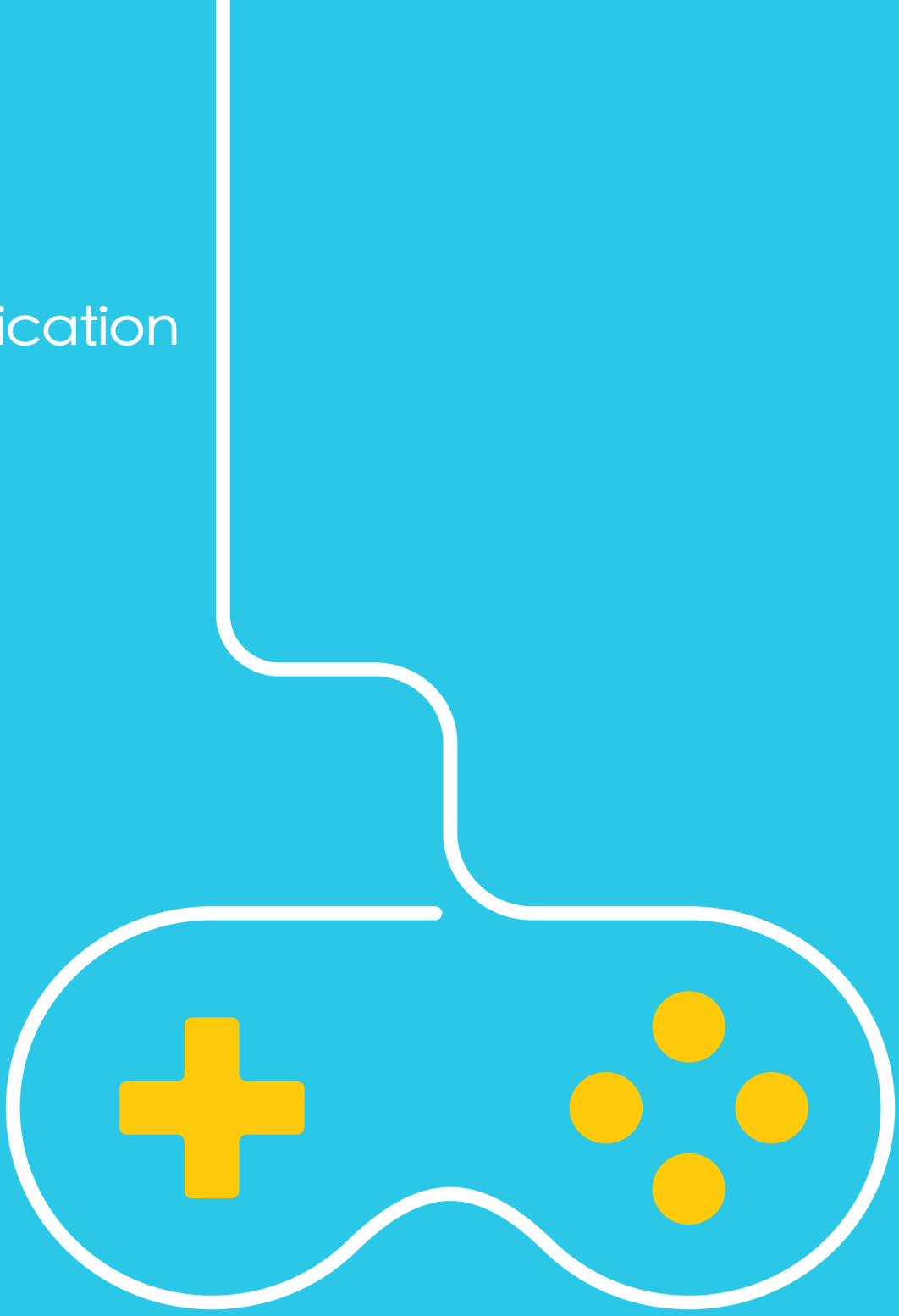
User-Centered Adaptive Gamification

Martin Böckle



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Mag.rer.nat Martin Böckle

born on January 9th, 1985 in Feldkirch, Austria

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Doctoral examination committee:

