognition system into the RAGE ecosystem. The efficient integration of a NER system into the RAGE ecosystem will not only facilitate knowledge discovery (efficient extraction and analysis of named entities and their interrelationships), but also, enable an automatic classification of text documents into the existing taxonomies of the RAGE ecosystem.

After reviewing and comparing common systems and tools for named entity recognition and document classification, we present real-world use case scenarios and derive features for training and managing NER models with the Stanford NLP machine learning API. Then, the integration of our NER system together with the Drools expert rule-based system is presented, allowing an automatic classification of text documents into different taxonomy categories available in the knowledge management system. Finally, the results of a cognitive walkthrough are shown, serving as a qualitative evaluation and the optimization of the user interface and enabling a suitable integration into the target system.

2. State of the art and related work

2.1 Rage

As stated earlier, the RAGE social platform can be used to import questions from the Stack Exchange platform and other text documents from the Web, which

generally consist of a title, a description, and other metadata. RAGE includes a *taxonomy management system* that serves at organizing and categorizing these documents into existing, hierarchical taxonomies found in its ecosystem. *Taxonomy* is the practice and science of classifying things and concepts including the principles underlining such classification [8]. It is used in RAGE to support faceted browsing, which is a technique allowing users to drill down their large number of search results, enabling faster information retrieval. However, it is hard to classify documents with multiple taxonomies. The user can easily mix up one with another while analyzing and classifying a document into multiple hierarchical taxonomies. Each individual document (including its metadata like title, description, tags) have to be analyzed each time manually in order to understand the context in which the document is used, before making a proper classification into the existing taxonomies. This process can be very challenging and time-consuming, especially with multiple documents and various taxonomies having complex hierarchical structures. To fulfill the requirements of the project, a very desirable goal would be to develop and integrate a named entity recognition system into RAGE that can automatically recognize and classify various kinds of named entities from the multiple social networks connected with the ecosystem. Then, to apply an expert rule-based system that will enable an automatic document classification by reasoning about the extracted named entities, the hierarchical taxonomies and other textual features found in RAGE textual documents.

2.2 Named entity recognition techniques

NER techniques generally include handcrafted rules or statistical methods that rely on machine learning (ML) [2], or even a combination of those. A NER technique is denoted as *rule-based* or *handcrafted* if all the parameters (including rules) that are used to identify and categorize named entities are defined manually by a human. *Machine learning* based techniques will use a computer to estimate those parameters automatically [7]. Existing ML techniques include *supervised learning* (parameter estimation is based on already annotated data), *semi-supervised learning* (parameter estimation uses only a small set of annotated data), and *unsupervised learning* (does not use annotated data for estimation). Most popular machine learning systems are relying on Conditional Random Fields (CRF), the state-of-the-art statistical modeling method for sequential text labelling [9]. CRF has been widely used with machine learning to support different NLP tasks, such as, *part-of-speech tagging* [10], *sentence splitting* [11] and *NER* [12]. Developing a machine learning-based NER system is however very challenges and requires a lot of data for model training. Often, *gazetteers* (dictionaries of specific named entities) are introduced as additional features to recognize unknown named entities - words that were not used in the training process. Likewise, *regular expressions* can be applied to optimize ML models, because they detect more complex named entities like compound words [13].

Many factors can influence the performance of a NER system, such as a) The *language*. Some NER systems were developed for one specific language like English. b) The *named entity type*. For instance, the class of a datetime can be easily found if it only contains absolute dates (2003; 6.2.2005, April 5, 2011), but it can be difficult to detect relative dates (next Saturday, in December). c) The *domain* of the processed texts (corpora). If a classifier was trained using juristic texts, it will be difficult for this same classifier to deal with material originated from bioinformatics. The standard measures for evaluation machine NER systems are *precision*, *recall* and *F1* for this task. Recall is the ratio of correct annotated NEs to the total number of correct NEs. Precision is the ratio of correct annotated NEs to the total number (correct and incorrect) of annotated NEs. F1 score is calculated from precision and

recall and describes the balance between both measures. Most NER tools have functions to calculate precision, recall and F1 from a set of training and testing data.

2.2.1 Comparison of NER tools

Many tools have been proposed in the literature for named entity recognition. We need to review and compare them to enable a suitable integration into our target system. Therefore, we introduce the following **selection criteria**: a) the selected tool should not be limited to a specific type of text or knowledge domain b) should include a rich set of NLP features (including *NER, POS, Tokenization, Dependency Parsing, Sentiment Analysis*), c) must be stable, extendable, distributed as opensource, and should have an active community of developers. Our solution is designed to classify a relatively small amount of data. The RAGE contents have a limited size and do not consist of many gigabytes of data. Therefore, we prefer to achieve good results with a high level of accuracy and do not need a very fast classification process which often results in lower accuracy.

Our tool comparison is based on the work of Pinto [14]. According to our selection criteria, we exclude from our comparison non-opensource tools, tools without NER support, and those focusing only on specific data. To compare state-of-the-art tools, we added SpaCy, Spark NLP and Stanza to our list, because these tools arose in the last view years and may be relevant in our work.

GATE ANNIE[1] is a more general solution for various NLP tasks. It was first developed to help software engineers and researchers working in NLP but has been optimized to a more powerful system with an integrated user interface, which supports different data preprocessing tasks and pipeline executions. GATE is distributed with an integrated information extraction system called ANNIE that supports NER and many other NLP tasks. ANNIE relies on the JAPE[2] specification language, which provides finite state transduction over annotations based on regular expressions. Using the GATE interface, users can capture the provenance of machine and human-generated annotated data to create new metrics for NLP tasks like named entity recognition. Additional metrics for more specific scenarios can be added, but this requires an existing implementation in the RAGE architecture, which introduces the overhead of familiarization with the entire GATE architecture.

The **Natural Language Toolkit (NLTK)**[3] is a Python library that supports most of the common NLP tasks. It was launched in 2001 under the Apache license. Each NLP task is performed by an independent module and it is possible to train an own model for NER. The main disadvantage is that it lacks support for dependency parsing and an interface for the standard Universal Dependencies[4] dataset is missing.

Apache OpenNLP[5] is written in Java and based on machine learning. Launched in 2004 and licensed under the Apache License, the software supports NER and many NLP tasks. But it lacks support for dependency parsing.

The **Stanford CoreNLP**[6] is a Java-based tool suite from Stanford University that was launched in 2010. It supports all relevant NLP tasks, including NER and dependency parsing. CoreNLP can train new NER models independently from the data types, languages, or domain. Its API includes more than 24 different

[1] https://gate.ac.uk/ie/annie.html

[2] https://gate.ac.uk/sale/tao/splitch8.html

[3] https://www.nltk.org/

[4] https://universaldependencies.org/

[5] https://opennlp.apache.org/

[6] https://stanfordnlp.github.io/CoreNLP/

annotators for text annotation, regular expressions and language processing tasks. These annotators can be easily combined and executed sequentially in different pipelines. A REST service interface is also available, which can be used by other external systems for different NLP tasks execution. Thus, CoreNLP may be easily integrated with a rule-based expert system to support the automatic document classification in RAGE. Finally, the training of NER models is very flexible and customizable. CoreNLP includes nearly 100 parameters for CRF-based model training and performance fine-tuning, including other options for adding gazette lists that can recognize unknown named entities. CoreNLP is licensed under the GPLv3 and has a very big active community. Thus, state-of-the-art NLP methods and algorithms are permanently developed and integrated into the software.

Stanza[7] is a Python Library, developed by Stanford University as a possible successor for CoreNLP. It was launched in 2019 under the Apache license. Even the system is rather new it supports many features needed in our work, only sentiment analysis is missing. The ML models trained by CoreNLP are not directly supported in Stanza and need to be trained again. Stanza brings a client to connect to the CoreNLP server, so it is possible to use CoreNLP features over this interface, which increases the complexity. **SpaCy**[8] is one of the newer systems for NLP that was launched in 2015. It is written in Python and was published under the MIT license. It is used to produce software for production usage, which should be easy to use and fast. SpaCy supports most of the common NLP features, including dependency parsing and features for training custom models for NER. But it lacks support for sentiment analysis. The main disadvantage for our purpose is, it focuses on fast classification, which leads to a lower accuracy compared to other systems. **Spark NLP**[9] is one of the most recent NLP tools that was released in 2017. It is a library build on top of Apache Spark and TensorFlow. It supports Python, Java and Scala and focuses the usage in production systems. It has more dependencies to get it up and running compared to other systems, due to the Apache Spark architecture. The supported NLP features include all relevant features, including dependency parsing and the training of a custom model for NER. Due to its young age, the community is not as big and active compared to others. On Stack Overflow, only a few number of questions are tagged with "johnsnowlabs-spark-nlp", while the "stanford-nlp" tag has more than 3000 questions. We decided to use the Stanford CoreNLP suite for our project. CoreNLP is the only NLP software which met all our requirements. The competitors may be better or faster in one or another subtask, but overall CoreNLP seems to be the tool with the best mix of all required features. Especially the rich feature set in combination with an active and living community is a huge advantage of Stanford CoreNLP, compared to the other solutions.

2.3 Rule-based expert systems

Expert systems are rapidly growing technology of Artificial Intelligence (AI) that use human expert knowledge for complex problem-solving in fields like Health, science, engineering, business and weather forecasting [15–17]. An expert system represents knowledge solicited by a human expert as data or production rules within a computer program [17]. These rules and data can be used to solve complex problems. For instance, a rule-based classification system can be applied to classify text documents into organized groups by applying a set of linguistic rules.

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[7] https://stanfordnlp.github.io/stanza/

[8] https://spacy.io/

[9] https://nlp.johnsnowlabs.com/

The rules will instruct the system to use semantically relevant elements of the document and its contents to identify useful categories for automatic classification [18]. Over the last decades, many expert systems have been proposed but essentially all of them are expressed using IF THEN-like statements which contain two parts: the conditions and the actions. In the mathematical sense, a rule can be defined as X == > Y, where X is the set of conditions (or antecedent) and Y is the set of actions (or the consequent). Rules are used to represent and manipulate knowledge in a declarative manner, while following the first-order logic in an unambiguous, human-readable form, and at the same time retaining machine interpretability. Rule-based systems generally include a "production memory" which contain a set of rules that are matched against facts stored in the "working memory" of an "inference engine" [40].

The **C Language Integrated Production System (CLIPS)** is a public domain software tool for building expert systems. It was developed by the NASA in 1985 [19]. It has become one of the most used RBES in the market because of its efficiency and portability [20]. CLIPS was written C, and for C programming. But, it is now incorporating a complete object-oriented language for writing expert systems, called COOL. COOL combines the programming paradigms of procedural, object-oriented and logical languages. While CLIPS can separate the knowledge base (the expert rules) from its inference logic, it is not that user friendly in the formulation of rules like many other systems [19].

Ten years after CLIPS, the **Java expert System Shell (JESS)** was launched by Ernest Friedman-Hill of Sandia National Lab [19] as a Java-based implementation of the CLIPS system. It supports the development of rule-based expert systems that can be tightly coupled to Java code and is often referred to as an expert system shell [21]. JESS is compatible with the CLIPS rule language, but a declarative language (called JessML) is also available for specifying rules in XML. JESS is free to use for educational and governmental purpose, but it is not an opensource software. There is no free source code under any available license[10].

The **Drools** expert system is an opensource software that was first developed by Bob McWhiter (in 2001), and later on, absorbed by the JBoss organization (in 2005). Drools is based on Java and its rule definitions rely on IF...THEN statements which are easier to understand than the syntax provided by CLIPS and JESS. Drools rules can be also specified using a native XML format. The rule engine essentially is based on the Rete algorithm [22], however, extended to support object-oriented programming in the rule formulation. Drools is available under the Apache Software Foundation's opensource license [23]. Because its easy and far more readable rule syntax, Drools has been widely used as an expert system in various domains [6]. Therefore, we chose Drools to enable an automatic document classification in the RAGE ecosystem.

3. System design

Our system design relies on the user-centered design (UCD) approach by [24], which has proved to be very successful in the optimization of the product usefulness and usability [25]. Applying the UCD to design a system includes: a) understanding the context in which users may use the system, b) identifying and specifying the users' requirements, c) developing the design solutions, and finally, d) evaluating the design against users' context and requirements.

[10] https://jess.sandia.gov/jess/FAQ.shtml

Our system allows any user (experts or novice developers) to customize and train a machine learning-based NER model in their domain of expertise. In the target system, the user starts with a named entity recognition definition, which is a set of parameters and configuration steps to train a named entity recognition model using machine learning. With the support of the system, the user can upload a text corpus, define the named entity categories, and the named entity names (including their related synonyms) based on the requirements of the target domain. Then, he/she can customize all the conditional random fields and optimization parameters used to train a model with machine learning. The information about the NE categories, the NE names, and their related synonyms is used for the automatic annotation of the text corpus, using the BIO annotation mechanism which is integrated into our system. This is very useful because machine learning-based NER systems generally require a lot of annotated data for model train. However, while the system is able to suggest a first annotation of the text corpus, which can then be used for training and testing, it is necessary for the user to customize the testing data to avoid overfitting issues which may lead to very poor quality of the trained model [7]. Once a NER model is trained, the user can finally use it to construct flexible rules (by referring to the extracted named entities in the text) for automatic document classification in various domains. These rules are business rules and are constructed using a rule-based expert system. They will be used to represent and manipulate knowledge in a declarative manner using a set of WHEN ... THEN statements in a human-readable form. The next sections will now provide an overview of relevant use cases and describe the overall architecture of the system.

3.1 Use case

Our use case diagram in **Figure 1** describes all tasks for a user to create a NER model definition, train a model, manage it, and finally use the trained model to support automated document classification in RAGE. We call our system the Standford Named Entity Recognition and Classification (SNER), as it relies on Standford NLP for NER, and Drools for document classification. Our actor is a

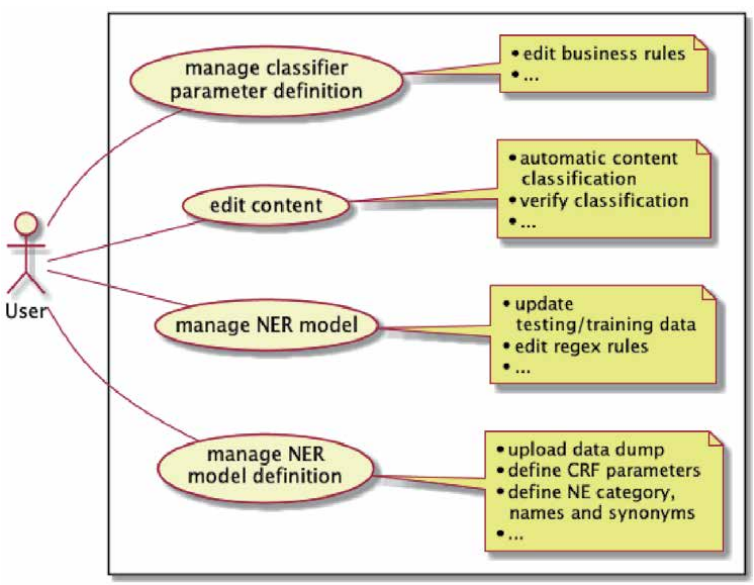

Figure 1.
SNERC use case.

registered and logged-in user in KM-EP. There are four main actions that can be executed by the user: **1) "Manage NER model definition"**. This includes uploading a data dump for use in the target domain, defining the corresponding NE categories, names, and synonyms, customizing CRF and performance parameters, adding regular expressions to identify complex named entities (like Java 11.0), preparing the NER model, which includes features for the automatic annotation of the text corpus and the splitting of the annotated text into testing and training data. Finally, training the NER model using CronJobs and the Stanford NLP machine learning API. **2) "Manage NER model"**. This includes dealing with the management of the created NER models, reviewing the performance indicators like precision, recall and F1, edition and deletion of NER models, and upload of already existing NER models in the system. **3) "Manage classifier parameter definition"**. This action deals with adding, editing or deleting business rules that are used for classifying text documents into existing taxonomies. To create new rules, the user can select the taxonomies and NER models that are relevant for its specific domain. 4) The **"Edit content"** action describes the steps, where a KM-EP content is edited and the automated classification suggestion is retrieved, supervised and saved.

3.2 Taxonomies in serious games development

Our system is developed to enable automatic document classification into hierarchical taxonomies. Since, our research is applied to the domain of serious games development, we need to review existing taxonomies and find out, which ones may be useful to validate our approach. We can refer to our previous study about software search during serious games development [26] to figure out which taxonomies may be relevant for the domain of serious games. In this research [26], we applied the LDA statistical topic modeling to automatically discover 30 topics about serious games development, from which the following belong to the most popular ones: *Programming and Scripting Language, 3D-Modeling, Game Design, Rendering, Game Engines, Game Physics, Networking, Platform*, and *Animation*. We can now review the current state-of-the-art in taxonomies for serious games and select a list of taxonomies to be used in our proof-of-concept.

Taxonomies in serious games have many aspects and dimensions. Most relevant taxonomies for our work are related to 1) *Game genre*, 2) *programming languages*, 3) *video game tools*, 4) *machine learning algorithms*, and 5) *video game specification* and *implementation bugs*. Many researchers have proposed different hierarchical taxonomies in the domain of serious games. Their main objective was to elucidate the important characteristics of popular serious games and to provide a tool through which future research can examine their impact and ultimately contribute to their development [27]. Our first classification taxonomy reflects the *game genre* [GEN], as it is one the basic classification schemes proposed by researchers in the classification of serious games [27–30]. A serious game can be classified based on the market [GEN/MAR] (e.g. Education, HealthCare, Military), the game type [GEN/TYPE] (board-game, card-game, simulation, role-playing game, toys, etc) or the platform [GEN/PLA] in which the game runs (Browser, Mobile, Console, PC) [27]. Many Stack Overflow discussions are already tagged with specific words like "education", "board-game", "simulation", "console". Therefore, we want to classify SG-related discussions in the game genre dimension. Second, our analysis of SG-related online discussions in Stack Overflow has revealed that developers of serious games are generally concerned with finding ways to implement new features using a specific programming language (or scripting) language [LANG]. So, a taxonomy in the programming language dimension is essential. To classify programming languages, we refer to Roy's work [31] and use the *programming paradigm* as the main

attribute in our work. We focus on serious game development, where existing game engines and tools for classic video game development are used, and we want to classify the Stack Overflow posts in this way. Third, [30] proposed a lightweight taxonomy to standardize the definition of common *tools*, *development environments* [TOOL/IDE], and game engines [TOOL/ENG] that are used for game development. We can use this taxonomy as a classification scheme for the Stack Overflow posts. Fourth, another aspect is *machine learning [ML]*, the most trending aspect in serious games development. Machine learning is one of the main techniques used in reusable software components [32] and for creating intelligent learning systems. For instance, pedagogical systems use observational data to improve their adaptive ability, instead of relying on theoretical guidelines [33]. This motivates us to integrate a machine learning-based classification scheme in our work. [34] created such a scheme and gave a brief overview of state-of-the-art machine learning algorithms. We will use this in our work for classifying posts in the machine learning dimension. Our final dimension is regarding video game bugs [BUG]. As shown in our study, one of the main concerns of serious games developers (like most of the software developers) is to find solutions to fix their bugs, whether during the design or implementation of their games. [35] developed in 2010 a taxonomy for video game bugs, which differentiate between specification bugs [BUG/SPEC] and implementation bugs [BUG/IMP]. A specification bug is generally referring to a wrong requirement in the game design document. This may refer to missing of critical information, conflicting requirements, or incorrectly stated requirements. A bug in an implementation is an error found in any asset (source code, art, level design, etc.) that is created to make the specification into a playable game [36]. A failure in an implementation is generally a deviation of the game's operation from the original game specification [35].

3.3 Drools extensions for document classification

This section presents our Drools extensions that is relevant to enable a flexible classification of text documents into the RAGE taxonomies. Our features extension rely on techniques for *Linguistic Analysis*, *Syntactic Pattern Matching* and *Document Structure Analysis*. Our classification system will be implemented as a standalone RESTful webservice so that it can be easily integrated within RAGE and any other external systems that may need to classify documents into predefined taxonomies.

Linguistic Analysis. We use the Stanford NLP API to support linguistic analysis in our System. Stanford NLP supports many NLP tasks like part-of-speech tagging (POS), tokenization, and NER. By analyzing specific part-of-speeches and recognizing various mentions of named entities discussion sentences, we can analyze the syntactic structure of each sentence. Then, we can refer to the **sentence components** (subject, predicate, object), the ***sentence form*** (whether it is *affirmative* [37] or *negative*), and the ***sentence mood*** (whether it is *interrogative* or *declarative*) to understand the structure of each sentence and derive its meaning. A similar approach was proposed by [37] for the classification of Stack Overflow discussions into software engineering-related facets, but this approach relied on hand-crafted rules for recognizing named entities in discussion posts. Instead of applying hand-crafted rules for NER, we will rely on our NER system to extract SG-related named entities (like game genres, programming languages, or game engines) from the existing text documents. To detect the *sentence form* and determine if a sentence is positive or negative, we will rely on the *StanfordNLP Sentiment Analysis API*[11], as it

[11] https://nlp.stanford.edu/sentiment/index.html

includes a machine learning-based API for this purpose. We will rely on regular expressions to determine the *sentence mood*. We will consider a sentence to be *interrogative*, if it contains a question mark, or if it starts with an interrogative word (what, how, why, etc.) (e.g. what is the best way to record player's orientation?), otherwise the sentence is *declarative*. Using our linguistic analysis features, we can understand the meaning of each individual sentence, and use this information to derive the semantic of a document. Then, it becomes easier to group documents having similar semantic into a single taxonomy.

Syntactic Pattern Matching. Research on web content mining has demonstrated that certain lexico-syntactic patterns matched in texts convey a specific relation [38]. Liu's study has revealed that many online questions belonging to similar topics have similar syntactic patterns. They found that many programming languages usually appear after a preposition, like **with** Java, **in** JavaScript. After carefully analyzing the title and description of some SG-related topics in Stack Overflow, we could easily observe similar behavior for game genres, game engines and tools, such as **for** educational games, **in** Unity 3D, **with** GameMaker, etc. Thus, the categories of a question can be derived based on the syntactic patterns of its sentences.

Table 1 shows the list of our syntactic patterns that can be used to classify Stack Overflow discussions into taxonomies of the RAGE system. Our syntactic pattern definition is based on a rich set of terms, term combinations, and standardized synonyms (**Table 2**), that we observed in various Stack Overflow discussions. Applying synonyms in our approach is very important to automatically detect name variations in text and enable a classification to perform better. For instance, we can use a pattern that includes the term "implement" and use the same pattern to identify texts that include the term "develop" or "build". To achieve this goal, we will need to create a domain dictionary with a set of semantic classes, each of which includes a standardized term and its synonyms [37].

For each parameter in our defined template shown in **Table 2**, and for each taxonomy and category that the template applies to, we will use a list of popular terms found in Stack Overflow to instantiate our template and created a semantic

Pattern	Description
PA	Entity or Term appears after a preposition
PB	Entity or Term appears before a preposition
SG	Entity or Term appears in the subject group
PG	Term appears in the predicate group
OG	Entity or Term appears in the object group
SA	The sentence is affirmative
SI	The sentence is interrogative
SP	The sentence is positive
SN	The sentence is negative
TT	Term combination <*term*1> <*term*2> appears in a sentence
TTSG	Term combination <*term*1> <*term*2> appears in the subject group
TTOB	Term combination <*term*1> <*term*2> appears in the object group
TTPB	Term combination <*term*1> <*term*2> appears before a preposition

Table 1.
List of syntactic patterns.

Taxonomy Category	Term	Term synonyms
Programming Language	< *implement* >	implement, develop, code, create, construct, build, set
Specification Bug	< *specify* >	design, require, define, determine, redefine
Implementation Bug Specification Bug	< *error* >	error, bug, defect, exception, warning, mistake
Game Engine	< *configure* >	configure, setup, adjust, adapt, optimize
—	< *howto* >	How to, How do (I,we), How can (I,we), How should (I,we)
... Bug	< *fix* >	fix, solve, remove, get rid of, eliminate

Table 2.
List of synonyms.

class with each term. We will rely on the WordNet API[12] to create semantic classes of candidate synonyms using standardized terms. When a new term is added, all its synonyms should be identified using WordNet and then considered for inclusion. By combining different terms and synonyms, we can discover a wide range of expressions and term combinations and phrases used in the majority of SG-related discussions. For instance, the term combination < *Best* > < *Way* > can be used to identify posts containing the expressions: "best way", "best strategy", "proper design", "optimal solution", etc. This will allow us to have a more generic syntactic pattern definition that can easily scale in different domains compared to [37]'s system (**Table 3**).

Document Structure Analysis. This feature is used to explore the structure of online text documents. We can refer to specific HTML elements to find out if a document contains a code snippets (< *code* > ... < /*code* >), bullet points (< *ul* > ... < /*ul* >), or even images (< *img*/ >). Exploring the structure of online discussion can help us to classify documents into specific taxonomies like *Programming Languages* or *Video Game Bugs*. A quality study of Stack Overflow online discussion [39] has revealed that explanations (generally represented using bullet points in the question bodys) accompanying code snippets are as important as the snippets themselves. Also, existing survey research on document structure analysis has demonstrated that analyzing the hierarchy of physical components of a web page can be very useful in indexing and retrieving the information contained in this document [40]. For instance, if a Stack Overflow post, contains the word "bug" in its title, and one or more code snippets in its body, then it may be assigned to the *Implementation Category* of the *Video Game Bug Taxonomy*. Generally, such a discussion would include sentences like "How to **fix** my bug in ... " or "How can I

Pattern	Description
LS	Text contains multiple bullet points as HTML list
CS	Text contains one or multiple code snippets
IM	Text contains one or multiple images followed by a text description

Table 3.
Patterns for document structure analysis.

[12] https://wordnet.princeton.edu/

solve this issue... in my game" in its title or description body. Similarly, if a bug discussion includes terms like "requirement, design, or specification" in its title (e.g. I want to **fix** ... in my **specification**), with multiple bullet points in its description body, then it may indicate that the user is seeking help to solve an issue in a particular section of its design specification. In this case, the discussion post may be classified into the *Specification Bug* category of the *Video Game Bug Taxonomy*.

Our features extensions are very flexible and can be easily combined to construct even more complex rules in the Drools language. There is also no limitations for adding new extensions to document classification in our system (**Table 4**).

3.4 System architecture of SNERC

This section presents the system architecture of SNERC. Based on our use cases, we have defined 5 main components which will want to describe here (**Figure 2**).

NER Model Definition Manager manages all the necessary definitions and parameters for model training using machine learning. It includes 3 main classes. The first two, Named Entity Category and Named Entity, hold information about the domain-specific named entities names and categories. The third class, NERModelDefinition, is used to stored data like the model name, text corpus,

Pattern Matching	Taxonomy Categories	Examples
PA (SG || OG) && SA	LANG, GENRE, ...	<**How to**> to do animation with <**unity3d5.2**> An <**Educational Game**> for learning prog. Language.
(TT && SI) || PA	SPB	It might be an issue in the <**game**> <**design**> spec.
PB && CS	IMB	I am using a nstimer and it has a <**bug**> with my game loop <**code**>...</**code**>

Table 4.
Pattern matching rules for matching stack overflow discussion posts.

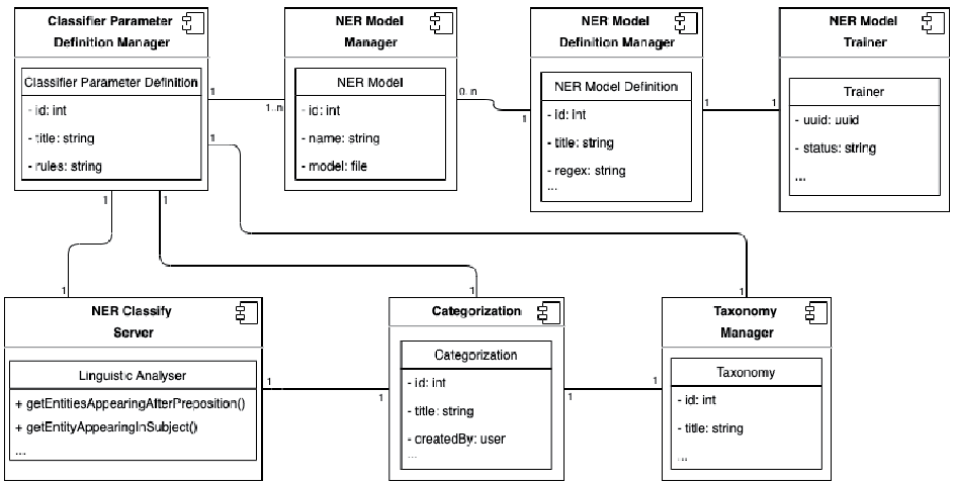

Figure 2.
Model of the conceptual architecture.

gazette lists, and regex. We use the Stanford RegexNER API to construct and store complex rules, as they can easily be combined with already trained models.

NER Model Trainer is our second component that is used to prepare a NER model. This includes the automatic annotation of the domain text corpus (or data dump) based on the previously defined NE categories, NE names and synonyms. Our system is also able to split the annotated text corpus into testing and training data. The testing data, however, needs to be reviewed by a human expert and uploaded again to avoid overfitting, and thus a realistic calculation of precision, recall and F1 scores. When this is done, the NER Model Trainer component can execute the task for training a NER model using jobs and the Stanford CoreNLP. As the NER Model Trainer is written in Java and KM-EP is a PHP project, we designed it as a separate REST service component. This has further advantages. First, the service can be developed independently and does not affect KM-EP. Second, this service can be used separately from KM-EP as it is defined as a REST API. Other external systems will just need to define the input data in a JSON format and send them via an HTTP REST call to this service. The NER Model Trainer has a class called *NER Model Definition* which represents the corresponding GUI components in KM-EP. The Trainer class is used to control the training process.

NER Model Manager. This component is very straightforward since it only serves the storage of the trained NER models into the KM-EP filesystem so that they can be used by other systems like a linguistic analyzer or our document classification system. If a model is prepared with a NER Model Definition, users can update the created testing and training data within the NER Model Manager to get better Precision, Recall and F1 scores. Also, the created Stanford Regex NER rules can be edited and updated. It is also possible to upload a StanfordNLP NER model that was trained with another system and use it in KM-EP. **Figure 3** shows an example of a recognized named entity with the NER Model Manager.

Classification Parameter Definition Manager. This component is used to manage and store business rules in KM-EP. To construct business rules that mention named entities and can be used to classify documents into existing taxonomy categories, the design of the "Classification Parameter Definition Manager" component needs to include links to the "NER Model Manager", "Content Manager" and "Taxonomy Manager" of KM-EP. We use the *Simple Knowledge Organization System (SKOS)* as the unique connection between our business rules and the taxonomy categories found in KM-EP. Even each taxonomy category in KM-EP has a SKOS persistent identifier representing the category.

NER Classifier Server. The NER Classify Server is our last component. It is developed as a standalone RestFul service to classify documents into taxonomies. To execute a document classification, the NER Classify Server needs information about the document (title, description, tags), the Drools rule, and references about the NER models, so that named entities can be used in the rule formulation. This information is sent to the server from KM-EP in a JSON format. With the provided document data and the references to the NER models, the server can now execute the NER, perform the synonym detection (with WordNet), and execute Linguistic Analysis, and Syntactic Pattern Matching on the Document structure and content. This analysis is done in the "classify()" method of a Java object, called Document. The analysis result is then stored into the properties of this object and can be used

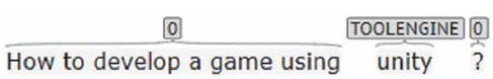

Figure 3.
Example of a recognized named entity.

during the execution of Drools rules. The following code snippet shows the implementation of our Document.classify() method.

```
Server
  Document
    title
    description
    tags
    ...
    classify()
      LinguisticAnalyzer.check(sentence)
        detectNamedEntities()
        detectSynonyms()
        appearsAfterPreposition()
        appearsBeforePreposition()
        isAffirmative()
        appearsInSubject()
        isSentencePostive()
      DocumentStructureAnalyzer(text)
      hasCodeSnippet()
      hasBulletPoint()
      hasImages()
```

3.4.1 System service implementation

To make the features of our implemented REST services available to the various KM-EP components, we created two new services in KM-EP. These services are used as an adaptor between KM-EP and its objects and our developed REST services. Each service bundles the features of the corresponding REST service and is connected with the KM-EP PHP API. The big advantage of relying on this service-based architecture is that, if we decide to change or update our REST APIs, we will only need to change the KM-EP services and leave their underline implementations untouched.

NER Model Trainer Service. The NER Model Trainer Service of KM-EP is used to connect with the NER Model Trainer REST service. As already discussed in the previous sections, this component includes the creation of a NER Model preview, the preparation of a NER Model and model training. Because the NER Models are created using the NER Model Trainer component, they need to be downloaded from there into KM-EP and deleted afterwards.

Classifier Service. The Classifier Service of KM-EP is used for the communication between KM-EP and the NER Classify Server REST service. To handle the automatic document classification, we first need to manage the NER Models using the NER Classify Server. Then, the Classifier Service of KM-EP can trigger the execution of the operation for adding or deleting NER Models by calling the NER Classify Server. Furthermore, the Classifier Service will be able to trigger the automatic classification of documents to be suggested to the user.

3.5 Proof-of-concept

After presenting our major use cases and showing details about our implemented components, we can now present a common use case scenario where Stack Overflow discussions about SG topics can be classified in RAGE. With an existing NER model in the system, a classification parameter definition can be created with the

Classification Parameter Definition Manager component to classify discussion texts into taxonomies of the system. For instance, there may be a Stack Overflow post like this in RAGE:

> Title: "bug in my game loop"
> Keywords: "cocoa-touch, nstimer"
> Description:
> "I am making a game on xcode 5. I am using a nstimer in C\# and there may be a bug in my game loop. Can you help me please. All help is great. <code>...</code>"

According to our previous definition, we can create Drools rules to automatically classify this document into *Video Game Bug* and *Programming Language* taxonomies. First, we will start with the creation of a "Classification Parameter Definition", where we select the desired taxonomy and NER models for named entity extraction. Then, we will construct our classification rules using the WHEN ... THEN syntax provided by Drools. Based on the selected taxonomy, the NER models, and our rich set of features extensions, we can easily refer to specific named entities (like C# (LANG), cocoa-touch (TOOL)) in our rule definitions and perform *Linguistic Analysis*, *Syntactic Pattern Matching*, and *Document Structure Analysis* on the document. **Figure 4** shows an example of such classification rules in the Drools language.

- Lines 6–7 (of rule 1) refer to our *WordNet* integration to detect if the term "bug" (or one of its synonyms) is included in the discussion title. Line 9 analyzes the document structure to identify if the post description includes a code snippet. Because both conditions are true, the document is automatically assigned to the *Implementation Bug* of the *Video Game Bug* taxonomy.

- Line 19 (of rule 2) checks the syntax of the post description to identify if a named entity of type LANG appears after a preposition. Since it is true, the post is assigned to the C# category of the *Programming Language* taxonomy.

To make it easier for the user to test the created rules, we implemented a form to test the developed rules. The user can input some text, execute the classification parameter definition and see a classification report with the results of the annotation and classification process. There is also a visualization of the NLP features

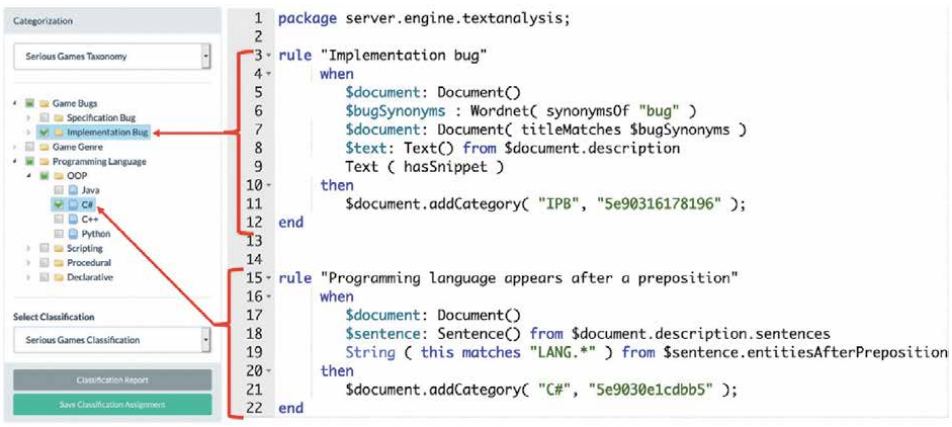

Figure 4.
Selected categories and their rules.

detected by Stanford CoreNLP which is based on CoreNLP Brat[13]. The reports include the following information:

A list of persistent identifiers of the **detected categories**, an area for the detected **sentences** with the results of the Stanford CoreNLP features, representation of detected **Parts-of-Speech**, **detected NEs**, detected **basic dependencies** and the detected **sentiment**. For further analysis the original Stanford CoreNLP output is also available in JSON format in the GUI.

4. Evaluation of SNERC

In the last chapter, we have described the implementation of our SNERC system, and presented a proof-of-concept scenario, where a machine learning NER model is used to support a rule-based classification of Stack Overflow discussions into taxonomies used in the domain of serious games. The concepts, models, designs, specifications, architectures, and technologies used in chapter 3 has demonstrated the feasibility of this prototype.

Now, we need to evaluate our developed system and prove that it is usable, useful, effective, efficient, etc. Therefore, this chapter presents different evaluations, that we conducted to evaluate different aspects of SNERC. There are several evaluation methods that can be used to evaluate software systems.

Our first evaluation is introduced to test the functionality of our NER system, as it the basic component used for NE recognition and classification, and also for supporting automatic document classification in RAGE. Thus, we use a standard text corpus to train a set of NER models and compare our evaluation values with another system, that is also based on Stanford CoreNLP. We use a text corpus of the medical area to demonstrate cross-domain portability of our approach. *Precision*, *recall*, and *F1* are also applied in this evaluation, as they are the standard evaluation parameters for comparing machine learning-based NER models.

Our second evaluation relies on the "Cognitive Walkthrough" [41] approach, which is a usability inspection method for identifying potential usability problems in interactive systems. This approach focuses on how easy it is for a user to accomplish a task with little or no formal instruction or informal coaching. We have used this method to identify possible issues in the SNERC user interface, while working through a series of tasks to perform NER and classify textual documents using business rules.

4.1 Comparison with a standard corpus

In this section, we describe the functional evaluation of our Stanford-based NER system and demonstrate the reproductivity of our approach in the medical research area. Thus, we refer to different text corpus previously used in the medical domain to train NER models with our system. Then, we compare our training result with another Stanford-based NER system applied on the same data set. Our system is compared with the work of [42], where various NER models for discovering emerging named entities (eNEs) were trained and applied in a medical Virtual Research Environments (VREs). As stated in Section 2.2, eNEs in medical environments are new research terms, that are already in use in medical literature, but are widely unknown by medical experts. The automatic recognition of eNEs (using

[13] https://github.com/stanfordnlp/CoreNLP/tree/master/src/edu/stanford/nlp/pipeline/demo

NER methods) can make them easily usable in Information Retrieval by search queries or indexing of documents.

4.1.1 Data preparation and system setting

Duttenhofer [42] used the Stanford CoreNLP for model training with the following data sets to train NER models in the medical context.

- CoNLL2003 ("english-training-data.txt"): a reference data set used to evaluate NER systems dealing with English documents.

- The NE dictionary Medical Subject Headings (MeSH) ("training-data.txt"). A dictionary (or thesaurus) of standard medical terms.

- User Relevance Feedback(URF) ("urf1.txt, urf2.txt, urf3.txt"). A set of known emerging Named Entities (eNEs) provided by experts in the medical field.

Data sets from CoNLL2003 and MeSH were selected and combined with three different variants of URF data sets. The following listing shows the parameters used for model training using Stanford CoreNLP.

```
map=word=0,answer=1
maxLeft=1
useClassFeature=true
useWord=true
useNGrams=true
noMidNGrams=true
maxNGramLeng=6
useNeighborNGrams=true
usePrev=true
useNext=true
useDisjunctive=true
useSequences=true
usePrevSequences=true
useTypeSeqs=true
useTypeSeqs2=true
useTypeySequences=true
wordShape=chris2useLC
```

These parameters describe the methods and features required for training NER models using the machine learning-based system available in Stanford CoreNLP (see chapter 2.2). These parameters include:

- map: describes the data format of the training data. The data must be separated using tabs. Column 0 must include the word (or NE), and column 1 the corresponding label used to annotate this NE.

- maxLeft: The number of words to be used as contextual feature for observing words on the left of the current word during the model training [6].

- useClasses: The "NE class" should be used as an additional feature during training.

- useWord: Each "word" of the text corpus should be used as an additional feature during training.

- useNGrams: Derive features from N-grams, such as Substrings of the word
- Other features includes are used for word shape like useTypeSeqs (for upper/lower case), useTypeSeqs2, useTypeySequences. WordShape defines the word share function to be used (here "chris2useLC'").

We use the same list of parameters for training the three models (classifierURF1, classifierURF2 and classifierURF3) initially developed in [42] (see **Table 5**). For testing these models, we use the data set ("test-document-with-O-and-NE-and-eNE-replaced1.tok"), which is an update version of the MeSH data set used by Duttenhofer.