Head: Prof. Dr. Houdou Basse Mama, ESCP Business School, Berlin, Germany

Examiner: Prof. Dr. Markus Bick, ESCP Business School, Berlin, Germany

Examiner: Priv.-Doz. Dipl.-Ing. Dr.techn. Martin Ebner, University of Technology Graz, Austria

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Overview of Research Output

ID	Title	Authors	Type of publication	VHB	Status	Points
MA1	Towards Adaptive Gamification: A Synthesis of Current Developments	Böckle, Martin; Novak, Jasminko; Bick, Markus;	Proceedings European Conference on Information Systems (ECIS)	B	Published	0.66
MA2	A Design Framework for Adaptive Gamification Applications	Böckle, Martin; Isabel, Micheel; Markus, Bick; Jasminko, Novak;	Proceedings Hawaii International Conference on System Sciences (HICSS)	C	Published	0.37
MA3	A Design Theory of User-Centered Score Mechanics for Gamified Competency Development	Böckle, Martin; Novak, Jasminko; Bick, Markus;	Journal Journal of the Association for Information Systems (JAIS)	A	Passed Desk Reject	1.00
MA4	Exploring gamified persuasive system design within energy saving environments	Böckle, Martin; Novak, Jasminko; Bick, Markus;	Journal Journal of Enterprise Information Management	C	Revise and Resubmit (third round)	0.50
SM1	Designing at the Intersection of Gamification and Persuasive Technology	Böckle, Martin; Yeboah-Antwi, Kwaku;	Proceedings Lecture Notes in Computer Science (LNCS)	C	Published	0.75
SUM						2,53

N.B.: The manuscripts shaded grey and in italic font are included in the dissertation at hand. The points (1.0) from LNCS are not included in the sum of points above.

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List of Abbreviations

ACM	Association for Computing Machinery
ANOVA	Analysis of variance
DP	Design principles
DR	Design requirements
DSR	Design Science Research
ECIS	European Conference on Information Systems
EIPCM	European Institute for Participatory Media
EU	European Union
GST	Goal-Setting Theory
HCI	Human-Computer Interaction
HICSS	Hawaii International Conference on System Sciences
HVSG	Humboldt-Viadrina School of Governance
IS	Information Systems
ISDT	Information System Design Theory
ITS	Intelligent tutoring system
JAIS	Journal of the Association for Information Systems
JEIM	Journal of Enterprise Information Management
KST	Knowledge Space Theory
MA	Manuscript
MDA	Mechanics, Dynamics, Aesthetics
PLS-SEM	Partial Least Squares Structural Equation Modeling
RM-ANOVA	Repeated measure analysis of variance
SDT	Self-determination theory
SLR	Structured Literature Review
TUG	University of Technology Graz
UCD	User-Centered Design
UTAUT	Unified theory of acceptance and use of technology

Chapter 1

Introduction

Since the introduction of gamification "as the use of game design elements in non-game contexts" (Deterding et al., 2011, p. 10), the emerging trend has received great attention in the information systems (IS) community as a method to create playful experiences to support the end-user's overall engagement (Huotari & Hamari, 2012). Generally, the concept aims to introduce successful game elements (e.g., badges, leaderboards, levels, etc.) into a business context to increase end-user motivation. Well-known real-world examples include DuoLingo[1], a mobile application to study languages, and Stackoverflow[2], a question-and-answer platform for programmers that applies scores and badges to increase their knowledge-sharing activities. Gamification has been defined by several scholars such as Werbach (2014), who has described it as "the process of making activities more game-like" (Werbach, 2014, p. 266) with the aim of enhancing the overlap between the perspectives of academics and practitioners. Furthermore, Huotari & Hamari (2012) have examined gamification from a service-marketing angle and have defined the approach as "a process of enhancing a service with affordances for gameful experiences in order to support users' overall value creation" (Huotari & Hamari, 2012, p. 19). Although several approaches have been discussed within the present body of gamification literature, this doctoral thesis is aligned with the widely accepted definition by Deterding et al. (2011) cited in the introductory sentence.