4.1.2 Model training with SNERC

To train the same models developed by Duttenhöfer [42], we first defined three "NER Model Definitions" in our SNERC system. The data sets used in [42] are already annotated, thus, there is no need to upload a new data dump or use our automatic annotation tool to generate training and testing data. Also, we skipped the step for cleaning up the data dump (removal or HTML tags, code snippets, URLs, etc.). We continued by adding all the parameters for model training in the tab "Training Properties", where each of them can be easily changed, if needed. Then, we clicked on "Prepare NER Model" in the tab "Train Model" to prepare our models. Our model preparation function generated three documents representing the prepared models, which we renamed to remain consistent with our input data. The input documents used for training in Duttenhofer ("training-data.txt, english-training-data.txt, urf1.txt, urf2.txt, urf3.txt") were combined and uploaded to the respective prepared models. Then, we uploaded an annotated document "'*test-document-with-O-and-NE-and-eNE-replaced1.tok*'" for testing to the generated models. Finally, the training process was triggered using job. **Figure 5** shows the final result of our trained models using SNERC, which also displays the evaluation values precision, recall and F1 (**Table 6**).

4.1.3 Result

Table 7 shows the evaluation values of our trained models and the comparison with the system of Duttenhofer [42]. We have used a text corpus previously used in

Classifier	Precision	Recall	F_1
classifierURF1	93,52%	55,96%	70,02%
classifierURF2	98,92%	75,90%	85,89%
classifierURF3	97,18%	95,29%	96,22%

Table 5.
Evalutation results of Duttenhöfer [42].

ID	Name	Training date	Precision	Recall	F1	Status
44	cerc_classifier_urf1	20.08.2020 08:17:08	93.52%	55.96%	70.02%	OK, view log
45	cerc_classifier_urf2	20.08.2020 08:17:11	98.92%	75.9%	85.89%	OK, view log
46	cerc_classifier_urf3	20.08.2020 08:17:15	97.18%	95.29%	96.22%	OK, view log

Figure 5.
SNERC evaluation of Duttenhofer trained models.

Generated model names	Renamed models	Text corpus
d3dbc3839dx	*SNERC_classifier_urf1*	training-data.txt, english-training-data.txt, urf1.txt
x5dhgfb33gh	*SNERC_classifier_urf2*	training-data.txt, english-training-data.txt, urf2.txt
bc8ac12fgdb	*SNERC_classifier_urf3*	training-data.txt, english-training-data.txt, urf3.txt

Table 6.
Generated classifier names and text corpus for training.

		Duttenhoefer			SNERC		
Classifier	**Entity**	**P**	**R**	**F1**	**P**	**R**	**F1**
classifierURF1	NE	93,52%	99,51%	96,42%	93,52%	99,51%	96,42%
	eNE	0,00%	0,00%	0,00%	0,00%	0,00%	0,00%
	total	93,52%	55,96%	70,02%	93,52%	55,96%	70,02%
classifierURF2	NE	98,50%	97,04%	97,77%	98,50%	97,04%	97,77%
	eNE	100,00%	48,73%	65,53%	100,00%	48,73%	65,53%
	total	98,92%	75,90%	85,89%	98,92%	75,90%	85,89%
classifierURF3	NE	98,47%	95,07%	96,74%	98,47%	95,07%	96,74%
	eNE	95,57%	95,57%	95,57%	95,57%	95,57%	95,57%
	total	97,18%	95,29%	96,22%	97,18%	95,29%	96,22%

Table 7.
Comparion of evaluation values (precision, recall, F1) between SNERC and Duttenhofer system.

the medical area to train three different NER models and show the cross-domain portability of approach. As it can be seen, all the models trained with SNERC have the same evaluation values as in the reference work, since both systems are relying on Stanford CoreNLP for machine learning-based NER. We also note, that all the evaluation values shown in picture 5 are automatically computed by SNERC and can be read in the log output function of the "NER Model Definition Manager component" (see Section 3.4). This feature is always available and can used by a user to check the performance of a model during the preparation or training process.

4.2 Cognitive walkthrough

After we implemented SNERC, it is needed to prove the usability of the system. There are several evaluation methods available to perform this task. Automated and formal methods are testing a system with a computer program, based on a formal specification, or with formal models. As it is difficult to create such a specification or model, we will not use one of these methods. Other methods like empirical methods involve a crowd of potential users of the system, which will perform common tasks in it. Such an evaluation is very resource-intensive and therefore not appropriate to our purpose. Informal methods are based on the knowledge and experience of the evaluating persons. It is known, that these methods create good results and detect many problems in a given system. On the other hand, they are not very difficult or expensive to implement, so they may be a good approach for our project. One of these informal inspection methods is the "Cognitive Walkthrough" [41], where a group of experts simulates a potential user of the system. The group navigates the system and tries to perform the typical steps to achieve the results a user tries to get. Potential problems and defects are documented and solved.

Afterwards, the cognitive walkthrough may be repeated. We chose the cognitive walkthrough as an appropriate evaluation method for our system.

Our evaluation was performed in two steps. First, we performed a cognitive walkthrough in a collaborative meeting with three experienced experts: **Expert 1** is a very experienced professor and since many years Char of Area of Multimedia and Internet Application in the Department of Mathematics and Computer Science at FernUniversität in Hagen. **Expert 2** is a PhD, significantly responsible for the concept and design of KM-EP. **Expert 3** is a PhD student, researching in the area of serious games and named entity recognition.

First, the menu structure of SNERC was navigated exploratively, to simulate the navigation of a potential user in the system. Then each SNERC component was tested. Finally, the creation of an automated classification was evaluated. Within these steps, there were overall eight defects detected, which needed to be fixed. Then, a second evaluation was performed. We extended the expert group by two new evaluators: **Expert 4** is a PhD student, researching in the medical area and emerging named entity recognition. **Expert 5** is a PhD student, researching in the area of advanced visual interfaces and artificial intelligence.

Within the second cognitive walkthrough all typical steps where performed, as a potential user would do it. There were no further defects detected. Expert 4 pointed to the problem of unrealistic performance indicators due to overfitting. This could be disproved with the possibility to supervise and edit the automatically generated testing data within the NER Model Manager. A further note was, SNERC may not be suitable to deal with huge data sets, because of its web-based GUI architecture. As KM-EP does not deal with such huge data sets this is not a real problem for our approach.

We saw the informal evaluation method lead to many results with a limited amount of time and resources. Nevertheless, an empirical evaluation with a bigger group of potential users should be done, to prove the usability and robustness of the system further.

5. Conclusion and final discussion

In this research, we presented a system for named entity recognition and automatic document classification that was integrated into an innovative Knowledge Management System for Applied Gaming. After presenting various real-word use case scenarios, we demonstrated, that it is possible to support users in the process of automatic document classification by combining techniques, such as, semantic analysis, natural language processing techniques (like named entity recognition) and a rule-based expert system. Our NER system was validated using the standard metrics for machine learning models. We demonstrated the portability of this system by using standard text corpus for model training and testing in various domains. Our overall system consisting of both, the NER and document classification system, has been successfully integrated into the target environment and was validated using Cognitive Walkthrough. A future evaluation with a bigger group of potential users may help to gather further insights about the usage, usability and error handling of the entire system.

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References

[1] David R, Sandra L. Serious games: Games that educate, train, and inform. ACM; 2005.

[2] Nadeau D, Sekine S. A survey of named entity recognition and classification. Lingvisticae Investigationes. 2007;30:3–26.

[3] K X, Zhou Z, Hao T, Liu W. A bidirectional LSTM and conditional random fields approach to medical named entity recognition. International Conference on Advanced Intelligent Systems and Informatics. 2017.

[4] Newman D, Chemudugunta C, Smyth P, Steyvers M. Analyzing entities and topics in news articles using statistical topic models. International conference on intelligence and security informatics. Springer; 2006.

[5] Ye D, Xing Z, Foo CY, Ang ZQ, Li J, Kapre N, editors. Software-specific named entity recognition in software engineering social content. IEEE; 2016.

[6] Tamla P, B¨ohm T, Hemmje M, Fuchs M, editors. Named Entity Recognition supporting Serious Games Development in Stack Overflow Social Content. International Journal of Games Based Learning; 2019.

[7] Konkol IM. Named entity recognition [PhD]. PhD thesis, University of West Bohemia; 2015.

[8] Sokal RR. The principles and practice of numerical taxonomy. Taxon. 1963; p. 190–199.

[9] Sutton C, McCallum A, Rohanimanesh K. Dynamic conditional random fields: Factorized probabilistic models for labeling and segmenting sequence data. Journal of Machine Learning Research. 2007;8:693–723.

[10] Gimpel K, Schneider N, O'Connor B, Das D, Mills D, Eisenstein J, editors. Part-of-speech tagging for twitter: Annotation, features, and experiments; 2010.

[11] Tomanek K, Wermter J, Hahn U. Sentence and token splitting based on conditional random fields. In: Proceedings of the 10th Conference of the Pacific Association for Computational Linguistics. vol. 49. Melbourne, Australia; 2007. p. 57.

[12] Ritter A, Clark S, Etzioni O, editors. Named entity recognition in tweets: an experimental study; 2011.

[13] Nagy I, Berend G, Vincze V. Noun compound and named entity recognition and their usability in keyphrase extraction. In: Proceedings of the International Conference Recent Advances in Natural Language Processing 2011; 2011. p. 162–169.

[14] Pinto A, Gonc¸alo Oliveira H, Oliveira Alves A. Comparing the Performance of Different NLP Toolkits in Formal and Social Media Text. In: 5th Symposium on Languages, Applications and Technologies (SLATE'16); 2016. p. 16 pages. Artwork Size: 16 pages Medium: application/pdf Publisher: Schloss Dagstuhl - Leibniz-Zentrum fuer Informatik GmbH, Wadern/Saarbruecken, Germany. Available from: http://drops.dagstuhl.de/opus/volltexte/2016/6008/.

[15] Koppich G, Yeng M, Ormond L. Document management system rule-based automation. Google Patents; 2009. US Patent 7,532,340.

[16] Awan MSK, Awais MM. Predicting weather events using fuzzy rule based system. Applied Soft Computing. 2011; 11(1):56–63.

[17] Abu-Nasser B. Medical expert systems survey. International Journal of Engineering and Information Systems (IJEAIS). 2017;1(7):218–224.

[18] Blosseville MJ, Hebrail G, Monteil MG, Penot N. Automatic document classification: natural language processing, statistical analysis, and expert system techniques used together. In: Proceedings of the 15th annual international ACM SIGIR conference on Research and development in information retrieval; 1992. p. 51–58.

[19] Velickovski F. Clinical decision support for screening, diagnosis and assessment of respiratory diseases: chronic obstructive pulmonary disease as a use case [PhD]. University of Girona; 2016. Accepted: 2017–11-27T07: 51:26Z Publisher: Universitat de Girona. Available from: https://dugi-doc.udg.edu/handle/10256/14611.

[20] Batista-Navarro RTB, Bandojo DA, Gatapia MAJK, Santos RNC, Marcelo AB, Panganiban LCR, et al. ESP: An expert system for poisoning diagnosis and management. Informatics for Health and Social Care. 2010;35(2): 53–63. Publisher: Taylor & Francis eprint: https://doi.org/10.3109/17538157.2010.490624. Available from: https://doi.org/10.3109/17538157.2010.490624.

[21] Friedman-Hill EJ. Jess, the java expert system shell. Sandia Labs., Livermore, CA (United States); 1997.

[22] Forgy CL. Rete: A fast algorithm for the many pattern/many object pattern match problem. In: Readings in Artificial Intelligence and Databases. Elsevier; 1989. p. 547–559.

[23] Cavalcanti YC, Machado IdC, Neto PAdMS, de Almeida ES, Meira SRdL. Combining rule-based and information retrieval techniques to assign software change requests. In: Proceedings of the 29th ACM/IEEE international conference on Automated software engineering. ASE '14. Association for Computing Machinery; 2014. p. 325–330. Available from: https://doi.org/10.1145/2642937.2642964.

[24] Norman DA, Draper SW. User Centered System Design; New Perspectives on Human-Computer Interaction. L. Erlbaum Associates Inc.; 1986.

[25] Vredenburg K, Mao JY, Smith PW, Carey T. A survey of user-centered design practice. In: Proceedings of the SIGCHI conference on Human factors in computing systems; 2002. p. 471–478.

[26] Tamla P, B¨ohm T, Nawroth C, Hemmje M, Fuchs M, editors. What do serious games developers search online? A study of GameDev Stackexchange. vol. VOL. 2348 of PROCEEDINGS OF THE 5TH COLLABORATIVE EUROPEAN RESEARCH CONFERENCE (CERC 2019). CEUR-WS.ORG; 2019. Available from: http://ceur-ws.org/Vol-2348/paper09.pdf.

[27] RATAN RA, Ritterfeld U. Classifying serious games. In: Serious games. Routledge; 2009. p. 32–46.

[28] Buchanan L, Wolanczyk F, Zinghini F. Blending bloom's taxonomy and serious game design. In: Proceedings of the International Conference on Security and Management (SAM). The Steering Committee of The World Congress in Computer Science, Computer . . . ; 2011. p. 1.

[29] De Lope RP, Medina-Medina N. A comprehensive taxonomy for serious games. Journal of Educational Computing Research. 2017;55(5):629–672.

[30] Toftedahl M, Henrik E, editors. A Taxonomy of Game Engines and the Tools that Drive the Industry; 2019.

[31] Van Roy P, et al. Programming paradigms for dummies: What every programmer should know. New computational paradigms for computer music. 2009;104:616–621.

[32] Van der Vegt W, Nyamsuren E, Westera W. RAGE reusable game

software components and their integration into serious game engines. In: International Conference on Software Reuse. Springer; 2016. p. 165–180.

[33] Melo F, Mascarenhas S, Paiva A. A tutorial on machine learning for interactive pedagogical systems. International Journal of Serious Games. 2018;5(3):79–112.

[34] Dasgupta A, Nath A. Classification of Machine Learning Algorithms. International Journal of Innovative research in Advanced ngineering. 2016; 3(3).

[35] Lewis C, Whitehead J, Wardrip-Fruin N. What went wrong: a taxonomy of video game bugs. In: Proceedings of the fifth international conference on the foundations of digital games; 2010. p. 108–115.

[36] Varvaressos S, Lavoie K, Gaboury S, Hall'e S. Automated bug finding in video games: A case study for runtime monitoring. Computers in Entertainment (CIE). 2017;15(1):1–28.

[37] Liu M, Peng X, Jiang Q, Marcus A, Yang J, Zhao W. Searching StackOverflow Questions with Multi-Faceted Categorization. In: Proceedings of the Tenth Asia-Pacific Symposium on Internetware; 2018. p. 1–10.

[38] Liu B, Chen-Chuan-Chang K. Special issue on web content mining. Acm Sigkdd explorations newsletter. 2004;6(2):1–4.

[39] Nasehi SM, Sillito J, Maurer F, Burns C, editors. What makes a good code example?: A study of programming Q&A in StackOverflow. IEEE; 2012.

[40] Mao S, Rosenfeld A, Kanungo T. Document structure analysis algorithms: a literature survey. In: Document Recognition and Retrieval X. vol. 5010. International Society for Optics and Photonics; 2003. p. 197–207.

[41] Polson PG, Lewis C, Rieman J, Wharton C. Cognitive walkthroughs: a method for theory-based evaluation of user interfaces. International Journal of man-machine studies. 1992;36(5):741–773.

[42] Duttenhöfer A. Automated Feedback Based Emergent Named Entity Recognition (ENER) in medical Virtual Research Environments (VREs); 2020.

Chapter 5

Accessible Learning Management System (LMS) for Disabled People: Project Development Based on Accessibility Guidelines, Gamification, and Design Thinking Strategies

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Abstract

We live in a time of expansion and popularization of the processes of acquisition, retention, and sharing of knowledge in virtual media. Platforms geared towards digital learning now play a fundamental role in mediating knowledge processes. Many of them already use gamification with the use of game elements to increase engagement and stimulate the participants' immersion and flow status. But in addition to the development of dynamic platforms that enhance learning, it is essential that they are accessible to disabled people, allowing gamification resources and interactions between participants to be used by any audience, including people with visual and hearing disabilities. From this premise, this research problematizes the need to think from the initial project on the accessibility tools of an LMS following the recommendations prepared by groups such as the World Wide Web Consortium (W3C) and Global Learning Consortium (GLC), including Web Accessibility Initiative - World Wide Web Consortium (WAI-W3C), IMS GLC - Accessibility Guidelines (IMS GLC-ACC) and Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA). In addition to studies for the development of accessible LMS, this research also presents the use of gamification strategies and design thinking in the development process, also using the method called Design Science Research to define the steps, thus seeking to promote engagement and immersion of the team, stimulating practical experiences with the gamification process. For the result, the proposal for the development of accessible LMS based on gamification and design thinking strategies is presented, with explicit use in the phases of empathy, definition, and ideation.

Keywords: Accessibility, Learning Management System (LMS), Gamification, ICT Awareness, Stakeholders Engagement

1. Introduction

Technological advances in the areas of computing, software development, internet, internet of things, cloud computing, and several other areas that encompass the New Information and Communication Technologies (ICT) brought changes in work routines, education, and even in social relationships. The ICT concept refers mainly to processes and products related to knowledge stemming from electronics, microelectronics, and telecommunications. These technologies are characterized by being evolutionary - that is to say, they are in permanent transformation. According to [1, 2], the Information Society or Knowledge Society is a phenomenon in which different instances (social, political, cultural, educational) are mediated by technological means. This new articulation allowed the consolidation of several remote activities such as virtual work, online classes, virtual communities for the development of activities of various kinds, providing new forms of the process of generating, acquiring, retaining, and sharing knowledge, with the emergence of platforms dedicated to formal and informal teaching-learning processes in digital media. Some researchers still believe that the maturity and excellence of remote work and education processes has not yet been reached. The processes of knowledge acquisition and sharing in digital environments still present several barriers. [2] emphasizes that access to technology is not what guarantees access to the digital world, as it is necessary "to be in a position to actively participate in the collective intelligence processes that represent the main interest of cyberspace".

The concepts of digital literacy and media literacy are also relevant, as they are defined in this work as elements linked to the use of ICT that enable the construction and sharing of knowledge. As defined by Livingstone [3], the concept of media literacy is a set of basic and advanced skills relating individual skills to social practices, crossing the border between formal and informal knowledge. For [4], the literacy is conditioned to the process of access to information, its critical understanding, and the production of new knowledge from this process, since they consider that "the critical dimension of literacy is the basis to ensure that participants can not only act in a practice and build a meaning within it, but can transform and actively produce it in various ways". Thus, digital literacy is related to different competencies that allow network users to access information on multiplatform, to critically and strategically evaluate it, and to use it for different purposes, from the acquisition process to sharing said knowledge, thus reaching the objectives sought.

Starting from the ICTs, the concepts of digital and media literacy, and the processes of knowledge sharing in LMS, we enter into the contemporary proposals of the use of gamification for the development and consumption of teaching-learning platforms and contents. From this introduction, the chapter structure presents the methodology used, the gamification relationships with accessible LMS, the use of Design Thinking as a model for building the gamification process, the importance of developing accessible LMS, strategies for the development of accessible platforms from gamification and design thinking, and the conclusions and proposals of future works.

2. Methodology

The research methodology adopted was qualitative, with an exploratory and descriptive study approach. According to [5, 6], through the qualitative method, one seeks in the process of collecting, analyzing, and interpreting data, paradigms that can validate the observations and considerations regarding the research. [5] also points out that during the process, the researcher immerses themselves in

the environment in which the research is being developed to relate their object of research to the study environment, drawing the conclusions in relation to the initial proposal.

The bibliographic review was carried out in books, articles, journals, dissertations, and theses, and with research also supported in scientific databases. The themes cut out for this first filter were the search for works that brought approaches related to objects of learning, gamification, design thinking, and accessibility on the web.

Then, we sought to filter the results of the first research with the scope of developing education platforms, accessibility, and possible gamified approaches. As an exploratory study, we sought to use the collection of information and studies from the bibliographic review, identifying the possibilities of applying gamification and design thinking in the development of accessible LMS, aiming to list steps to develop an accessible LMS with gamified resources for visually and hearing-impaired people, and the proposal to use design thinking and also gamification for organizing the flow of production and development of LMS, exploring gamification with a focus on accessibility tools, stimulating their implementation since the beginning of the project. Combined with the exploratory and descriptive study, Design Science Research - DSR precepts were adopted. The method is based on Design Science and was chosen for bringing an iterative construction proposal according to the prototyping, construction, and product evaluation processes.

The Design Science methodology seeks a scientific or technological gain from a raised problem. Technological research points to the design of an artifact to solve the problem and/or contribute to the area through gains in the field of research. But in addition to building a product, model, artifact, method, instance, it is essential to advance the theory and that the knowledge produced is disseminated in academic bodies and in the area in question, so that it can spread the dissemination of the knowledge produced to researchers, scientists, professionals and/or users in the research area, in order to guide them in solving problems. The choice of DSR is justified because, according to [7] the method "underlies and operationalizes the conduct of research when the objective to be achieved is an object or prescription".

Under the DSR's precepts, the path outlined in the research used the following DSR steps:

- Problem identification;
- Awareness of the problem,
- Literature review;
- Identification of artifacts and configuration of problem classes;
- Proposition of artifacts to solve the problem.

As mentioned, the DSR methodological scope was not applied in full, as the following steps (artifact design and artifact development); evaluation of the artifact; clarification of learning) will be applied in future steps, as we present in this chapter the scope of the research project and artifact proposal.

The initial steps of the research are presented here due to their relevance to the particular discussions regarding the artifact, which according to [8], is the organization of the components of the internal environment to achieve objectives in a given external environment.

Figure 1 shows how the design of an artifact should consider the different layers of the artifact's development process:

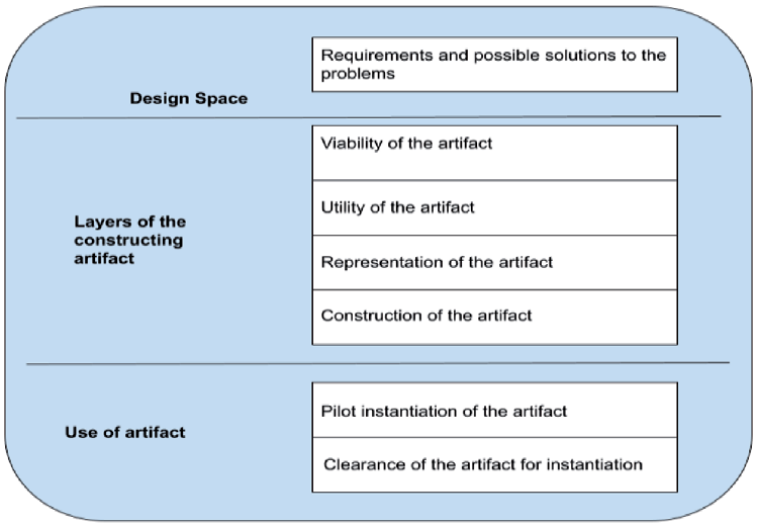

Figure 1.
Layers of the artifact development process: Adapted from [8].

Thus, artifacts are built to seek a solution in a given class of problems. According to [8], before starting the design or development of an artifact, it is necessary to consult what exists about this artifact in the scientific bases as well as its application in real environments. With this, it is possible to ensure greater assertiveness of the researcher when proposing the artifacts that can solve a given problem situation. Once a possible artifact solution is chosen, the researcher must take care of the development of the artifact itself. From the DSR, this research presents the DSR as a basis for the research, development and testing of the artifact, also associating the steps of design thinking with the method.

3. Gamification and accessible LMS

Gamification is presented in this research as a tool to enhance learning in accessible LMS, as well as to stimulate the development of accessibility tools by developers. For [9], the resource can help in the enrichment of educational experiences, as a way in which the student recognizes and responds through a differentiated use experience, very close to the experience he has in the simple act of playing. The term gamification was used for the first time in the early 2000s, but it was not noticed as something that deserved the attention of the industry. As of 2010, its use began to be observed in a series of conferences and events of great public in the world [10]. According to [9], the use of game design elements outside the context of games is called gamification. [11] see in gamification a possibility of creating "learning spaces mediated by challenge, pleasure, and entertainment". [12] defend the use of gamification in education, suggesting that the use of game mechanics in the learning process increases the commitment of users, making activities more attractive and captivating. Based on the authors, it is pointed out that in addition to the proven benefits to the target audience, also proposing that the development of software with game elements can bring benefits to the final product, as the developers are also experiencing the user experience process by following a gamified dynamic.

Gamification appears as a possibility of education in which the barriers of time and space can be broken with the use of appropriate technologies. However,

changes in the behavior of the subjects involved in the teaching and learning process are necessary so that demotivation does not occur and the main focus, which is education, is not lost. [13] present several characteristics and recommendations for the use of gamification in learning objects, among which we can mention the use of challenges, the possibility of teamwork, self-motivation, and the construction of social bonds. [14] bring other essential characteristics: the goal of the game, the well-defined rules, the feedback system, and voluntary participation.

For [15], gamification is formed by four principles - the basis, mechanics, esthetics, and thinking as in a game:

- the foundation of games is the creation of an environment or system in which people want to invest their cognition, time, and energy. Basically, it seeks to favor the engagement of individuals in abstract challenges defined by rules that have interactivity and feedbacks that result in quantifiable responses, culminating emotional reactions;

- mechanics are crucial blocks of rules used in the gamification process. Mechanics alone are not enough to transform a given experience into an engaged one, but they contribute to it;

- esthetics corresponds to the look and feel of experience, essential elements in the gamification process. It encompasses how the experience is esthetically perceived by the individual;

- thinking as in a game is the most important attribute in the gamification process - It corresponds to the idea and thought of converting a boring or monotonous task into a motivating activity, applying elements such as: competition, exploration, cooperation, and narrative. It becomes a virtual facts manager that promotes insights into real-world operations.

The development of platforms, LMS and other content flows related to knowledge has been increasingly developed through gamification. Among the justifications for its use, [16] points out that the challenges present in the games are invitations to the adventure of knowledge and to a dynamic learning experience within the work and education processes.

In relation to the learning mobilized in gamified LMS, for Piaget, errors mobilize learning because they allow reflection to solve problems. The immersion process of students within the LMS is enhanced by the gamification process and the experience can even articulate interactions and collective missions between students, providing the construction of knowledge shared through the Human Computer Interaction – HIC - process. This correlation indicates the associative potential of the gamification process with learning objects in classroom or distance education. The process uses an articulation of knowledge through an initial base, challenges to promote acquisition and sharing, missions that allow and enable learning from mistakes and the achievement of objectives, culminating in performance feedback and the advancement of levels, with benefits and prizes.

4. Design thinking as a model for building the gamification process

According to [17], "the evolution from *design* to *design thinking* is the story of the evolution of the creation of products to the analysis of the relationship between people and products and, finally, between people and people".

Analyzing the use of the Design Thinking approach to education and the gamification process, we can see the possibility of applying some of the concepts proposed by [18] such as empathy, prototyping, and design of experiences. In this perspective, the gamification process based on design thinking must work with the construction of a platform and its contents using steps like discovery, interpretation, ideation, experimentation, and evolution.

As [19] point out, this type of development must be collaborative and integrated, with group-oriented actions, collective participation in decision-making, self-regulating coordination, systemically organized thinking, and by building relationships through empathy.

Design thinking associated with gamification seeks to optimize products by matching human needs with available technical resources and considering the practical constraints of the projects. Thus, in the development of gamified platforms under the precepts of design thinking, the teacher and the team of developers carry out an intense investigation of how the platform and its contents meet the needs of students, as well as how to create added value for students who use it. To [20] the design thinking process is essentially centered on the human being who emphasizes observation, collaboration, rapid learning, visualization of ideas, rapid construction of prototypes, learning from failures, allowing a project to be validated more effectively and with public feedback.

This project model used in gamification in education contributes to the development of platforms closer to the needs of students, since, according to [21], agents are organized based on behaviors derived from mental models, focused on insights, observation and empathy, linked to other concepts of design thinking such as collaboration, creation, experimentation, and prototyping. From the initial ideas, one can use premises and hypotheses developed from the students' experiences, bringing to their content the insights; the "collaboration" process with the multidisciplinary team; the creation of prototypes in a simplistic and objective way, and experimentation of prototypes with students to collect feedback on inconsistencies and errors, redefining the product.

This process should always be guided by the student's needs, raised at the beginning of the project and the premises of knowledge construction through game strategies that, according to [22] mobilizes students to interact with the gamified environment receiving immediate feedback of their actions, being able to interpret their choices according to their goals. When they continuously repeat this cycle (action-feedback-interpretation) it allows players to gradually develop their cognitive abilities. Combined with design thinking, gamification allows developers and users to benefit from these processes, allowing LMS to be thought of since its development with triggers to stimulate immersion and the "Flow State", defined as "an activity carried out without the expectation of any future benefit, but simply because doing it is the reward itself" [22]. **Figure 2** shows the flow path:

The Theory of Flow by Csikszentmihalyi presents how some experiences can take its participant to a Flow state. Mihaly created the autotelic experience model, considered "a self-sufficient activity, carried out without the expectation of any future benefit, but simply because doing it is the reward itself" [22]. With the proposal to develop an accessible LMS with gamification we intend to promote this flow from A1 to A4, promoting students and developers of different profiles to rise from their challenges occurring according to their ability (A1). When starting the path, the Flow state is suggested, but this soon turns into boredom (A2), as the skills have already increased and no longer correspond to the initial challenge. But as soon as a new challenge is proposed, the feeling becomes anxiety (A3), since now the person intends to overcome this new challenge and reach the Flow state (A4) again.

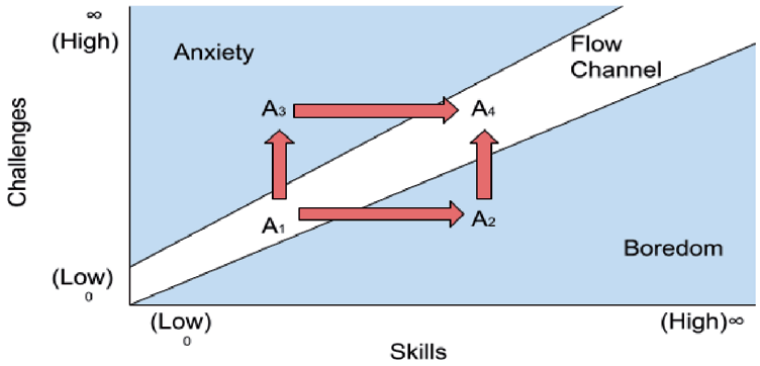

Figure 2.
Diagram showing the path for the flow state (source: Adapted from Csikszentmihalyi for authors, p. 74).

According to [23] the individual reaches their Flow state in two moments: A1 and A4, which are equally pleasant. What differs these times is the level of skill acquired, because upon reaching the full Flow state the individual realizes that his skill corresponds to the level of the challenge proposed, transforming motivation into stimulus.

In the article "Flow in games (and everything else)", [24] it is pointed out that Csikszentmihalyi's research and personal observations identified eight major components of Flow that can be associated with the gamification process: challenging activity requiring skill; a merging of action and awareness; clear goals; direct, immediate feedback; concentration on the task at hand; a sense of control; loss of self-consciousness; an altered sense of time. In addition to platforms that allow dynamic knowledge, that encourage and mobilize students to learn, exchange experiences, and share knowledge, it is also important to think about the experience of the different users who can use the platforms. In this context, in addition to the development of the platform and its contents and dynamics, the accessibility of disabled people must also be taken into account, following the accessibility guidelines from the beginning of the project to allow any user to have access to the available content.

5. The disabled person and accessibility feature in LMS

People with any type of disability have always lived on the margins of society for centuries. According to [23], the history of prejudice has always been present and many people have been placed on the margins of society because they have some type of disability. The search for inclusion begins to occur mainly in the post-1960s period, as a result of the struggle of organizations working to defend the rights of disabled people. Through innumerable guidelines, regulations and norms carried out, actions emerge that mobilize the path of social inclusion. In the search for rights, a very important motto for disabled people arises: "Nothing About Us Without Us". According to [25], the motto communicates the idea that no policy or decision regarding the rights of disabled people without the full and direct participation of the members of the group affected by this policy. The author also points out that in the words of the disabled person, there would be the understanding that "no matter how good the intentions of non-disabled people, public agencies, companies, social institutions or society in general, we no longer accept to receive results forged against us, even for our benefit."

Ref. [25] also points out that inclusion is necessary, as it cannot be seen as a utopia, but a possibility before the eyes against prejudices and masked forms of exclusion. It is not possible to think about inclusion without fighting the processes of exclusion inherent in life in society.

In this research, we propose the development of accessible environments based on the recommendations made by groups such as the World Wide Web Consortium (W3C) and Global Learning Consortium (GLC), including Web Accessibility Initiative - World Wide Web Consortium (WAI-W3C), IMS GLC - Accessibility Guidelines (IMS GLC-ACC) and Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA) and [26] proposal, in which he proposed based on the web accessibility guidelines, on universal design and their possibilities to promote inclusion in Learning Objects accessible to people with visual impairments and people with hearing impairments. According to the researcher, to promote accessibility in digital content, varied media such as texts, audio, videos, animated images, static images, etc. should be used. The guidelines created provide recommendations for making media elements accessible by making alternative media available.

According to [26] alternative media are alternative content which function as an extension of equivalent content and are provided in different ways, but with the same ultimate learning objective. Alternative texts can be considered alternative texts; textual transcription of the video; extended audio description; audio description synchronized with the video; subtitles or captions for sounds; sign language interpretation for sounds. Equivalent media, on the other hand, are content identical to each other, but provided in a different mode, for example, a text available in the LMS and the same text associated with a file for printing in Braille.

But in addition to the recommendations of the W3C and GLC groups - categorization of menus and submenus and high-contrast, for example, the researcher also proposed as alternative media to ensure accessibility the use of resources that must be available to be activated in digital environments such as printing Braille text, audio description, sign language, subtitles for the deaf and people with hearing loss.

The general organization of the media and the alternatives required to ensure accessibility of the content must be thought of from the initial design of an LMS, promoting the native development of the environment to ensure accessibility. Using the proposed by [26], this research makes an initial cut for the development of accessibility in LMS for people with visual impairment and people with hearing impairment, presenting some peculiarities in the next items.

5.1 The person with sight loss

For educators, the concern with blindness focuses on the necessary and appropriate conditions for satisfactory development and learning. The moment in which blindness occurs is also important. For [27] "the person who is born blind, who establishes his object relations, structures his ego, and organizes all of his cognitive structure from hearing, touch, kinesthesia, smell, and taste, differs from someone who loses their vision after their development has already occurred". This distinction is made because the perceptions constructed by those who have had visual acuity are imagery.

The references of those who were born blind - or became blind until the age of 5 - are built and centered in other senses, having a different perception of the world in relation to those who have low vision or acquired blindness. Thus, this relationship with the imagery world is compromised but this does not mean the loss of their ability to understand. Researchers start to emphasize the disabled person as a social being in which, their marginalization in relation to the world deprives them of a development of the senses. [28] brought this reflection in relation to the

construction of identity, pointing out that blindness is not a defect, a lack, a weakness, but in some sense, it is also the origin of a new manifestation of skills, an additional, a strength - however strange and paradoxical that this idea may seem. The researcher starts to interpret the lack of a sense - the vision - as a means of linking a process of improvement of the other cognitions, in which they start to develop and refine the touch, smell, and hearing to compensate for the loss of vision. In relation to learning, [29] point out that the individuality of each person, in a more latent way for the visually impaired due to their lack or reduced vision, makes the learning processing mode also present specific characteristics, combining remaining sensory information for the mental construction of space. The researchers reinforce the value of language and the social experience it provides among people with sight loss and people with vision. Through language, the visually impaired individual is able to approach the culture and context of the person with vision.

Thus, it is essential that the materials available on the internet and in VLE have alternative media resources (such as text resources with larger sources or audio description, for example) to provide access and mediation to language and knowledge. As previously mentioned, the process of knowing and relating to the world goes through the process of language acquisition and mastery that can be of an oral, written, visual, and gestural nature, mediated by different cognitive senses.

5.2 The person with hearing loss

Hearing loss is expressed by the reduction or absence of the ability to perceive sounds. According to [30] it can be understood as a type of sensory deprivation whose common symptom is an abnormal reaction to the sound stimulus, expressing the hearing loss through deafness or low hearing. For [31], deafness is called the decrease in the capacity of normal perception of sounds, and is considered as being deaf the person whose hearing is not functional in ordinary life. Many people develop hearing problems throughout their lives, due to accidents or illness.

By having their capacity for sound perception reduced, the person with hearing loss has difficulty understanding the language used through orality - which has its expressive mark in the sound expression, in synchrony with the gestural. [32], define that it is through language that human beings establish communication with others around them, thus allowing the production of new knowledge. When sensory factors (such as hearing loss, for example) prevent oral language from being established, new forms of linguistic manifestation begin to emerge, such as visual and sign language, which allows the deaf person to have a new possibility of contact with the world, because the insertion of a deaf person in the digital environment faces the same challenges already experienced throughout their history. If, on the one hand, the standards established by WCAG 2.0 favor the accessibility of disabled people in the web environment, on the other hand, the question of language remains the obstacle that separates the deaf from their first language.

It can be seen that although there are different definitions and categorizations for hearing loss, it should be understood here that promoting accessibility on the web and VLE for people with any type of hearing loss, regardless of the language it expresses, is a step to reduce exclusion.

Another important point is the relationship of language built in these environments and their adaptations to promote accessibility. [33] point out that research related to didactic content for people with hearing loss in virtual environments points out the need to adapt short texts, reduce difficult vocabulary, use images to introduce a concept, use -when necessary- video with a Brazilian Sign Language interpreter, videos with sizes suitable for visualization of sign language and lip reading, adequate presentation speed, clear navigation.

When thinking about the precepts of web accessibility, we bring the concept of universal design, which, according to [34], is defined as a product, a physical environment or information, which must be accessed, understood, and used without the need for adaptation, modification or use of specialized solutions by anyone, regardless of their skills or disabilities. For an accessible LMS, the validation of the Universal Design concept only occurs when people with any type of disability or restrictions can have access to a product, physical environment or information.

Regarding the web, some sites are already looking to make adaptations for accessibility, but there is still much to be done. The WCAG guide and the W3C web "Accessibility Booklet" present the main idea contained in the Universal Design that the projected world should adapt as best as possible to all people, instead of requiring a great effort to adapt. However, most websites and LMS available on the Internet do not yet have accessible resources such as audio description, subtitles and sign language translation. Thus, the use of Universal Design means a big step towards an increasingly more inclusive world, which adapts to the different skills and needs of people, with less individual adaptive effort.

6. Strategies for developing accessible platforms from gamification and design thinking

For the development of accessible education and learning platforms, let us start with the theoretical framework related to the development of computer systems. According to [35], quality in Software Engineering must be directed taking into account three aspects: product quality, quality of the development process and quality of the development team. [35, 36] consider that the processes used to develop the software are directly linked to the quality of the product. Regarding development standards and quality, [37] considers that it is not uncommon for software development companies to deliver their products with features that were not requested by users, with delays in the schedule and low quality of the final product. Some processes are indicated by the authors, which show that many organizations that have adopted agile methodologies for software development has several benefits as result: more satisfied customers, better rates of return on investment, reduced development costs, faster results, among others.

Associated with agile methodologies, gamification and design thinking can be used to produce environments with accessibility.

For [38], one of the main objectives of agile software development is to develop the software more quickly and with quality through a series of iterations (short periods of time) that are feasible in terms of cost and time. Each iteration produces a version of the software bringing business value to the customer in a way that ensures that the defined requirements have been implemented.

Unlike traditional software development methods, agile methods are marked for being more collaborative and for encouraging team interaction through constant communication [39]. For [40], "We are discovering better ways to develop software by doing it ourselves and helping others to do it. Through this work, we started to value individuals and interaction between them more than processes and tools; Software in operation more than comprehensive documentation; Collaboration with the client more than contract negotiation; Responding to change rather than following a plan." The 'Agile Manifesto' does not reject processes and tools, documentation, contract negotiation, or planning, but it simply shows that they are of secondary importance when compared to individuals and interactions, with the software being executable, with customer collaboration and quick responses to changes and changes.

Based on what was proposed by [41], the use of design thinking for the process of developing accessible platforms is possible through the organization of multidisciplinary teams, with research teams from the design areas; programming; communication and accessibility specialist consultants. Starting from Theory of Flow, it was listed which premises could be followed in the stages of Empath, Definition, and Ideation, correlating to these processes the concepts of gamification and the accessibility guidelines in education platforms, as shown in **Figure 3**.

The figure presented in the research "Gamification in Education Through Design Thinking" presents the confluence and the different definitions of the theory of flow, design thinking, gamification, and accessibility in the phases of empathy/discovery; definition, and ideation of design thinking.

Empath: in this phase, the process is user-centered, for the user to immerse, engage, and observe. The development teams use bibliographic research, the mapping of gamified LMS focused on mathematical concepts and accessible gamified LMS.

Definition: from the empathy studies presented above, a first definition about the project is sought, synthesizing the concepts raised and presenting the focus of the problem. Again, this step begins looking for definitions that can converge to solutions of the points presented in Theory of Flow.

Ideation: from the focus of the defined problem (making LMS platforms and their gamified tools accessible), solution possibilities are presented and ideation is carried out, taking into account how the design of the artifact.