Moreover, this thesis relates to the mechanics, dynamics, and aesthetics (MDA) framework

[1] `https://www.duolingo.com/`

[2] `http://stackoverflow.com/`

proposed by Hunicke et al. (2014), wherein the mechanics represent the rules of the game, the dynamics the run-time behavior of the mechanics, and the aesthetics the emotional response by the end-users. Generally, the term "game design elements" (Deterding et al., 2011) is used as a more general description, which summarizes the three terms mentioned above.

Since the concept of gamification has been applied and studied in many domains such as health (Miloff et al., 2015; Sardi et al., 2017; Alahäivälä & Oinas-Kukkonen, 2016), education (Huang & Hew, 2018; Roy & Zaman, 2018; Santhanam et al., 2016), and business (Suh et al., 2017; Carignan & Kennedy, 2013; Stanculescu et al., 2016), the endeavor of gamification research emerged in two waves. While the first wave mainly highlights definitions, frameworks, and gamification taxonomies (Nacke & Deterding, 2017), the second wave reveals a higher level of maturity by covering theory-driven empirical studies, design methods, and application areas (Nacke & Deterding, 2017).

Specifically, within the first wave, well-known gamification research by Hamari et al. (2014) has focused on the investigation of fundamental questions like "Does gamification actually work, and why?" (Nacke & Deterding, 2017). Identified studies have been clustered into psychological outcomes, where criteria like motivation, attitude, and enjoyment play a major role, whereas, the second cluster highlights gamification research, where behavioral outcomes like the level of engagement or participation after the application of game design elements play a major part. Within this first wave, gamification has emerged as a discipline where mainly gamified prototypes and services have been evaluated. Scholars simply aimed to show the effects between gamified versus non-gamified services (Rapp et al., 2018).

Subsequently, the second wave of gamification research intends to understand how individual game-design elements are perceived by different types of users. For instance, Nacke & Deterding (2017) have highlighted that fundamental questions like "how?", "when?", and "how and when not?" are dominating this research stream. An example is Morschheuser et al. (2017), who proposed a method of how to gamify by considering best practices within the gamification

design process. Relevant research within this stream has also been proposed by Mekler et al. (2017), who have revealed effects of individual game-design elements on motivation and performance. Within this wave, authors have suggested the importance of systematic research focusing on challenges and methods of how to design gamification by considering the application context and the end-users at the same time. This is especially vital because people are motivated differently (McAdams, 1995), and major tasks that need to be gamified tend to have various contextual characteristics.

One major issue of gamification research and present gamification studies in general involves the shortcomings of the one-size-fits-all approach. This is particularly true for standard solutions that do not consider distinctions in the target group or the fact that certain game-design elements are perceived differently. Accordingly, to design user-centered gamification approaches, there is a need to understand which gamification mechanics and dynamics actually create enjoyment and improve end-users' engagement by considering their personalities, needs, and motivations (Codish & Ravid, 2015; 2014b; Klock et al. 2015). Moreover, the effectiveness of gamification approaches is often mixed, is highly context specific, and shows different outcomes among individuals (Seaborn & Fels, 2015; Koivistio & Hamari, 2014; Blohm et al., 2013, Hamari et al., 2014), all of which represents the challenges of this doctoral thesis and suggests the need for further research in this direction.

Consequently, this doctoral thesis focuses on the emerging and fast-growing research stream of adaptive gamification and aims to provide a fundamental understanding of how to enhance traditional gamification approaches with user-centered, personalized incentive mechanisms. The proposed manuscripts (M1–M4) provide research results that can be categorized within the second wave of gamification research, discussed by Nacke & Deterding (2017).