In relation to the method, Design Thinking is associated with the Design Science Research method (see **Figure 1**), with confluent steps in which empathy, definition are associated with "Space of Design" of the DSR, listing requirements and possible solutions to problems and ideation, is associated with the layers of the artifact under construction, presenting the viability, utility and representation of the artifact. The prototype and testing steps are also related to the DSR with the construction of the artifact; and use of the artifact with pilot instantiation and clearance of the artifact.

This research does not include the Prototype and Tests phases, as they are subsequent steps for the construction of the prototype based on the concepts presented.

In software development, it is also possible to use gamification to promote the encouragement of fulfilling the stages in the processes of agile methodologies. It can be organized through groups of hierarchical and partially ordered challenges that must be overcome, with a developer or a team of developers who need to have various skills, different knowledge and organization of workflows. This concept is directly related to the steps of design thinking presented above; the game mechanics present in gamification and the different stages and sprints present in agile methodologies.

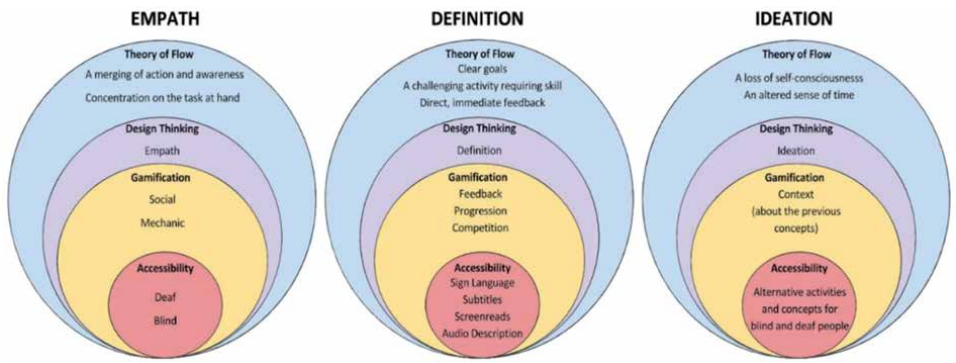

Figure 3.
Correlation between the theories presented and the empath, definition, and ideation steps. Source: from the authors.

This set of characteristics can be organized so that they can learn new skills and knowledge, combine them to overcome challenges during development and be rewarded with effective completion after each stage of the journey, whether they get rewards or not, depending on success or failure, respectively.

Flow State: The Flow State sought in this work is in the first instance to promote the engagement of developers with gamification strategies during development, and, from the development of web platforms with accessibility, to promote the Flow state in students as well.

The design thinking methodology applied to the project follows the definition of Bootcamp Bootleg by [42]. The approach proposed by [42] is divided into five phases: empathy (user-centered process, to immerse, engage and observe the problem); definition (makes a synthesis, presents a focus of the problem or point of view); ideation (generation of ideas, exploration of solutions); prototyping (producing ideas in a more real context, bringing material character); tests (to redefine solutions and put the prototype in contact with people).

Accessibility: As proposed by [43], the process of inserting gamified activities into a learning object must follow the precepts of game design and gamification. The authors [43, 44] use a taxonomy of user satisfaction metrics and intend to extend their studies to the area of Distance Education and to studies on 'Gamification'. [45], starting from [46], presents some characteristics and recommendations for the use of gamification in digital environments. Through this categorization it is possible to use the above precepts for the production of gamified and accessible OA. Thus, the concepts of gamification can also be inserted into the conceptual basis of an LMS.

Based on the categorization made by [44], associated with that proposed by [45, 46], we can list similarities between the two approaches. **Table 1** shows how the concepts can be related by these categories.

Based on the above, engagement is sought based on the application of the precepts of implementing accessibility for people with vision and hearing disabilities in the programming phases, based on accessibility guidelines, to ensure inclusive access for anyone in online environments through friendly and intuitive interfaces.

This step is already a first challenge, as there are still no recommendations or accessibility guidelines for LMS.

	Concepts of [44]	**Concepts of [45, 46]**
Feedback	Time that the user takes to dominate the game or perform a certain task	Pleasant productivity, the players see applied efforts and energies achieving the desired results
Social	Socialization- interaction between the system and users; and duty - the system's and the generated social relations' capacity of creating and accepting the user's emotional investment	Generation of the possibility of working cooperatively, in teams and groups in order to solve problems / Construction of stronger social relationships through emotional bonds
Competition	Self-competition and effort to overcome the results	Pursuit of self-motivation to remain in the activity (intrinsic motivation)
Progression	The system's capacity of providing persistence to the user	Activities created with challenges that can be overcome
Mechanics	Pleasure that the user finds in the game	Epic meaning of achieving something expected
Context	Context of the system's actions	_____

Table 1.
Relation between the concepts of [44–46].

Developers should follow the recommendations made by groups such as the World Wide Web Consortium (W3C) and Global Learning Consortium (GLC), including Web Accessibility Initiative - World Wide Web Consortium (WAI-W3C)[1], IMS GLC - Accessibility Guidelines (IMS GLC- ACC)[2] and Web Accessibility Initiative - Accessible Rich Internet Applications (WAI-ARIA)[3]), which are institutions that created parameters of accessibility in websites and virtual environments, of which they are the bases for the development for this research, because currently they are the ones that determine the guidelines of web accessibility, being the basis of the proposal for the recommendations presented for the proposal for the development of accessible LMS.

In relation to the visually impaired person, in order to browse the websites/ web systems, these people make use of assistive technologies, categorized as screen reader software, whose function is to interpret the page code and reproduce by audio through a speech synthesizer. However, the interaction of screen readers on websites will only work properly if certain coding standards are applied in the development, established in the International Web Accessibility Guidelines, which were developed by the Web Accessibility Initiative (WAI), an organ created by the W3C (World Wide Web Consortium). Among these initiatives, the WCAG (Web Content Accessibility Guidelines) and the WAI-ARIA (Web Accessibility Initiative - Accessible Rich Internet Applications) guidelines will be highlighted, a standard created to make dynamic content and applications more accessible, which together with HTML, guarantee a navigation with accessibility for screen reader users.

When a website is not developed thinking about the access of people with vision disabilities, users of assistive technologies of screen readers not following the international standards mentioned may present several accessibility barriers that will hinder or even prevent access to the functionalities for a great number of people. Hearing impaired people, on the other hand, need resources such as the interpretation of texts in sign language and the use of subtitles for the deaf and people with hearing loss.

With the use of recommendations, WCAG (Web Content Accessibility Guidelines), and WAI-ARIA, and, with the production of audio description resources, self-contrast, subtitles for the deaf and people with hearing loss and sign language, it is sought that developers are encouraged to develop these steps with gamified strategies.

6.1 Gamification

From what was proposed, it is then presented what are the strategies for the development of an LMS based on gamification strategies. In the case of this study, the use of challenges is suggested, with the availability of a ranking of scores, as well as the use of badges as trophies, for example.

For the application of the elements of gamification in the design steps aligned with design thinking and accessibility, the steps follow the criteria of scoring and badges present in the gamification mechanics. The main strategy of gamification of the developed learning object occurs through the appropriation of the reward system of conventional games where the player earns points for each development task performed in the correct period and with proposals for solving the problems that arose during the execution.

[1] Web Content Accessibility Guidelines. Available at https://www.w3.org/TR/wcag-3.0/

[2] IMS Guidelines for Developing Accessible Learning Applications. Available at https://www.imsglobal.org/accessibility/accessiblevers/index.html

[3] Accessible Rich Internet Applications (WAI-ARIA. Available at https://www.w3.org/TR/wai-aria

Activity	Points earned
Complete a step or sprint	100 points
Solve a problem	100 points + trophy
Post a reply on the forum	50 points

Table 2.
Scoring system for gamified development

Scoring rewards are awarded after the completion of each sprint or troubleshooting presented. Also, a forum is proposed between the development teams so that doubts can be exposed to the teams and solutions proposals are sent.

6.2 Gamified development steps

It is therefore suggested that gamification from the rewards system be used for planning the development of the platform in all its phases, from presentation and training in the language chosen for the development to the identification of the system requirements, the test scenarios, prototyping, system modeling, implementation, testing and deployment, delimited by the phases of design thinking and Design Science Research.

The scoring system follows that specified in **Table 2**.

For [47] this type of strategy is known in the world of conventional games as badges and consists of an element that integrates reward at the same time. For the author, using badges is equivalent to a process of defining, seeking, and achieving goals and objectives, which increases performance in three ways: increasing the level of expectations regarding the result of the process, which leads the participant to increase his performance; defining clear goals which facilitates self-assessment during the process; and increasing satisfaction from meeting the target. Corroborating with this, in an experiment carried out with students through a virtual learning environment, [48] found an improvement in the results of practical activities through the adoption of gamification strategies with the use of badges.

With the adoption of this system of rewards, what is intended is to use gamification, as raised in the literature, to increase motivation and engagement in activities. In addition to these positive reinforcements materialized through points and trophies, the strategies developed also aim to mitigate negative reinforcements and frustration. In the case of scoring, it works as a personal motivation for development teams to seek to beat their records.

Likewise, winning trophies when correctly completing a step or solving problems generates a reward.

6.3 Score ranking

The score ranking serves to encourage developers to achieve leadership, as well as direct their efforts from their greatest qualities. The ranking itself is not just a query tool, but an agent that mobilizes engaged developers to seek to be in good positions on the table. In each of the steps, the following types of punctuation are defined:

- User score for each week
- Final user score for each sprint
- Scoring teams for each week

- Final team score for each sprint
- Punctuation for forum responses

6.4 Trophies

Trophies will be awarded for specific tasks and achievements, which are strategic for the progress of the project. In this project, they are similar to the reward systems of conventional games and are triggers for interaction, collective work and team engagement, and participation in problem solving. The trophies will be made available for:

- The team with the highest score in each step
- The developer who solves problems during the process

6.5 Accessible platform development steps

6.5.1 Step I—empathy

Presentation of the importance of accessibility in LMS - This process is user-centered to immerse, engage, and observe the problem. Regarding the gamification requirements, we have an emphasis on the social and mechanic requirements of the games, presenting the work of the multidisciplinary team being carried out through the concepts of Design Thinking, seeking a direct relationship with the issue of empathy for a product to be closely related to a social issue, in which users can, through the system, promote relationships of socialization and interaction, triggering the phases of competition and progression also in the product development process. Here, the work in cooperation is also directed, in teams and groups, to solve problems, mobilizing the construction of social bonds and stronger relationships through affective bonds. The mechanics, on the other hand, are directed towards the construction of the gamified LMS based on the generated relational situations.

The association with accessibility in this phase, however, occurs with studies directed to dynamics used in gamified LMS that, from the phases of a merging of action and awareness and concentration on the task at hand; Social and Mechanical, and Accessibility Strategies and Universal Design;

6.5.2 Step II—definition

Presentation of the concepts of accessibility, the accessibility guidelines, and case studies - This step makes a synthesis and presents a focus of the problem or point of view. For gamification requirements in this step, we have an emphasis on feedback from the empathy step, with a focus on different skills and a framework of prior knowledge. Thus, feedback related to the time when the user performs a certain task is essential, as well as the feedback regarding mistakes and successes. In the validation phase, this process must be mapped so that it continues and manages to feel the satisfaction of meeting the challenges. With this, the process of progression occurs;

Progression: In order for it to remain stimulated to develop accessibility in the LMS, its goals and actions must be clarified and what are the key points for it to be able to fulfill them. It is suggested to work in the team, with personalized progression according to the profile of the developer or the team, in which the goals are set according to the profile presented. Another possibility is for the developer or team to define their tracks and challenges, directing actions and goals according to their abilities and skills.

Competition: It was decided to seek in the definition step the possibility of, in addition to self-competition, also bringing collective challenges. This feature should be explored, but in a very reflective way in learning environments. Promoting competition in gamification is one of the engines that generates the process of immersion and resumption. As previously mentioned, the scores and trophies in the steps can increase engagement.

Accessibility: Emphasized points: sign language, subtitles, environment architecture for screen readers, and audio description. For accessibility, it is the moment, from the studies and the project proposal stimuli that came with gamification, to elaborate the framework of possibilities for the proposal of an LMS following the IMS-GLC and W3C-WCAG and WAI-ARIA guidelines with accessibility features such as sign language, subtitles, environment architecture for screen readers, and audio description.

6.5.3 Step III—ideation

In the ideation, all the information and data obtained during the immersion are gathered and it is time to sit down with everyone involved and devise the possible solutions. It is essential to take into account the point of view of each of the participants at this time, also realizing the various possibilities for the development of the accessible LMS. In this step, the ideas most voted by the team can be scored, with the score and trophies for developers and teams. It is worth remembering that the concepts presented must be articulated so that people with vision or hearing disabilities can explore them. Thus, it defines the importance of using what [4] defines as alternative media that, with studies for the execution of sign language resources and subtitles for people with hearing impairment, and organization of the Virtual Environment architecture according to with the guidelines of IMS-GLC and W3C-WCAG and WAI-ARIA, to be accessed by screen readers, in addition to the audio description feature of videos and images. It is the phase of generating ideas, exploring solutions to define teams and development steps.

As the proposal places LMS accessibility as the main element, in each step the scores must be articulated in relation to the development of accessibility requirements such as:

Organization of navigation elements on the website with the correct semantic structure of HTML provided by WCAG:

- Use of headers hierarchically
- Objective description in links
- Forms developed with labels, differentiated color, HTML fieldset and legend tags, description of the buttons,
- Accessible images
- Keyboard access
- Page titles
- Modal window
- Insertion of sign language window in the platform texts, videos, audios, podcasts and audiovisual resources.

- Inserting subtitles for deaf people and people with hearing loss in videos, podcasts and music
- Description of images, Audio description of videos;
- High contrast of images and platform.

It is also important to note that when developing a project that contemplates accessibility, it is worth noting the available options such as CMS, frameworks, and libraries. Many of the aforementioned options already have resources in their code to assist in development in compliance with international accessibility standards, providing guidance and information in the respective documentation. We can mention some as "Bootstrap", "React", "Angular", "Wordpress", "Moodle", among others. Based on what was discussed above, it is suggested that the entire production flow of an LMS and its tools have a gamified strategy for product development teams.

As previously presented, the next steps (Prototype and Tests) will not be presented, as they will be the scope for the development of accessible and gamified LMS, and will be described in future works.

7. Conclusion

The research develops the proposal for software development actions so that gamified LMS can be designed and programmed through design thinking, having gamified resources in the development process, encouraging the use of WCAG (Web Content Accessibility Guidelines) accessibility guidelines and WAI-ARIA (Web Accessibility Initiative - Accessible Rich Internet Applications).

From the bibliographic survey and the steps described in Design Science Research and Design Thinking, and the search for accessible and gamified platforms, requirements were raised for a first gamified development experience of an accessible LMS. With the initial questions of this research, a proposal for prior planning is presented so that these platforms and their media - videos, texts, audios, and games contain accessibility resources and allow the disabled public to experience the same processes as those who do not have deficiency. As a way to streamline the workflow and incorporate game elements from the initial design, gamification and design thinking are used as part of the work methodology of the development teams.

The goal is to promote an immersive and gamified experience from the beginning of an LMS project, placing the development team itself in the midst of UXm stimulated by the theory of Flow for the production of the platform and its accessibility features. Gamified development inserts game elements into the various software engineering practices used by the team, and mainly the focus on project management to assist in the gamification of any software process. It is noteworthy that currently many development teams have used the agile methodologies and practices of software engineering expecting that, when applied during the development, the mechanics of the games allow a broad and analytical vision in the process of aligning the steps and sprints with challenges and exchanges between teams being crucial moments for the prototyping and testing phases - which must also be carried out with the disabled public. Thus, the proposal allows to follow the processes of [Lockwood], with the processes of observation, collaboration, rapid learning, visualization of ideas, rapid construction of prototypes, learning from failures, outlined by gamification strategies, allowing a validation of the project more effective.

Regarding the gamification of the steps of software development, it is expected that the teams will encourage increased dedication in carrying out tasks; the search to face the challenges of each step and to solve the problems autonomously; assisting other employees by stimulating punctuation and team satisfaction in seeking the best results from the gamification processes.

With the steps of empathy, definition, and ideation, and the proposal of gamification in the development of accessible LMS, we seek to initiate a path to stimulate new possibilities for software development, as well as the proposal to design LMS with accessibility since its initial draft. In addition to the use of gamification in the development process, this work seeks to bring reflection to researchers, educators, developers, and instructional designers about the need to advance in research that develop alternatives to foster the inclusion process and the active participation of disabled people in society.

8. Future steps

For future steps, it is suggested the development of an LMS with accessibility from the model proposals presented in this research;

To present the requirements of an accessible and gamified LMS for the end user, with tests carried out with disabled people;

It is important to emphasize that it is essential to present the execution and validation of a prototype, showing how the concepts of UX and accessibility applied since the development will benefit the accessibility and the gamification resources in the accessible LMS.

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References

[1] Castells, M. A Era da informação: economia, sociedade e cultura. São Paulo, Paz e Terra, 1999. 3 v.

[2] Lévy, P. Cibercultura. 2. ed. São Paulo: Editora 34, 2000.

[3] Livingstone, S. Internet Literacy: a negociação dos jovens com as novas oportunidades on-line. In: Revista Matrizes, São Paulo, ano 4, n. 2, jan./jun. 2011.

[4] Lankshear, C.; Knobel, M. Critical Literacy and New Technologies. Symposium paper, American Educational Research Association Annual Conference, 13-17 April, 1998, San Diego. Available at http://www.geocities.com/c.lankshear/critlitnewtechs.html

[5] Creswell, J. W. Projeto de pesquisa: Métodos qualitativo, quantitativo e misto. 3. ed. Porto Alegre: Artmed, 2010. p. 206-237.

[6] Trivinos, A. N. S. Introdução à pesquisa em ciências sociais: a pesquisa qualitativa em educação. São Paulo, Atlas, 1987. 175p.

[7] Dresch, A; Lacerda, D. A.; Antunes Junior, J. A.; Design Science Research: Método de Pesquisa para o Avanço da CIência e da Tecnologia. Bookman, 2014.

[8] Dresch, A. Design Science e Design Science Research como Artefatos Metodológicos para Engenharia de Produção. Dissertação Universidade do Vale do Rio dos Sinos, Programa de Pós-graduação em Engenharia de Produção e Sistemas, São Leopoldo, RS, 2013.

[9] Deterding, S., Dixon, D., Khaled, R., Nacke, L.: From game design elements to gamefulness: Defining "Gamification". In: Proceedings Of The 15th International Academic Mindtrek Conference On Envisioning Future Media Environments, p.9-15. ACM, New York (2011)

[10] Groh, F. Gamification: State of the art definition and utilization. 2012. Available at:< http://hubscher.org/roland/courses/hf765/readings/Groh_2012.pdf >.

[11] Alvez L. R. G.; Minho, M. R. da S.; Diniz, M. V. C. Gamificação: diálogos com a educação. In: FADEL, Luciane Maria et al (Org). Gamificação na educação. São Paulo: Pimenta Cultural, 2014. Cap. 3. p. 74-97. Available at: http://www.pimentacultural.com/#!gamificacao-na-educacao/c241i.

[12] Simões, J., Redondo, R.. D., Vilas, A. F.: A social gamification framework for a K-6 learning platform. In: Computers In Human Behavior, p.345-353. Elsevier B.V. (2013)

[13] Alves, M. M.; Teixeira, O. Gamificação e objetos de aprendizagem: contribuições da gamificação para o design de objetos de aprendizagem. In: FADEL, L. M. et al. (Org.) Gamificação na Educação: p. 74-97. São Paulo: Pimenta Cultural, 2014.

[14] Y. Vianna, M. Vianna, B. Medina e S. TanakaVIANNA, Mauricio et al. Design Thinking: inovação em negócios. MJV press, 2012. Available at: http://livrodesignthinking.com.br/

[15] Kapp, Karl M. The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. 1 ed. New Jersey:Pfeiffer & Company, 2012.

[16] Fialho, A. F. P.: From individual to social cognition: Piaget, Jung and commons, In: CSDC'15 World e-Conference Complex Systems Digital Campus '15. Arizona (2015).

[17] Brown, T.: Design thinking: uma metodologia ponderosa para decretar o fim das velhas ideias. Elsevier, Rio de Janeiro (2010)

[18] Amaral, S. F., Garbin, M. C.: Design Thinking: A Colaboração como Mola Propulsora da Inovação na Educação. Inova Educ. 2, (2013)

[19] Lockwood, T.: Design thinking: Integrating innovation, customer experience, and brand value. Allworth Press, New York (2009)

[20] Brown, T. Design Thinking. Harvard Business Review, 2008.

[21] Prensky, M. (2001) Fun, Play and Games: What Makes Games Engaging, Chap. 5 in Digital Game-Based Learning, McGraw-Hill. Prensky, M. (2005) Computer games and learning:Digital game-bades learning, Handbook of Computer Game Studies, MIT press.