Existing research links to related concepts like the approach of meaningful gamification by Nicholson (2012), which considers the end-user's background and organizational context of the task. Similarly, the framework for meaningful engagement, proposed by Liu et al. (2017),

suggests that the overall gamification design should not only result in enjoyable experiences to increase end-user engagement but also provide job-related instrumental benefits like learning new skills. Although these approaches suggest that there is a need for more meaningful gamification design, the proposed method of adaptive gamification emphasizes the holistic nature of the design and development of its applications by tailoring personalized incentive mechanisms to different characteristics of individual users and contexts. Thus, this doctoral thesis contributes to this fast-growing research stream by addressing the following objectives:

(a) Review the classifications and challenges of current adaptive gamification approaches discussed in the present body of gamification literature

(b) Investigate how to systematically design adaptive gamification applications

(c) Analyze how to apply the score mechanic in a user-centered way

(d) Explore the design of gamified persuasive systems by considering the application of the gamification user types and the application context

The following chapter highlights related concepts and reveals the idea behind user-centered adaptive gamification, including the anatomy of gamification research. Followed by the dissertation structure, which reveals research objectives and questions, the manuscripts are presented in the fourth chapter. The discussion includes key findings and major contributions followed by the final remarks.

Chapter 2

Gamification:
A New Paradigm for Creating Gameful Experiences

2.1 Background

Since the introduction and definition of gamification by Deterding et al. (2011), this approach has emerged as a research discipline with a significant rise in maturity (Nacke & Deterding, 2017). The research stream currently covers a wide variety of application domains like health, workplace engagement, crowdsourcing, and marketing (Seaborn & Fels, 2015). With roots in marketing, where well-known concepts like rewards and membership cards have been introduced, gamification has also undergone various movements like cheap sensors for tracking personal behavior and case studies like Nike+ and Foursquare, which highlighted the application of gamification as a great success (Deterding, 2012).

Before the emergence of the gamification research stream, similar concepts and terms have been discussed within literature. For instance, the actual idea of transferring game elements into different contexts has been investigated by Malone (1982), who proposed heuristics for designing enjoyable user interfaces. Approaches like variable difficulty levels, performance feedback, and the optimal degree of information complexity to challenge a variety of users have been researched, which underscores first adaptive attempts with similar objectives.

Since the field has gained maturity and attraction for professions such as user experience designers (Deterding et al., 2011), terms like motivational affordances, defined as the "prop-

erties of an object that determine whether and how it can support one's motivational needs" (Zhang, 2008, p. 1) have been mentioned within literature and applied by gamification scholars (Hamari et al., 2014). A similar concept as hedonic attributes relates to personal psychological well-being, for example, excitement or stimulation, while pragmatic attributes focus more on functional characteristics like utility and usability (Hassenzahl, 2003).

At the same time, researchers have introduced several approaches under the umbrella of gamification. Firstly, there are games with a purpose, a concept where end-users collectively solve large-scale problems by playing computer games since the designed tasks are relatively simple for individuals (e.g., tagging images, translating text, etc.) but still challenging enough for computer programs (Ahn 2006; Ahn & Dabbish, 2008). Secondly, the rather well-known concept of serious games "do not have entertainment, enjoyment, or fun as their primary purpose" (Michael & Chen, 2005, p. 21) and range from application domains like education and training to the military (Laamarti et al., 2014). Thirdly, playful design aims to provoke end-users toward an emotional response with game-based aesthetics but with limited usability (Borges et al., 2013). Furthermore, Borges et al. (2013) have provided a visualization (Fig. 1) where the different concepts are compared regarding video games, which contain a high level of interactivity.

Finally, all these parallel, interrelated concepts and trends share similarities, but the aim of researchers was to develop an academic definition that highlights and situates previous gamified concepts by analyzing their relationships to each other. The proposed definition by Deterding et al. (2011) used in this thesis is positioned against the aspects of gaming and playing, including their degrees (parts/whole). Since serious games make use of fully fledged game environments, gamification can be distinguished by the dimensions of wholes and parts (Fig. 2 – Deterding et al., 2011):

Although the boundaries between the related concepts are somewhat blurry, the concept of

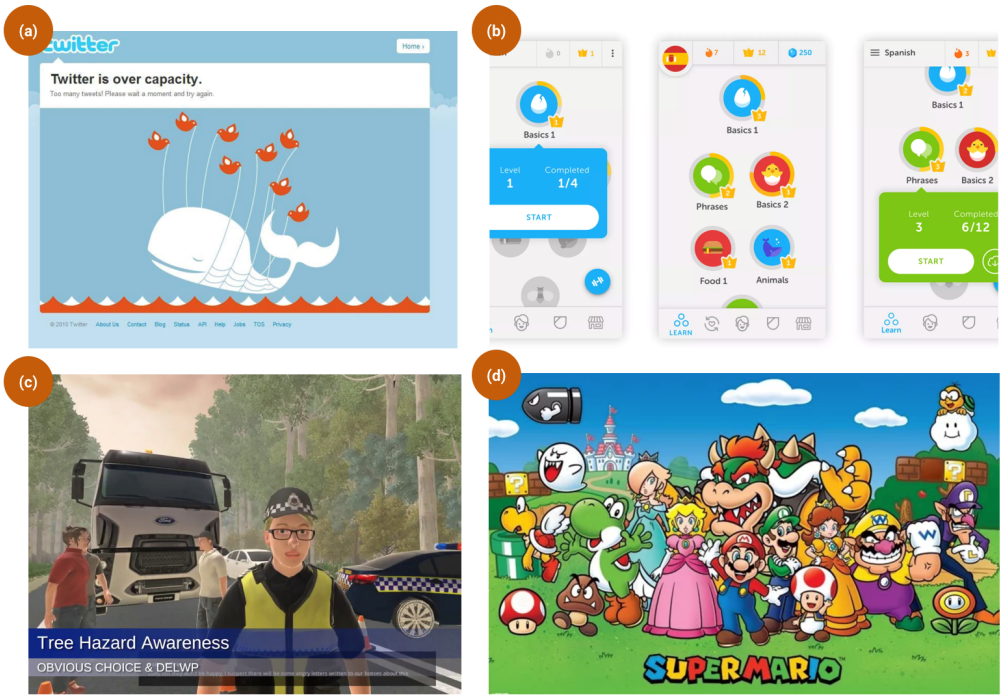

Figure 1: (a) Playful design, (b) Gamification, (c) Serious games, and (d) Digital games

gamification should always be used for non-entertainment purposes and be inspired by games and their components, specifically those that do not require a full-fledged environment (Seaborn & Fels, 2015).

2.2 User-centered adaptive gamification: what it is and why it is important

Within the last several years, gamification has become a well-established technique in the field of human-computer interaction (HCI) (Rapp et al., 2018), although the research stream is still facing various challenges. One of them is the lack of applied theory in practice (Seaborn & Fels, 2015) since the main objective of gamification approaches is to increase the end-user engagement and provoke behavior change, which entails a high level of complexity. Further-