[22] Csikszentmihalyi, M.: Flow: The Psycology of Optimal Experience. Harper & Row, New York (1990)

[23] Silva, Otto Marques da. A epopéia ignorada: a pessoa deficiente na história do mundo de ontem e de hoje. São Paulo: CEDAS, 1987.

[24] Chen, J.: Flow in games (and everything else). In: Communications of the ACM, pp. 31-34. (2007)

[25] Sassaki, Romeu Kazumi. Inclusão, construindo uma sociedade para todos. Rio de Janeiro: WVA, 1997.

[26] Macedo, C. M. S. Diretrizes para criação de objetos de aprendizagem acessíveis. 272 p. Tese (Doutorado) - Universidade Federal de Santa Catarina. Florianópolis, 2010.

[27] Amiralian, M. L. T. M. . Compreendendo O Cego: Uma Visão Psicanalítica da Cegueira Por Meio de Desenhos-Estórias. 1. ed. SÃO PAULO: CASA DO PSICÓLOGO, 1997. 321 p.

[28] Vygotsky, L.S. Pensamento e Linguagem. São Paulo: Martins Fontes, 1993.

[29] QUEVEDO, S.R.P.; ULBRICHT, V.R. Como os cegos aprendem. In: ULBRICHT, V.; VANZIN, T.; VILLAROUCO, V. (orgs). Ambiente Virtual de Aprendizagem Inclusivo. Florianópolis: Pandion, 2011. p. 155-188.

[30] Gagliardi, C. e Barella, F.F. Uso da informática na educação do deficiente auditivo: um modelo metodológico. In: SOCIEDADE BRASILEIRA DE PSICOLOGIA (ORG.), XVI.,1986, Ribeirão Preto. Reunião Anual De Psicologia. Ribeirão Preto: SPRP, p. 120-123, 1986.

[31] Ballantyne, J; Martin; M. C., Martin, A. Surdez. Tradução: Sandra Costa. 5. ed. Porto Alegre: Artes Médicas Sul, 1995.

[32] Flor, C. S. ; Vanzin, T. ; Ulbricht, V. R. . Recomendações da WCAG 2.0 (2008) e a acessibilidade de surdos em conteúdos da web. Revista Brasileira de Educação Especial , v. 19, p. 161-168, 2013

[33] Lapolli, M. ; Bleicher, S. ; Vanzin, T. . Aprendendo com infografia na web: uma proposta voltada aos surdos. Conceitos e Práticas em Ambiente Virtual de Aprendizagem Inclusivo / Vania Ribas Ulbricht, Tarcísio Vanzin, Sílvia R. P. de Quevedo, organizadores. - São Paulo: Pimenta Cultural, 2014. 327p.

[34] Burgstahler, D. & Dichev, I. (1997). Earnings management to avoid earnings decreases and losses. Journal of Accounting and Economics, 24(1), p. 99-126.

[35] Pressman, R. S. Engenharia de Software - Uma Abordagem Profissional. l8a Ed. Amgh Editora, 2016.

[36] Sommerville, Ian. Engenharia de Software. 9o Edição. PEARSON EDUCATION - BR, 2011.

[37] Rubin, K. S. Essential Scrum: a practical guide to the most popular Agile Process. Pearson Education, 2013.

[38] Adikari, S., Mcdonald, C., & Campbell, J. (2013). Reframed Contexts: Design Thinking for Agile User Experience Design. In A. Marcus (Ed.), DUXU'13 Proceedings of the Second international conference on Design, User Experience, and Usability: design philosophy, methods, and tools (Vol. 8012, pp. 3-12). Springer. https://doi.org/10.1007/978-3-642-39229-0_1

[39] Beck, K., Beedle, M., Bennekum, A. V., Cockburn, A., Cunningham, W., Fowler, M. Thomas, D. (2001). Manifesto for Agile Software Development.

[40] Inayat, I., Salim, S. S., Marczak, S., Daneva, M., & Shamshirband, S. (2015). A systematic literature review on agile requirements engineering practices and challenges. Computers in Human Behavior, 51(0). doi:http://dx.doi.org/10.1016/j.chb.2014.10.046

[41] Schimmelpfeng L.E, Sombrio. G.; Ulbricht V. R;.Villarouco V.: Gamification in Education Through Design Thinking. 311-321. In: Design, User Experience, and Usability: Novel User Experiences - 5th International Conference, DUXU 2016, Held as Part of HCI International 2016, Toronto, Canada, July 17-22, 2016, Proceedings, Part II. Lecture Notes in Computer Science 9747, Springer 2016, ISBN 978-3-319-40354-0.

[42] D.School. Bootcamp Bootleg. 2008. http dschool.stanford.edu/wpcontent/uploads/2011/03/METHODCARDS2010v6.pdf

[43] Netto, M.: Aprendizagem na EaD, Mundo Digital e 'Gamification'. In: Fadel, L., Ulbricht, V. R., Batista, C. R., Vanzin, T. (eds). Gamificação na educação. pp. 98-121. Pimenta Cultural, São Paulo (2014)

[44] Petrovic, V. ; Ivetic, D.: Gamifying education: a proposed taxonomy of satisfaction metrics. In: Conference proceedings of "eLearning and Software for Education", p.345-350. Universitatea National de Aparare Carol I, Frankfurt (2012)

[45] Alves, M. N. Mídia e Produção Audiovisual: uma introdução. Curitiba: Ibpex, 2008.

[46] Mcgonigal, J.: Reality is broken. Why game make us better and how they can change the world. The Penguin Press, London (2011)

[47] Hamari, J., Koivisto, J. and Sarsa, H. (2014) 'Does gamification work?--a literature review of empirical studies on gamification', System Sciences (HICSS), 2014 47th Hawaii International Conference on, pp. 3025-3034. doi: 10.1109/HICSS.2014.377.

[48] Domínguez, A; Navarrete, J. S; Marcos, L; Sanz, .F; Pagés, C; Herráiz, J.J.M. Gamifying learning experiences: Practical implications and outcomes. **Journal Computers & Education**, Virginia, v. 63, p. 380-392, 2013.

Chapter 6

Social Factors Influence on Accounting Students Attitude to Use Games Based Learning

Rui Silva, Ricardo Rodrigues and Carmem Leal

Abstract

The general objective of this article is to analyze the impacts of a gamified resource created (Accountingame) as learning tools to teach the curricular unit of Accounting. Theory of Planned Behaviour was used to investigate social factors such as Social Influence, Recognition and Reciprocal Benefits, which are predictors of Attitude to use this kind of game like a learning accounting tool. The relevance of this study is due to the lack of empirical studies that analyze the application, viability, and effectiveness of gamified resources in the teaching areas of knowledge, such as Accounting. The game was used by students of Accounting (n = 816) for the first time in the scope of Higher Education in Portugal in the academic year 2018/2019. Results of this research suggest the importance of these resources to increase Attitude, Continued Use Intention and Intention to Word of Mouth related to Games Based Learning as an effective method of support for the learning process of accounting students. We believe that this study can be a contributor to researchers in this area to understand why the study of Accounting is genuinely challenging for students. This research will be enabling managers of Higher Education Institutions, professors and other educational agents to decide on the best strategies to use in order to increase student involvement in Accounting learning.

Keywords: games based learning, social factors, attitude, students, accounting, higher education

1. Introduction

Games Based Learning (GBL) utilization has been increasing in many areas, from the business world to the educational systems, and it is considered a persuasive technological method [1]. This method can generate beneficial changes in the users' attitude, nearly at the motivational level [2]. It has used in different fields of knowledge, such as marketing, medicine, sports, engineering, mathematics, computing, history, languages, physics, chemistry, biology, among others. Hence, the relevancy of this study given the lack of empirical studies on the application, feasibility, and effectiveness of gamified resources in Accounting Curricular Units. In a time when social networks and social interaction is constant, the increasing use of GBL in the teaching and learning process is a logical consequence of the evolution of technology. GBL is a social and technological phenomenon with the potential to create social benefits and foster social interaction [3]. GBL is the use of

game design elements in non-game contexts [4–6], to create motivational benefits to increase intrinsic and extrinsic motivation in users [7–9]. There are many forms of GBL activities that allow users to set and accomplish goals and tasks, earn rewards, points, classifications and feedback, or interact socially, and which recognised for their network activity [10, 11]. GBL has an extrinsic motivational effect and also strong social characteristics that need investigation [12]. Research has focused more on the results of GBL [13], and it is also necessary to obtain empirical evidence to show why people use GBL and their attitude towards this critical resource. People adopt this type of resource influenced by Word of Mouth [14] or other recommendation systems [15], and also because of social aspects [16]. User behaviour is strongly influenced by network exposure and the issue of other people's opinions, influencing their present and future behaviour [17, 18]. In this regard, the present study aims to investigate the influence of social factors on the attitude of higher education Accounting students concerning the use of this type of technological resources as a method of learning within these areas of knowledge and the ATT influence on Continued Use Intention (CUI) and Intention to Word of Mouth (IWOM) of this game to other future accounting students. The relevance of this study is due to the lack of empirical studies that analyze the application, viability, and effectiveness of gamified resources in the teaching of areas of knowledge such as Accounting. This research paper contributes to the development of the current body of literature related to the social factors that influence the attitude inherent to the use of GBL in accounting curricular units in Higher Education Institutions.

After the introduction, a longitudinal literature review follows which, over time, from the first to the most recent study about GBL applications. Section 3 describes the empirical research methodology of the article. The Results, Discussion, and Conclusions sections (Sections 4 and 5) present essential contents of the research study, as well in Section 6, we present the limitations and proposals for future research.

2. Literature review

2.1 Theory of planned behaviour

Ajzen's TPB (1991) is an extension of the Theory of Reasoned Action (TRA). It complements the TRA because it proved incapable of explaining the individuals' behaviours with full control over their actions as well as explaining how behaviour is an antecedent of intention [19]. Among many other uses, the TPB has also been used to explain, predict, and justify human behaviours related to the intention to use information and communication technologies [20]. This theory has allowed the prediction and explanation of human behaviour in several areas, including information technologies [21]. This human behaviour, which occurs when performing specific actions, is directly influenced by the intention to adopt an attitude in the execution of a specific behaviour [22]. Thus, attitude can explain how (favourably or unfavourably) an individual views the challenges that posed to them and the results that they intend to achieve, directly influencing behaviour and the way it will be the driving force for reaching specific outcomes [22]. Ajzen [22] referred in his investigations that the attitude of an individual depends on how they are predisposed, either by personal or by social influence, to acquire knowledge in a particular area of interest. This social influence is related to the subjective norm that is the social pressure exerted by friends, colleagues, family members, and others, for an individual to perform, or not, a certain behaviour. This behaviour depends

on previous experience and the obstacles faced, which can also happen in the use of technology, in general, and GBL, in particular. In several investigations related to the adoption of technology, the importance of attitude and behaviour control as intention-influencing variables has been verified [2].

The purpose of the TPB is to highlight the motivational factors that influence human behaviour, the willingness to act concerning a cause, the effort expended in that action, the willingness to perform a specific task that allows the development of favourable attitudes related to the individual's belief that that is the best way forward [23].

The TPB enables a comprehensive explanation of human behaviours related to beliefs, attitudes, norms, behavioural control, and intentions, in which behaviour, subjective norm, and perceived behavioural control influence an individual's intention. Thus, the probability of revealing a particular behaviour increases when the intentions to perform it is more substantial [24, 25]. This theory has been used in several empirical studies, evidencing an explanation of the intention and behaviour [19]. Despite the impressive prediction of behaviour, there is still a proportion of variation in it that remains difficult to explain, with enduring doubts about how all components of the TPB affect behavioural intent [22].

2.2 Games based learning and effective learning

GBL has excellent potential to motivate and teach students and enabling them to learn by playing in non-game environments [26], and aims to induce motivation in educational activities [27]. In this context, learning should not be a tedious activity, but a highly motivating and fun one [28, 29]. Several authors report that GBL has benefits for its target audience [30] because games allow users to commit mistakes and try again, experiencing learning without fear [26]. So, it is clear that GBL promotes student motivation and involvement [31], as well as their interest and progress in learning [32].

Literature-based on the efficacy of serious games, concluding that there were potential positive impacts, improving educational skills, and increasing interest in learning [33]. The relationship between digital games and learning has been investigated in several ways, essentially stating that learning is happening through the use of gamified resources [34]. This learning can be formal and informal, supporting the necessary intellectual and cognitive development [35], and making students more autonomous throughout the learning process [36]. Also, games can foster the students' critical thinking by making them more autonomous in solving problems from multiple perspectives [37]. GBL has become a popular and successful educational tool [38]. Researchers have demonstrated that it is not always practical [39]. Also, some investigations presented mixed conclusions regarding the use of GBL, with positive results in some ways and negative results in others [40]. Some authors claim the use of GBL in the classroom because it causes diverse behavioural effects. However, more research is needed to conclude how intrinsic and extrinsic motivation can be affected, as well as to discover, based on other theories, factors that may influence the use of this type of resources [41].

The effects of social factors on the utilization of gamified resources show that the number of users committed to using it increases, this being an essential requirement for the effectiveness of the resource [42].

2.3 Social factors that influence the adoption of GBL

The TPB incorporates several factors that can be tested and related to the use of technological resources inherent to GBL [22]. These social factors to Social

Influence [22], Recognition [43–47], and Reciprocal Benefits [45, 48, 49] as predictors of Attitude [22] towards using GBL and the way it influences Continued Use [49] and Intention to WOM [50].

The TPB is widely used and applied to predict behavioural intentions, measuring the attitude towards the intention of a given behaviour [22]. It is, therefore, essential to understanding how these factors can influence and persuade GBL users. So, we propose to test how SIN, RCG, and RCB directly influence ATT, just as we intend to perceive how ATT directly influences CUI and IWOM.

2.3.1 Recognition

Social feedback that users of a network or technological resource receive from the interactions among them is called social recognition [48, 51]. Recognition relates to the acceptance and approval by other members [52], reflecting the desire to achieve a positive reputation and thus leading people to become more involved in the activities [53].

When a user receives RCG, they become predisposed to recognize other users of the same service, which causes social interaction to enhanced by the reciprocal recognition promoted [54]. If the people who transmit recognition to others have relevant relationships between them, this interaction brings mutual benefits to the social community [48, 55, 56] when using a specific technological system [57]. In this regard, when a given service triggers recognition from others, ATT is positively affected [55], which means that when the experiences are positive, it is likely that the ATT towards that service is also positively influenced [58]. The search for positive recognition from others may represent a strong social, motivational effect in the learning context for the use of interactive tools [59].

As for students, they value the recognition obtained by their evolution, seeking to be acknowledged by colleagues, teachers, and family in order to be seen as experts in a particular subject and as the most intelligent in a specific area of knowledge [60]. The teachers' feedback is critical, as students feel motivated to behave in a way that increases the likelihood of teacher approval. We, therefore, hope that RCG has a positive effect on ATT towards the use of GBL. RCG is a positive experience, and the following investigation hypothesis is likely to occur. To test our final model research, we proposed the following research hypothesis H1: Recognition (RCG) has a positive influence on Attitude (ATT) towards using GBL.

2.3.2 Social influence

Based on the TRA, the TPB refers to SIN as a factor that explains individual behaviour [61]. SIN is related to the individual's perception about the social pressure exerted by others to accomplish, or not, a specific target behaviour, as well as to the importance that this person gives to the opinion that other people have about this adopted social behaviour [22, 62–64].

SIN is usually carried out by close people, such as family members, friends, co-workers, and others who have a direct effect on the person and their behavioural intention about certain phenomena [61, 65]. The importance of SIN as a predictor of ATT varies according to the specificity of the study population and group behaviour [62], which indicates that their attitudes may more influence individuals than by the perception of pressure [22, 66]. The effects of an individual's participation in social groups/networks may also explain the role of SIN in behavioural outcomes [67]. This factor has supported studies which show the acceptance of technology as a modifying element for user behaviour [68]. In this regard, there is a theoretical

basis and verified literature that demonstrates that e-learning resources can exert an essential change in the attitude towards using this type of tools. SIN can play an essential role in encouraging changes in behaviour towards learning based on technological resources [69].

SIN can be a way to encourage users, who discover that others around them attribute importance to this use, quickly perceive the benefits of it, and become more willing to use technology as a learning tool [45]. In the present investigation, the target behaviour is the use of GBL as a method that increases the learning in of management area, so we intend to understand if, in the context of GBL, SIN affects the ATT towards using the proposed gamified resource. For this, to test our final model research, we define the hypothesis of investigation H2: Social Influence (SIN) has a positive influence on Attitude (ATT) towards using GBL.

2.3.3 Reciprocal benefits

RCB can also a form of perceived social utility inherent to the use of a particular service, i.e. how this service can beneficially contribute to the social community [48]. In turn, the perceived utility is how a person believes that a given resource can increase their performance and the results of that use [43], as well as the direct effect on the intention to use and its influence through attitudes [70]. The users' ATT to perform a given activity is encouraged by the system of GBL reciprocally adopted by the social community [71]. The tendency of a particular group of people to pursue common goals leads to an increase in group cohesion. It prompts the importance given to RCB and the usefulness of this type of relationship within a given social community, stimulating their ATT to achieve specific objectives using tools of common interest [71]. Mutual recognition shared among a group of people allows the creation of a reciprocal interaction behaviour [54] that promotes the social utility of a given service, which contributes to the increase of benefits among the social community [48, 55]. We can say that receiving recognition increases the RCB of system usage [45, 48, 57]. To test our final model research, we proposed the following research hypothesis to verify if there is a positive relationship between RCB and ATT. The following investigation hypothesis has been defined H3: Reciprocal Benefits (RCB) has a positive influence on Attitude (ATT) towards using GBL.

2.3.4 Attitude, continued use intention, and intention to word-of-mouth

In the TPB, ATT is contextualized as a set of positive or negative evaluations for the realization or accomplishment of a given behaviour [22], and can be seen as a permanent and stable evaluation summary about something; it is a critical construct to predict behaviours and intentions [1]. In this regard, the greater the ATT concerning a particular behaviour, the greater the intention of a particular individual to perform it [22]. Users can assess ATT towards the use of a technological system or resource as favourable or unfavourable [22, 62]; however, there is a strong relationship between ATT and CUI [46, 72]. ATT has been identified in scientific studies as the cause of intention [73]. It can be classified into two sub-constructs: attitude towards objects and attitude towards behaviour [74]. People tend to opt for a favourable ATT when their assessment of that ATT's results is positive and when the evaluation of the resulting benefits and costs is also positive [75].

Regarding CUI, it is closely related to ATT because they depend on each other [76]. Without a positive ATT, CUI is affected, and it is possible to say that this is even more noticeable about the use of technology [22]. In the literature related to the use of technology, CUI is predicted by the perceived utility of a particular

system that directly interferes with the future intention to use it, and that allows us to reach specific objectives [43, 49]. On the other hand, the hedonic context has also been analyzed, and the pleasure of using a resource also has a relevant impact on CUI [77]. System acceptance (the pleasure and utility of use) by the user usually has a positive effect on ATT [78] which influences the CUI [77, 79] of services whose acceptance by the user is decisive [77]. The previous constructs are closely associated with promoting IWOM related to the willingness to recommend a service to others and to promote CUI [14, 80]. This IWOM usually demonstrates satisfaction with the service users and a positive ATT resulting from the fact that it has exceeded user expectations, as well as from the hope that it can exceed the expectations of others [50]. Expectations are relevant to the recommendation ATT or IWOM, with a substantial impact on the intentions of current and future users [81]. IWOM has a significant impact on behaviour, promoting an ATT of service counselling in satisfied users, either through word-of-mouth or digital means [82]. This desire to promote an appeal through IWOM is entirely independent of interests because it is carried out by users who are external to the service. People who have no economic interest in it and who, due to their unbiased opinion, recommend it without the intention of altering the truth about the real value of it [83]. User reviews can be positive or negative, significantly affecting the future behaviour of the users themselves and those who receive feedback via IWOM [84]. In fact, IWOM is recognised as being able to play a role in influencing social behaviours [85], resulting in positive ATT (IWOM positive) or negative ATT that can directly or indirectly change the behaviours and intentions to continue using a particular service in the future [86]. Several studies have reported the importance of WOM behaviours as a factor that can significantly impact behaviour and intention to use and recommend a resource, product, or service [86, 87]. IWOM influences friends, colleagues, family members and others in order to increase utilisation because it exerts an influencing effect on ATT and significant adoption behaviour as well as increases the users' loyalty towards future use [88]. Based on the exposed literature, to test our final model research, we suggest the following hypothesis of investigation H4: Attitude (ATT) has a positive influence on Continued Use Intention (CUI) to use GBL and hypotheses of investigation H5: Attitude (ATT) has a positive influence on Intent Word-of-Mouth (IWOM) about the use of GBL.

3. Empirical research

This research is the result of using AccountinGame that has been specially designed to serve as educational tools for teaching Accounting. The aim here is to prove that not only teachers may use this tool to complement their classes, but also students may benefit from it outside lesson hours, both as a study aid for the various subjects and a way to test their knowledge. This game was applied to first-year Accounting Portuguese undergraduates' students in 2018/2019 school year.

AccountinGame consists of a quiz containing questions about the syllabus of Accounting curricular units. It should be pointed out that the game contents were designed according to the programs in place in Portuguese Higher Education Institutions and that the ones that were chosen were shared by all the Higher Education Institutions that participated in the study. In order to be able to use this resource, students were expected to register themselves in the respective platforms and fill in their sociodemographic data, after which they could play the game either individually and networking.

Accountingame were developed to make Accounting classes more appealing and motivating and to facilitate student learning. The game consists of a board

divided into eight squares; each square contains a set of 200 questions the player must answer. Questions appear randomly and refer to Accounting. To continue playing, the player must give correct answers. During the game, players can learn several subject matters that have to do with the various topics addressed. The game begins at the centre of the board. Each player is placed randomly in one of the squares numbered from 1 to 8. The first player to play is the one placed in square n° one and so on, in ascending order. To move forward, the players must give correct and suitable answers to the questions they are asked, depending on the square they are in at the moment. Questions refer to the contents of the squares the players are in and are previously defined in the game rules. The aim of the game is that the first player answers correctly to at least one question of each topic of the prominent corners of the board and three questions of each topic of the remaining squares. For each correct answer, a star is lit. When all stars are lit, the player can, then, move to the centre of the board. The first player to light all the stars and get to the centre of the board by giving a correct answer to a question is the winner of the game.

This game must be preferably played by eight players or by groups of 2 players, totalling a maximum of 16 students per game. The game can be played by fewer students or even individually, in any case. Nevertheless, the main aim is that each time eight players play the game so that they can individually test their knowledge and learn from the errors and victories, theirs, and their opponents'. Starting from the centre of the board, the first player to play will have to correctly answer a question from the topic belonging to the square he/she is inside. If the answer is right, he/she can move forward to the square corresponding to the number on the dice and according to his/her game strategy; if the answer is wrong, he/she will remain in the same square. Each player has 90 seconds to answer the questions, after which time if this answer if not answered, it is considered wrong.

Whether the player gives a right or a wrong answer, it is always another player's turn to play and so on. When the player gets to the square-shaped part on the outside of the game, he/she can choose any direction according to his/her game strategy and the topics he/she wishes to handle first. Always bearing in mind that he/she will have to remain in that area of the board until all questions were answered and the answers are correct. Only when all stars are lit can the player move toward the centre. Players must plan their moves carefully, trying to choose the squares where it is more convenient for them to answer the questions. Once the players move in each direction, there is no going back. For instance, if the player throws the dice and number 5 comes up, he/she cannot move three squares to the right and 2 to the left. Each move must consider the most convenient direction, targeting a specific topic, regarding which no star has yet been lit. If the numbers on the dice do not allow the players to move to a topic to which they have not yet answered, they score points for giving a correct answer to a question regarding the square they are inside. More than one player can occupy the same square on the board (**Figure 1**).

During the game, players may check the game rules so that they know what is expected of them and have permanent feedback on their progress and results [89]. Additionally, they can check their score and position in the general ranking at all times, and, therefore, compare their performance with that of their opponents' [90]. Thus, the players' state of flow, interest, and understanding of the concepts is ensured [91]. Games are also an opportunity to develop social interaction, cooperation, a healthy competition, and a high focus on learning [89, 90].

The game has a general ranking which shows which students have higher scores resulting from the correct answers given while playing the game. This score accumulates from game to game and is national-wide. The students have immediate feedback on their score and performance throughout the game, and it is always

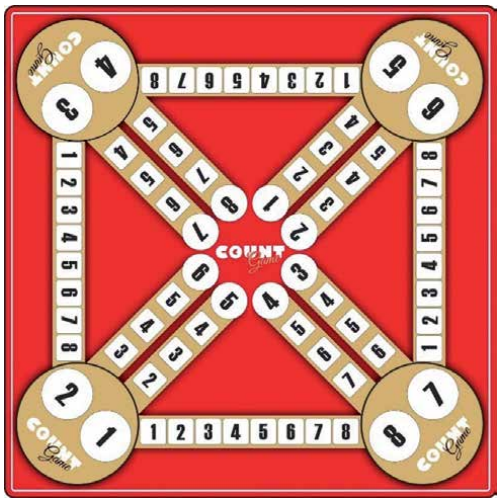

Figure 1.
Accountingame online board.

possible to visualize the correct answer, even when the student does not get it right. Such information is also available as regards other students who are playing the same game [92]. The possibility of playing as a group, creating a profile, and having access to the answers of other users allows for an interaction similar to that of a social network [76, 93].

Introducing this game in an educational context within Accounting in Higher Education Institutions helps students in their quest for knowledge, awakening their interest for new learning experiences through new and stimulating pedagogical situations [94, 95]. Thus, learning through playful activities acquires a more definite meaning, accompanying the student/player throughout his/her academic life, since the knowledge that obtained is comprehended and, when necessary, interactively expressed.

3.1 Participants

Participants were students, aged between 17 and 43 (the average age was 19,96), of which 39% were male and 61% female. A total of 860 questionnaires were gathered, in the paper during the classes, from a total population of 3083 Accounting students; 44 questionnaires were excluded for not being duly filled in (containing unanswered questions or more than one option for just one statement). 17 out of 20 Higher Education Institutions participated in this study, which corresponds to 85% of all Portuguese Higher Education Institutions (**Table 1**).

In **Table 1**, the column of the gamified group corresponds to the group of students who used the game as a Learning method. In the same table we can see with signal "--"the Higher Education Institutions, belonging to the Portuguese public education system, that did not accept to participate in this study, are also presented.

In total, 816 valid questionnaires were obtained among Accounting students, which makes for a final sample in a universe of 3083 students that were enrolled in this curricular unit for the first time. The total response rate was 26.5%.

Over the first six weeks of the semester, students registered themselves in the game, not having access to its content and attending regular classes with the teachers. From the seventh week onwards, the content of the game was made available so that teachers were able to use them in class as a complement to teaching their respective subjects.

Higher education institutions	Population	M	F	Gamified Group
Polytechnic Institute of Guarda	40	11	29	28
Polytechnic Institute of Bragança	84	35	40	48
Polytechnic Institute of Coimbra	20	—	—	—
Polytechnic Institute of Leiria	110	—	—	—
Polytechnic Institute of Lisboa	195	49	85	0
Polytechnic Institute of Portalegre	67	9	8	17
Polytechnic Institute of Viana do Castelo	90	35	23	38
ISCTE - University Institute of Lisbon	280	61	52	54
University of Beira Interior	102	45	53	0
University of Madeira	75	28	42	50
University of Aveiro	88	48	31	31
Coimbra School of Economics	243	38	43	0
University of Évora	101	32	59	65
Lisbon School of Economics and Management	380	95	149	156
University of Trás-os-Montes e Alto Douro	74	29	45	60
University of Algarve	165	20	49	64
University of Minho	152	43	91	80
Porto School of Economics	345	71	116	105
Azores School of Economics and Management	52	22	30	20
Lisbon New School of Economics	420	—	—	—
Total	**3083**	**671**	**945**	**816**

Table 1.
Sample characterization – Accounting students.

Students could autonomously use the game whenever they wished as a means to test what they had learned in class. This was monitored over the semester to gather information on such aspects as to how long each student played the game; the subjects that were studied; how often they had completed the game; how many questions had been answered; the number of correct and wrong answers.

The average game usage in the classroom was three to two-hour sessions per student, a figure that was higher when one considers the number of students (87,13%) who played the game, in a total of 816, outside the classroom, due to their having the possibility of accessing this resource autonomously outside class hours. This percentage of 87,13% corresponds to 711 students, in a total sample of 816, who played the game three to two-hour sessions as an Accounting Learning method. To obtain this percentage, we dived the total sample (816) by the number of game users (711). These were the players who played three to two-hour sessions.

At the end of the semester, before the final evaluation, students were asked to answer a questionnaire, assessing the importance and contribution of the game to their learning.

3.2 Measurement instruments

To collect data, we used a survey by questionnaire, collected both online and in-person, using validated literature scales. This questionnaire uses dimensions

such as RCB, SIN, RCG, ATT, CUI, and IWOM that the user of an e-learning game experiences when operating it as a learning tool. All questionnaire items resulted from adapting previously validated scales used in other relevant scientific studies (**Table 2**). The attitude was measured using a combination of scales by several authors (Appendix 1). We translated and adapted these scales to the Portuguese language. The adaptation of scales did not involve many changes and enabling the application of the same scale. All the items were measured using a 7 point-Likert scale, varying between "Does not fully correspond" and "Fully Corresponds". The questionnaire was administered at the end of the semester, before the final evaluation, to all students who had played the game for at least six hours. It should be noted that the average game utilization rate in class was three sessions of two hours each; nevertheless, the total rate of the students' individual use was over 87,2%, since they were allowed to play it outside school hours.

3.3 Research model

According to the literature review described in Section 2.3, we present in **Figure 2** the research model to test during this investigation.

3.4 Validity and reliability

The theoretical model presented here was estimated by using the SPSS/AMOS 24 structural equation modelling program [99]. The measurement model (validity and

Constructs	Authors
Social Influence (SIN)	[22, 45, 96, 97]
Recognition (RCG)	[44, 46, 92, 98]
Reciprocal Benefits (RCB)	[43, 47, 49]
Attitude (ATT)	[22]
Continued Use Intention (CUI)	[49]
Intention to Word-of-Mouth (IWOM)	[50]

Table 2.
Measurement instruments.

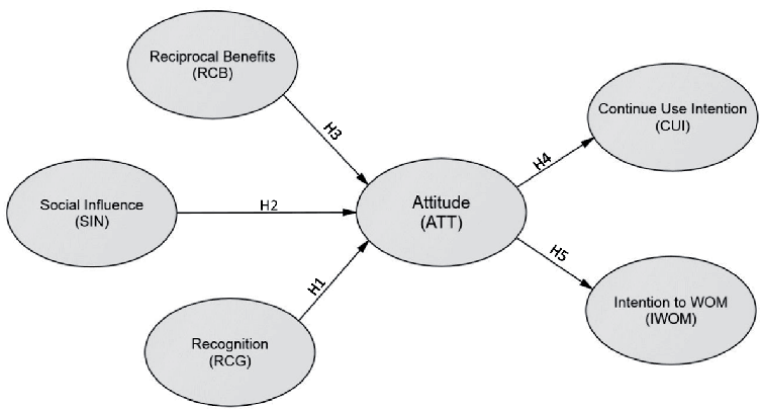

Figure 2.
Research model.

	CR	AVE	α	IWOM	SIN	RCG	CUI	ATR	RCB
IWOM	0.843	0.641	0.833	**0,800**					
SIN	0.909	0.769	0.909	0.750	**0.877**				
RCG	0.882	0.718	0.867	0.418	0.662	**0.847**			
CUI	0.738	0.526	0.891	0.436	0.525	0.402	**0.725**		
ATT	0.906	0.763	0.902	0.634	0.544	0.519	0.615	**0.873**	
RCB	0.857	0.667	0.842	0.793	0.651	0.553	0.687	0.735	**0.817**

IWOM = Intention to Word-of-Mouth, SIN=Social Influence, RCG = Recognition, CUI=Continued Use Intention, ATT = Attitude, RCB = Reciprocal Benefits.
Note 1: Diagonal represents the square root of the AVE.
Note 2: Outside the diagonal, we can observe the correlation between the constructs.

Table 3.
Convergent and discriminant validity.

reliability of the measures) was analyzed according to the literature, and several research hypotheses were tested to assess the meaning of the loads and coefficients of each path [100]. To evaluate convergent validity and reliability of the model, the Average Variance Extracted (AVE), the Composite Reliability (CR), and the Cronbach's Alpha (α) were analyzed, using only measurement items whose factor loads (AVE > 0,5; CR > 0,7; α > 0,7) were well within acceptable statistical parameters [100].

Table 3 presents the different dimensions of the study that are related and whose correlation between the different constructs is strong. The dimensions IWOM, SIN, RCG, CUI, ATT, and RCB present significant correlations that demonstrate the ability that the different constructs must explain the results of the study. The closer to 1, the greater the ability to explain the influence of each construct in explaining the reality that is being studied. On the other hand, we found that the AVE values for each of the latent constructs are more significant than the highest square correlation with any other latent variable. Therefore, discriminant validity is established at the construct level.

The results presented in **Table 3** have sufficient convergent and discriminant validity to validate the results presented in which the Attitude to learn accounting using gamified resources is influenced by social factors.

4. Results

The theoretical model presented here was estimated by using the SPSS/AMOS 26 structural equation modelling program [99]. The measurement model (validity and reliability of the measures) was analyzed according to the literature, and several research hypotheses were tested to assess the meaning of the loads and coefficients of each path [100]. To evaluate the model's convergent validity and reliability, the Average Variance Extracted (AVE), the Composite Reliability (CR), and the Cronbach's Alpha (α) were analyzed, using only measurement items whose factor loads (AVE > 0,5; CR > 0,7; α > 0,7) were well within acceptable statistical parameters [100]. In what concerns the measures that were used in this study, they are sufficiently valid and reliable (**Table 2**), and the sample that was obtained meets the criteria of structural equation analysis [101].

The research model tested (**Figure 3**) allowed us to verify that 67,6% of the ATT towards using GBL as a learning tool to teach management is explained by the RCB,

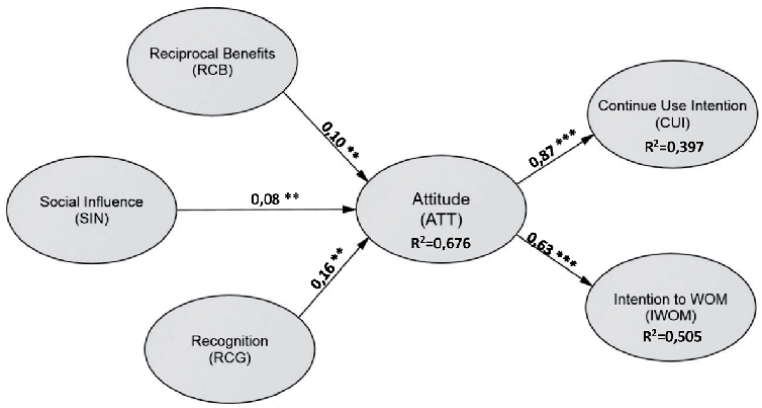

Figure 3.
*Structural model results. ** p<0.05; *** p<0.001.*

Hypotheses	Effect	Regression Coefficient	Standard Error	t	p-value	Results
H1	RCB → ATT	.100	.100	.813	<0.05	Supported
H2	SIN → ATT	.081	.106	.944	<0.05	Supported
H3	RCG → ATT	.161	.221	4.802	<0.001	Supported
H4	ATT → CUI	.874	.112	5.669	<0.001	Supported
H5	ATT → IWOM	.638	.122	7.163	<0.001	Supported

Table 4.
Research hypotheses and statistical results.

SIN, and RCG dimensions. The model also explains 39,7% of the CUI and 50,5% of the IWOM. The direct paths tested were all statistically significant. We verified the effect of the RCB, SIN, and RCG dimensions on CUI and IWOM dimensions mediated by the ATT dimension.

In **Table 4**, we can see the structural results of the RCB, SIN, and RCG dimensions, which have direct and positive statistical significance on ATT, validating the formulated hypotheses (H1, H2, and H3). The ATT dimension has a positive, statistically significant, direct influence on CUI and IWOM, validating the hypotheses (H4 and H5).

The estimated results of the research model indicated that Reciprocal Benefits, Social Influence, and Recognition Attitude, after using AccountinGame have a positive effect on Attitude. In the other side, Attitude has a positive effect in Continue Use Intention and Intention of Word of Mouth to use and advise the game like a learning tool. In its turn, the Attitude to study and learn after using the game also influenced the students. All relationship between dimensions was statistically significant, meaning that the fact that students are immersed with the use of the game to improve learning. Looking to the final results, we can start by saying: RCB has a positive impact on ATT($\beta = 0.10$, $p < 0.05$); SIN has a positive impact on ATT($\beta = 0.081$, $p < 0.05$) and RCG has a positive impact on ATT($\beta = 0.161$, $p < 0.001$); Results confirmed and validated research hypotheses H1, H2 and H3. In the other side, ATT has a positive and statistically significant direct strong influence on CUI ($\beta = 0.874$, $p < 0.001$) and in IWOM($\beta = 0.638$, $p < 0.001$) validating H4 and H5 od the research proposed model.

In what concerns ATT-mediated effects, some mediated relationships producing statistically significant total effects were observed, such as: RCB → ATT → CUI ($\beta = 0.10^*0.874 = 0.087$, $p < 0.001$); RCB → ATT → IWOM ($\beta = 0.10^*0.638 = 0.063$, $p < 0.001$). Talking about indirect effect of SIN in CUI and IWOM results showed that SIN → ATT → CUI ($\beta = 0.081^*0.874 = 0.070$, $p < 0.001$); SIN → ATT → IWOM ($\beta = 0.081^*0.638 = 0.051$, $p < 0{,}001$). Finally we analysed indirect effect of RCG in CUI and IWOM of Accountigame users and we concluded that RCG → ATT → CUI ($\beta = 0.161^*0.874 = 0.140$, $p < 0.001$); RCG → ATT → IWOM ($\beta = 0.161^*0.638 = 0.102$, $p < 0.001$).

5. Discussion and conclusions

In this article, we investigated how social factors influence the attitude of higher education students of Accounting towards using technological gamified resources as a learning method within these areas of knowledge. Using the theoretical background provided by the TBP [22], we tested how social factors like RCB [45];

C.-P. [48], SIN [22, 45, 61, 62, 97] and RCG [44, 45, 49] were predictors of ATT [61] towards using GBL and the influence of ATT in CUI [49] and IWOM [50].

We tried to understand how each factor influences HE students to increase the attitude towards using GBL as a complementary learning tool in one of the area of Management (Accounting) and if this construction of a positive attitude towards usage influences future intention to use and intention to recommend the tool to others. We tested if the students' behaviour after using GBL lead to the desire to continue using technology as a standard study tool. The results obtained indicate that the amount of recognition that users receive from others when using the resource directly and significantly affects the attitude towards GBL [57, 59]. Regarding the way other people (colleagues, family, friends) socially influence the use of this type of tools, we have verified that there is a statistically significant cause and effect relationship that corroborates previous research [22, 66, 69]. Concerning the benefits or usefulness resulting from using this type of technological resource, users are satisfied when the services are useful for learning, easy to use, and practical, previous corroborating research [45, 54, 57, 71]. The results also indicate that the ATT towards GBL service is a strong determinant of the CUI related to the future frequent use of the resource [47, 72, 76, 102], and IWOM, which is related to the intentions of recommending and saying positive things about the service used [50, 84, 103].

Previous studies have already tested the influence of social factors on ATT [42], as well as the influence of ATT on CUI and IWOM [104]; however, in this investigation, we used the TPB as the basic theory to test the influence of more social factors, simultaneously, on ATT and CUI and IWOM, based on the use of resources for the teaching of the area of knowledge management. Therefore, we seek to increase theoretical knowledge on this subject and to contribute to a better understanding of the influence of social factors on the continued use of the technology. After a minimum of six hours of use per student, the game used in this empirical study (Accountingame) allowed to test if the already mentioned social factors had direct effects on the attitude and if this dimension had a positive relation with the intention to continue using and recommending the service designed to support the teaching of Accounting in the context of Portuguese higher education.

The findings resulting from this research fill the gap in the literature regarding the effects of GBL in Accounting students, demonstrating that these areas of knowledge, like many others, can support the use of resources intended for this purpose.

The results of the present study, along with the findings previously achieved by other authors referenced in this study, indicate that the use of GBL has positive effects on attitude to learning, through intervention and because of several dominant social factors. In this regard, the validated hypotheses indicate that it is necessary to continue supporting the use of gamified technologies as a complementary teaching method for the acquisition of knowledge.

6. Limitations and future research

Future studies may investigate how social factors interfere with the attitudes of students towards using GBL, among other distinct areas of knowledge, noting that the results in these areas will be close to those obtained in the present investigation.

A study to compare the influence of social factors on the attitude towards GBL of students from different countries, in similar study fields, could also be carried out. An attempt to understand how social factors have more impact according to sociodemographic data variables such as gender, age, nationality, academic background, and

even family background could be carried out as well. Regarding family background, it would be useful to compare how Accounting students view GBL as a method of learning according to their family history, directly or indirectly related to these areas of knowledge. Future qualitative studies would be interesting to study the phenomenon from another perspective in the attempt to obtain other data resulting from an investigation, and this different methodology might bring other conclusions and other theoretical contributions.