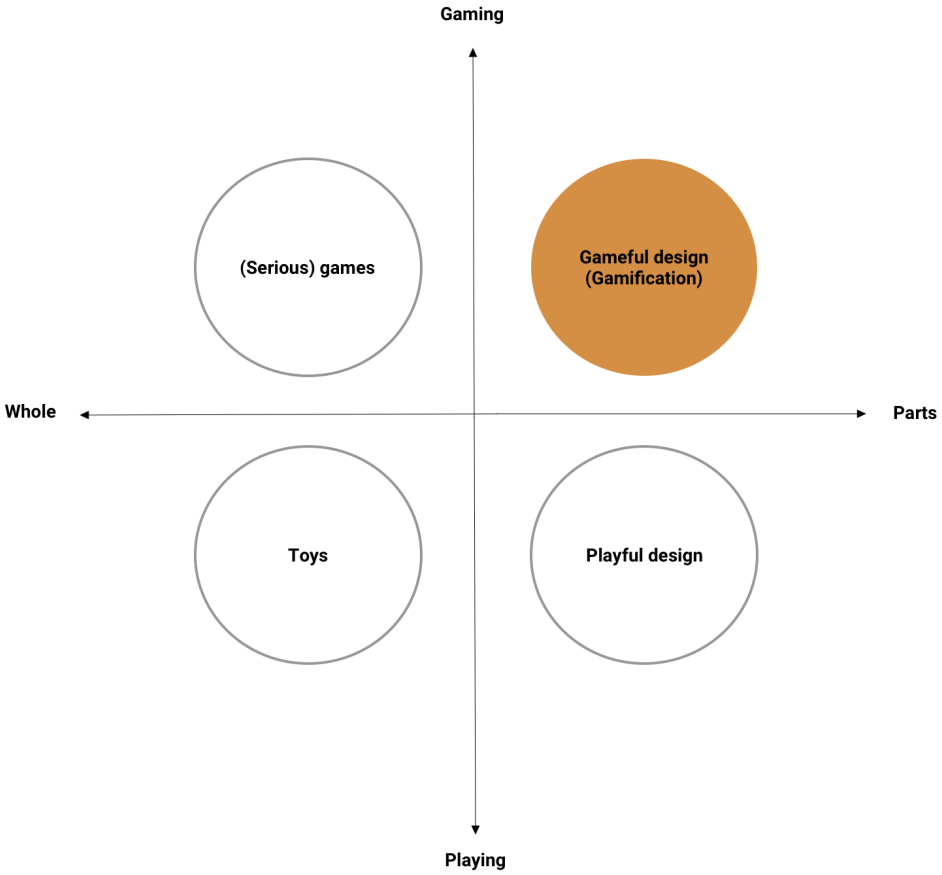

Figure 2: Gamification between game and play, whole and parts

more, methods and techniques of how to actually apply game-design elements remain majorly unchanged and are still matters of concerns.

Therefore, the second wave of gamification research aims to contribute more theory-driven approaches with a strong focus on how specific game-design elements work. This also includes how they are applied in the corresponding application domain and how they are perceived by different individuals. Such characteristics, which aim to overcome the one-size-fits-all approach, build the basis for the concept of user-centered adaptive gamification, highlighted in this doctoral thesis. The approach consists of several items summarized and derived from the

present body of gamification literature (Fig. 3) and highlighted by Rapp et al. (2018).
Furthermore, existing work in the literature has been identified but with a limited scope. Firstly, the notion of adaptive gamification has primarily been used by Monterrat et al. (2015) as an approach to personalize gamification by proposing an architecture that adapts game elements in the user interface, based on a player model. Secondly, the initial framework of Codish & Ravid (2014a) highlights initial ideas by proposing an analytics engine. The approach suggests to monitor the end-user engagement, creates user patterns, and informs the adaptive gamification engine to update the front-end layers accordingly and optimize the level of engagement (Codish & Ravid, 2014a). These approaches represent first steps and ideas toward adaptive gamification design, but there is little empirical work that can validate the effectiveness of such concepts. Therefore, this doctoral thesis aims to provide a holistic approach of how to design adaptive gamification and to contribute through empirical work within the information systems (IS) discipline to derive design knowledge for this fast-changing and advancing field of gamification research.
Generally, user-centered adaptive gamification describes the present movement within literature, especially the need for enhanced gamification approaches, by considering the following components:

- Context: This describes the consideration of contextual factors, for example, the complexity and type of processes to be gamified, which often differ inside the application context (e.g., health, crowdsourcing, workplace gamification, etc.). Morschheuser et al. (2018) have also considered characteristics like the underlying technology, platform, and architecture as important contextual factors within gamifying IS. Furthermore, contextual factors also include design-related decisions, for instance, when to apply which gamification elements or in which situation or context the end-user should be informed by the feedback mechanic.

- Analytics: For the design of adaptive gamification application, data analytics play a major role in the analysis of behavioral data (e.g., usage data like number of clicks, visits, and task success) to update or inform the predefined user models. User events are analyzed and connected to the game design elements to enable adaptive gamification solutions like the degree of difficulty in reaching levels (e.g., time and score) within the gamified IS. Heilbrunn et al. (2014) have introduced data-driven gamification design and reveal insights into specific opportunities to measure behavioral data to constantly improve the defined incentivization model.

- Personalization: This aspect is strongly related to analytics and represents the results of those measurements. By analyzing behavioral data, personalized gamification solutions (e.g., personalized feedback, personalized goals) are defined. Furthermore, personalization is part of the overall term or philosophy of user-centered design (UCD) but in this case relates to the personalization of game-design elements based on user models and analytics. For example, Miloff et al. (2015) have proposed customized challenges and personalized feedback inside an e-health application for social anxiety disorder, and Challco et al. (2016) have highlighted personalized gamified collaborative learning scenarios.

- User-centered design: The application of UCD within the gamification domain is becoming increasingly important (Chen, 2019). Since the approach or design strategy covers a whole process, the previously discussed components like analytics and context are part of the described phases, visualized in Figure 3.

For the design of adaptive gamification solutions, this thesis focuses on several aspects where UCD principles are applied as part of it. First is the end-users and their relationships to individual game-design elements. This is also heavily discussed in in the literature, where gamification scholars aim to identify the effects of individual gamification mechanics, for example, on end-user activities (Hamari, 2017) or intrinsic motivation and performance (Mekler

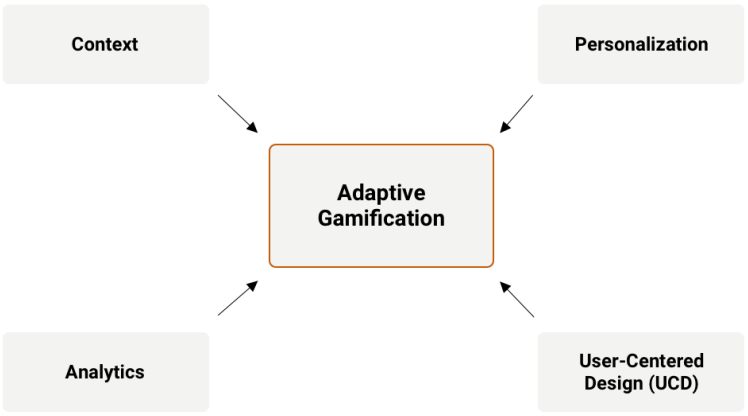

Figure 3: User-centered adaptive gamification

et al., 2017). Second is the concept of player typologies, which is still in its infancy but of major importance since user types provide a high degree of personalization. Third, theories have often been neglected in the design of novel gamification solutions and must be considered within UCD approaches or strategies, specifically in the phase where solutions are designed (Phase 3, Figure 4).

Most gamification approaches, which align design decision to a theory, use the self-determination theory or intrinsic and extrinsic motivation as their theoretical foundation (Seaborn and Fels, 2015). For instance, the study by Shi & Cristea (2016) has defined their design principles towards autonomy (e.g., flexible choice), competence (e.g., reasonable learning goals), and relatedness (e.g., reputation, etc.), the three components of self-determination theory (SDT).

In summary, user-centered adaptive gamification aims to provide personalized incentive mechanisms tailored to different user characteristics to improve gamification effects (Scott et al., 2014; Codish & Ravid 2015) by considering data-driven design approaches and contextual application factors. The relevance of this novel research stream results from the limitations of standard gamification applications. Early gamification scholars simply focused more or less on