Regarding the limitations of the investigation, we denote the fact that the data are self-reported and can influence the results because users, when interested in a service, can become emotionally involved in the activities, which affects their reasonable opinion about the utilized resource.

Regarding the collection instruments, although empirically and scientifically validated, they can be replaced by other relevant ones like structured or semi-structured interviews. Scales are always liable to questioning and replacement by others that may eventually have more statistically robust results.

The methodology of quantitative research itself and its generalization be limiting insofar as there are no two matching realities even when studying the same phenomenon.

Appendix 1

Question	Constructs	Authors
Using the game was important	Attitude	[22]
Using the game was a good idea		
Using the game was positive		
I anticipate keeping using the game in the future	Continue Use Intention	[49]
I intend to use the game frequently, as I have done so far		
I anticipate using the game more frequently than less frequently		
I feel good when my achievements in the game are acknowledged	Recognition	[44, 46, 92, 98]
I enjoy it when my colleagues understand my evolution throughout the game		
It is good to notice that other users follow my activities in the game		
The people who influence my attitudes would recommend using this game	Social Influence	[22, 45, 96, 97]
The people who I like would encourage me to use the game		
My friend's thing it is a good idea to use the game		
I will recommend the game to my friends	Intention WOM	[50]
I will recommend the game to people who ask my opinion about its usefulness		
I will say positive things about the game so that other people will use it		
I think the game is quite useful to learn	Reciprocal Benefits	[43, 47, 49]
It is easier to start studying by using the game		
Using the game, I feel that I am learning in a more effective manner		

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References

[1] Widyasari, Y. D. L., Nugroho, L. E., & Permanasari, A. E. (2019). Persuasive technology for enhanced learning behavior in higher education. International Journal of Educational Technology in Higher Education, 16(1), 15.

[2] Barr, M. (2018). Student attitudes to games-based skills development: Learning from video games in higher education. Computers in Human Behavior, 80, 283-294.

[3] Moon, J., & Ke, F. (2020). Exploring the Relationships Among Middle School Students' Peer Interactions, Task Efficiency, and Learning Engagement in Game-Based Learning. Simulation & Gaming, 1046878120907940.

[4] Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. CHI'11 Extended Abstracts on Human Factors in Computing Systems, 2425-2428.

[5] Hamari, Huotari, & Tolvanen. (2015). Gamification and economics. The Gameful World: Approaches, Issues, Applications, 139.

[6] Koivisto, J., & Hamari, J. (2014). Demographic differences in perceived benefits from gamification. COMPUTERS IN HUMAN BEHAVIOR, 35, 179-188. https://doi.org/10.1016/j.chb.2014.03.007

[7] Hamari, J., & Järvinen, A. (2011). Building customer relationship through game mechanics in social games.

[8] Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations : Classic Definitions and New Directions. 67, 54-67. https://doi.org/10.1006/ceps.1999.1020

[9] Silva, R., Rodrigues, R. G., & Leal, C. (2018). Academic Motivation Scale: Development, Application and Validation for Portuguese Accounting and Marketing Undergraduate Students. International Journal of Business and Management, Vol. 13(No. 11). https://doi.org/10.5539/ijbm.v13n11p1

[10] Hamari, J. (2013). Transforming homo economicus into homo ludens: A field experiment on gamification in a utilitarian peer-to-peer trading service. Electronic Commerce Research and Applications, 12(4), 236-245.

[11] Hamari, Koivisto, & Sarsa. (2014). Does gamification work?--a literature review of empirical studies on gamification. System Sciences (HICSS), 2014 47th Hawaii International Conference On, 3025-3034.

[12] Ngai, E. W. T., Tao, S. S. C., & Moon, K. K. L. (2015). Social media research: Theories, constructs, and conceptual frameworks. International Journal of Information Management, 35(1), 33-44.

[13] Martí-Parreño, J., Méndez-Ibáñez, E., & Alonso-Arroyo, A. (2016). The use of gamification in education: a bibliometric and text mining analysis. Journal of Computer Assisted Learning, 32(6), 663-676. https://doi.org/10.1111/jcal.12161

[14] Cheung, C. M. K., & Thadani, D. R. (2012). The impact of electronic word-of-mouth communication: A literature analysis and integrative model. Decision Support Systems, 54(1), 461-470.

[15] Li, Y.-M., Wu, C.-T., & Lai, C.-Y. (2013). A social recommender mechanism for e-commerce: Combining similarity, trust, and relationship. Decision Support Systems, 55(3), 740-752.

[16] Zhou, Zhang, & Zimmermann. (2013). Social commerce research: An integrated view. Electronic Commerce Research and Applications, 12(2), 61-68.

[17] Torres-Toukoumidis, Á., Ramirez-Montoya, M. S., & Romero-Rodriguez, L. M. (2019). Assessment and evaluation of games-based learning (GBL) in e-learning contexts. Education in the Knowledge Society, 19(4), 109-128.

[18] Westera, W. (2019). Why and how serious games can become far more effective: Accommodating productive learning experiences, learner motivation and the monitoring of learning gains. Journal of Educational Technology & Society, 22(1), 59-69.

[19] Chang, I.-C., Liu, C.-C., & Chen, K. (2014). The effects of hedonic/utilitarian expectations and social influence on continuance intention to play online games. Internet Research, 24(1), 21-45.

[20] Carter, S., & Yeo, A. C.-M. (2016). Students-as-customers' satisfaction, predictive retention with marketing implications The case of Malaysian higher education business students. INTERNATIONAL JOURNAL OF EDUCATIONAL MANAGEMENT, 30(5), 635-652. https://doi.org/10.1108/IJEM-09-2014-0129

[21] Ajzen, I. (2002). Perceived behavioural control, self-efficacy, locus of control, and the theory of planned behaviour. Journal of Applied Social Psychology, 32(4), 665-683.

[22] Ajzen, I. (1991). The theory of planned behaviour. Organizational Behavior and Human Decision Processes, 50(2), 179-211.

[23] Raines, C. (2013). In-app mobile advertising: Investigating consumer attitudes towards pull-based mobile advertising amongst young adults in the UK. Journal of Promotional Communications, 1(1).

[24] Ajzen, I., & Driver, B. L. (1992). Application of the theory of planned behaviour to leisure choice. Journal of Leisure Research, 24(3), 207.

[25] Berger, I. (1993). A framework for understanding the relationship between environmental attitudes and consumer behaviour. Marketing Theory and Application, 4(1993), 157-163.

[26] Lee, J., & Hammer, J. (2011). Gamification in education: What, how, why bother? Academic Exchange Quarterly, 15(2), 146.

[27] Gibson, D., Ostashewski, N., Flintoff, K., Grant, S., & Knight, E. (2015). Digital badges in education. Education and Information Technologies, 20(2), 403-410.

[28] Silva, R., Leal, C., & Rodrigues, R. (2017). Gamification in Higher Education: Motivation, Engagement and Knowledge. Theory and Applications in the Knowledge Economy, 444.

[29] Wu, M. G. (2012). 101: The Psychology of Motivation, Science of Social Blog. Lithium, 2012.

[30] Stott, A., & Neustaedter, C. (2013). Analysis of gamification in education. Surrey, BC, Canada, 8.

[31] Clark, M. C., & Rossiter, M. (2008). Narrative learning in adulthood. New Directions for Adult and Continuing Education, 2008(119), 61-70.

[32] Assaf, M., Van Hillegersberg, J., Spil, T., & Arikat, N. (2019). Teachers' perceptions about using serious games in formal education in Jordan: Possibilities and limitations. 2019 IEEE Global Engineering Education Conference (EDUCON), 436-441.

[33] Connolly, T. M., Boyle, E. A., MacArthur, E., Hainey, T., & Boyle, J. M. (2012). A systematic literature review of empirical evidence on computer games and serious games. Computers & Education, 59(2), 661-686.

[34] Armstrong, M. B., & Landers, R. N. (2017). An Evaluation of Gamified Training: Using Narrative to Improve Reactions and Learning. Simulation and Gaming, 48(4), 513-538. Retrieved from https://www.scopus.com/inward/record.uri?eid=2-s2.0-85026851586&doi=10.1177%2F1046878117703749&partnerID=40&md5=6b8b4c8a268d7b98c8f74caf4611c0ed

[35] Davis, & Singh. (2015). Digital badges in afterschool learning: Documenting the perspectives and experiences of students and educators. COMPUTERS & EDUCATION, 88, 72-83. https://doi.org/10.1016/j.compedu.2015.04.011

[36] Kebritchi, M., Hirumi, A., & Bai, H. (2010). The effects of modern mathematics computer games on mathematics achievement and class motivation. Computers & Education, 55(2), 427-443.

[37] Hew, & Kadir, S. A. (2016). Behavioural intention in cloud-based VLE: An extension to Channel Expansion Theory. Computers in Human Behavior, 64. https://doi.org/10.1016/j.chb.2016.05.075

[38] Kapp. (2012). Games, gamification, and the quest for learner engagement. Retrieved from T and D website: https://www.scopus.com/inward/record.uri?eid=2-s2.0-84862892253&partnerID=40&md5=3d5cd4a19949a11159e3e4ba67557dfe

[39] Christy, K. R., & Fox, J. (2014). Leaderboards in a virtual classroom: A test of stereotype threat and social comparison explanations for women's math performance. COMPUTERS & EDUCATION, 78, 66-77. https://doi.org/10.1016/j.compedu.2014.05.005

[40] Mekler, E. D., Brühlmann, F., Opwis, K., & Tuch, A. N. (2013). Do points, levels and leaderboards harm intrinsic motivation?: an empirical analysis of common gamification elements. Proceedings of the First International Conference on Gameful Design, Research, and Applications, 66-73.

[41] Hanus, M. D., & Fox, J. (2015). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. Computers and Education, 80. https://doi.org/10.1016/j.compedu.2014.08.019

[42] Hamari, J., & Koivisto, J. (2013). Social Motivations To Use Gamification: An Empirical Study Of Gamifying Exercise. ECIS, 105.

[43] Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS Quarterly, 319-340.

[44] Hernandez, Morris, & Picard. (2011). Call center stress recognition with person-specific models. International Conference on Affective Computing and Intelligent Interaction, 125-134.

[45] Hsu, C.-L., & Lin, J. C.-C. (2008). Acceptance of blog usage: The roles of technology acceptance, social influence and knowledge sharing motivation. Information & Management, 45(1), 65-74.

[46] Lin, & Bhattacherjee. (2010). Extending technology usage models to interactive hedonic technologies: a theoretical model and empirical test. Information Systems Journal, 20(2), 163-181.

[47] Venkatesh, V. (2000). Determinants of perceived ease of use: Integrating control, intrinsic motivation, and emotion into the technology acceptance model. Information Systems Research, 11(4), 342-365.

[48] Lin, & Bhattacherjee. (2008). Elucidating individual intention to use interactive information technologies: The role of network externalities. International Journal of Electronic Commerce, 13(1), 85-108.

[49] Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management Science, 46(2), 186-204.

[50] Kim, S. S., & Son, J.-Y. (2009). Out of dedication or constraint? A dual model of post-adoption phenomena and its empirical test in the context of online services. MIS Quarterly, 49-70.

[51] Cheung, C. M. K., Chiu, P.-Y., & Lee, M. K. O. (2011). Online social networks: Why do students use facebook? Computers in Human Behavior, 27(4), 1337-1343.

[52] Baumeister, R. F. (1999). The nature and structure of the self: An overview. The Self in Social Psychology, 1-20.

[53] Sundaram, D. S., Mitra, K., & Webster, C. (1998). Word-of-mouth communications: A motivational analysis. ACR North American Advances.

[54] Cialdini, R. B., & Goldstein, N. J. (2004). Social influence: Compliance and conformity. Annu. Rev. Psychol., 55, 591-621.

[55] Preece, J. (2001). Sociability and usability in online communities: Determining and measuring success. Behaviour & Information Technology, 20(5), 347-356.

[56] Wellman, B., & Wortley, S. (1990). Different strokes from different folks: Community ties and social support. American Journal of Sociology, 96(3), 558-588.

[57] Chiu, C.-M., Hsu, M.-H., & Wang, E. T. G. (2006). Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories. Decision Support Systems, 42(3), 1872-1888.

[58] Cialdini, R. B., Green, B. L., & Rusch, A. J. (1992). When tactical pronouncements of change become real change: The case of reciprocal persuasion. Journal of Personality and Social Psychology, 63(1), 30.

[59] Hwang, A., Kessler, E. H., & Francesco, A. M. (2004). Student networking behavior, culture, and grade performance: an empirical study and pedagogical recommendations. Academy of Management Learning & Education, 3(2), 139-150.

[60] Hennig-Thurau, T., Gwinner, K. P., Walsh, G., & Gremler, D. D. (2004). Electronic word-of-mouth via consumer-opinion platforms: what motivates consumers to articulate themselves on the internet?. Journal of interactive marketing, 18(1), 38-52.

[61] Ajzen, I., & Fishbein, M. (1980). Understanding attitudes and predicting social behaviour.

[62] Fishbein, M., & Ajzen, I. (1975). Belief, attitude, intention and behaviour: An introduction to theory and research.

[63] Liao, C., Chen, J.-L., & Yen, D. C. (2007). Theory of planning behavior (TPB) and customer satisfaction in the continued use of e-service: An integrated model. Computers in Human Behavior, 23(6), 2804-2822.

[64] Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User

acceptance of information technology: Toward a unified view. MIS Quarterly, 425-478.

[65] Nysveen, H., Pedersen, P. E., & Thorbjørnsen, H. (2005). Intentions to use mobile services: Antecedents and cross-service comparisons. Journal of the Academy of Marketing Science, 33(3), 330.

[66] Terry, D. J., Hogg, M. A., & White, K. M. (1999). The theory of planned behaviour: self-identity, social identity and group norms. British Journal of Social Psychology, 38(3), 225-244.

[67] Hogg, M. A., & Abrams, D. (1988). Social identifications.

[68] Kim, Kim, & Shin. (2009). Modeling roles of subjective norms and eTrust in customers' acceptance of airline B2C eCommerce websites. Tourism Management, 30(2), 266-277.

[69] Lai, H.-M., & Chen, C.-P. (2011). Factors influencing secondary school teachers' adoption of teaching blogs. Computers & Education, 56(4), 948-960.

[70] Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. Information Systems Research, 6(2), 144-176.

[71] Carron, A. V, & Brawley, L. R. (2000). Cohesion: Conceptual and measurement issues. Small Group Research, 31(1), 89-106.

[72] Mäntymäki, M., & Riemer, K. (2014). Digital natives in social virtual worlds: A multi-method study of gratifications and social influences in Habbo Hotel. International Journal of Information Management, 34(2), 210-220.

[73] Lu, J., Yu, C.-S., Liu, C., & Yao, J. E. (2003). Technology acceptance model for wireless Internet. Internet Research, 13(3), 206-222.

[74] Micallef, N., & Arachchilage, N. A. G. (2017). Changing users' security behaviour towards security questions: A game based learning approach. 2017 Military Communications and Information Systems Conference (MilCIS), 1-6.

[75] Cheng, S., Lam, T., & Hsu, C. H. C. (2006). Negative word-of-mouth communication intention: An application of the theory of planned behaviour. Journal of Hospitality & Tourism Research, 30(1), 95-116.

[76] Baker, R. K., & White, K. M. (2010). Predicting adolescents' use of social networking sites from an extended theory of planned behaviour perspective. Computers in Human Behavior, 26(6), 1591-1597.

[77] Heijden. (2004). User acceptance of hedonic information systems. MIS Quarterly, 695-704.

[78] Wang, Z., & Scheepers, H. (2012). Understanding the Intrinsic motivations of user acceptance of hedonic information systems: Towards a unified research model. CAIS, 30, 17.

[79] Atkinson, M., & Kydd, C. (1997). Individual characteristics associated with World Wide Web use: an empirical study of playfulness and motivation. ACM SIGMIS Database: The DATABASE for Advances in Information Systems, 28(2), 53-62.

[80] Bhattacherjee, A. (2001). Understanding information systems continuance: an expectation-confirmation model. MIS Quarterly, 351-370.

[81] Srinivasan, S. S., Anderson, R., & Ponnavolu, K. (2002). Customer loyalty in e-commerce: an exploration of its

antecedents and consequences. Journal of Retailing, 78(1), 41-50.

[82] Jalilvan. (2012). The impact of electronic word of mouth on a tourism destination choice. Internet Research, 22(5), 591-612. https://doi.org/10.1108/10662241211271563

[83] Silverman, G. (2011). Secrets of word-of-mouth marketing: how to trigger exponential sales through runaway word of mouth. AMACOM Div American Mgmt Assn.

[84] Sen, S., & Lerman, D. (2007). Why are you telling me this? An examination into negative consumer reviews on the web. Journal of Interactive Marketing, 21(4), 76-94.

[85] Sawyer, R., Rowe, J., Azevedo, R., & Lester, J. (2018). Filtered Time Series Analyses of Student Problem-Solving Behaviors in Game-Based Learning. International Educational Data Mining Society.

[86] Söderlund, M., & Rosengren, S. (2007). Receiving word-of-mouth from the service customer: An emotion-based effectiveness assessment. Journal of Retailing and Consumer Services, 14(2), 123-136.

[87] Lai Ying, H., & Chung, C. M. Y. (2007). The effects of single-message single-source mixed word-of-mouth on product attitude and purchase intention. Asia Pacific Journal of Marketing and Logistics, 19(1), 75-86.

[88] Gruen, T. W., Osmonbekov, T., & Czaplewski, A. J. (2006). eWOM: The impact of customer-to-customer online know-how exchange on customer value and loyalty. Journal of Business Research, 59(4), 449-456.

[89] Pagulayan, R. J., Steury, K. R., Fulton, B., & Romero, R. L. (2003). Designing for fun: User-testing case studies. In Funology (pp. 137-150). Springer.

[90] Lazzaro, N. (2004). Why we play games: Four keys to more emotion without story.

[91] Csikszentmihalyi, M. (1990). The domain of creativity.

[92] Hamari, J., & Eranti, V. (2011). Framework for designing and evaluating game achievements. Proc. DiGRA 2011: Think Design Play, 115(115), 122-134.

[93] Lin, K.-Y., & Lu, H.-P. (2011). Why people use social networking sites: An empirical study integrating network externalities and motivation theory. Computers in Human Behavior, 27(3), 1152-1161.

[94] Wynder, M. (2004). Facilitating creativity in management accounting: a computerized business simulation. Accounting Education, 13(2), 231-250.

[95] Wynder, M. (2018). Visualising accounting concepts: insights from Cognitive Load Theory for English as a Second Language students. ACCOUNTING EDUCATION, 27(6, SI), 590-612. https://doi.org/10.1080/09639284.2017.1361847

[96] Fishbein, M., & Ajzen, I. (1975). Belief. Attitude, Intention and Behavior: An Introduction to Theory and Research Reading, MA: Addison-Wesley, 6.

[97] Hernandez, B., Montaner, T., Sese, F. J., & Urquizu, P. (2011). The role of social motivations in e-learning: How do they affect usage and success of ICT interactive tools? Computers in Human Behavior, 27(6), 2224-2232.

[98] Smith, A., Graetz, B., & Westerbeek, H. (2008). Sport sponsorship, team support and purchase intentions. Journal of Marketing Communications, 14(5), 387-404.

[99] Ringle, C. M., Wende, S., & Becker, J.-M. (2015). SmartPLS 3.

Boenningstedt: SmartPLS GmbH, Http://Www. Smartpls. Com.

[100] Hair, Sarstedt, Hopkins, & Kuppelwieser, G. (2014). Partial least squares structural equation modelling (PLS-SEM) An emerging tool in business research. European Business Review, 26(2), 106-121.

[101] Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. (2010). L.(2010). Multivariate data analysis. Pearson.

[102] Bock, G.-W., Zmud, R. W., Kim, Y.-G., & Lee, J.-N. (2005). Behavioural intention formation in knowledge sharing: Examining the roles of extrinsic motivators, social-psychological forces, and organizational climate. MIS Quarterly, 87-111.

[103] Chevalier, J. A., & Mayzlin, D. (2006). The effect of word of mouth on sales: Online book reviews. Journal of Marketing Research, 43(3), 345-354.

[104] Hamari, & Koivisto. (2015). Why do people use gamification services? International Journal of Information Management, 35(4). https://doi.org/10.1016/j.ijinfomgt.2015.04.006

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Increasing user awareness in various information and communication technology (ICT) activities is one of the most challenging tasks for organizations. One popular way to engage users in various domains is gamification, which is the use of game elements and digital game design techniques in non-game applications. By using game elements, applications become more attractive and provide benefits such as increased user activity and sociability, quality, and productivity of actions. Gamification is introduced in various stages of the software development lifecycle starting with the first phase of eliciting requirements to the final phases of testing and evaluation of the system to be. In parallel, the introduction of game elements in non-games raises a number of security and privacy issues. This book presents innovative research efforts and technical solutions related to gamification and improving user engagement in all stages of the development process.

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