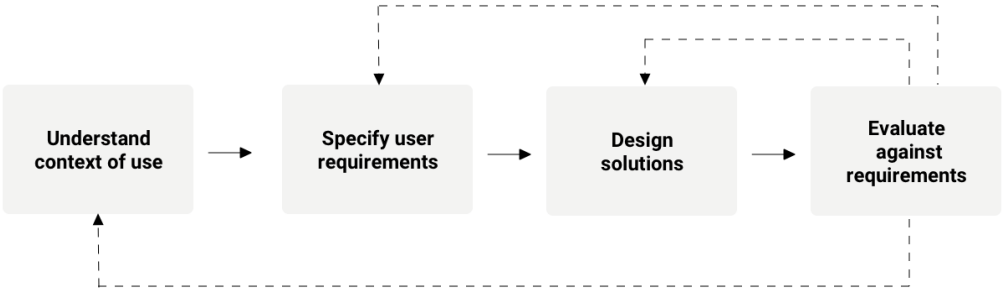

Figure 4: User-centered design (Interaction Design Foundation, 2019)

the demonstration that gamified systems produce a better outcome than non-gamified systems (Rapp et al., 2018). However, research has also shown that the effectiveness of gamification approaches is often mixed and context specific, varying among individuals (Hamari et al. 2014; Seaborn & Fels, 2015). One reason, explained by motivation theories and also discussed in the literature, is that different people are motivated differently, and there is a need to understand which gamification mechanics and dynamics create enjoyment by considering distinct personalities, needs, values, and motivations (Codish & Ravid, 2014b, 2015; McAdams, 1995; Klock et al., 2015). Specifically, the loss of interest and engagement over time requires an adaptive approach that dynamically re-engages users (Scott et al., 2014).

This doctoral thesis specifically highlights a synthesis of current developments in the present body of gamification literature (MA1). Based on these results, a design framework for the systematic development of adaptive gamification is proposed, which also reveals possible challenges in the design process (MA2).

Within this framework, the characteristics and potential of player types are shown by investigating the relationship between HEXAD user types (e.g., socializer) and persuasive strategies (e.g., Goal setting and suggestion). These are applied within the design of a prototype to provoke energy-saving behaviors (MA4). End-users are asked how they perceive different storyboards that contain the persuasive strategies. Furthermore, existing energy-saving behaviors

and their effects on the perceived persuasiveness are considered as well. The aim of this study is to explore user-centered design possibilities and contribute to the research stream of adaptive gamification applications.

Finally, an information system design theory (ISDT), which explains how to apply the score mechanic in a user-centered way, is developed (MA3). This is particularly important since design knowledge in this context is scarce.

2.3 The anatomy of gamification research

Seaborn & Fels (2015) have explored gamification from theoretical and practical angles by conducting a rigorous survey. Results reveal theoretical foundations used in gamification frameworks, for instance, intrinsic and extrinsic motivation or the self-determination theory proposed by Ryan & Deci (2008), which emphasizes the concepts of competence, relatedness, and autonomy within the design of gamification approaches.

Regarding intrinsic and extrinsic motivation, Nicholson (2012) has proposed a user-centered framework built mainly upon internal motivation factors since elements of extrinsic motivation have been perceived as negative (Seaborn & Fels, 2015). Further concepts have been highlighted by Seaborn & Fels (2015), for example, situated motivational affordance, proposed by Deterding et al. (2011), which requires the match between the end-users' characteristics and the general gamification approach. Furthermore, the present body of gamification research provides a variety of articles that emphasize and describe the relationship between different game-design elements (Ferro et al., 2013), personalities, and player typologies. These articles support motivational aspects for both sides (extrinsic and intrinsic) to accomplish certain tasks and emphasize the potential of user-centered gamification design.

Moreover, a major issue of gamification research is the variation in the use of terms and concepts (Seaborn & Fels, 2015) for addressing similar challenges. Several authors have also

mentioned that the reviewed gamification frameworks have been developed in isolation and must be validated to ensure applicability.

Generally, results by Seaborn & Fels (2015) have highlighted typical application domains of the gamification approach, namely, education, health, online communities, crowdsourcing, and sustainability. Real-world examples include the Khan Academy[3], a platform for online learning courses; Duo Lingo, an application for learning languages; and MySugr[4], a health application that supports people with diabetes. A well-known online community for software developers is Stackoverflow, which uses gamification elements (e.g., badges, scores, etc.) for knowledge exchange. In this context, empirical research has been conducted by Bosu et al. (2013) to emphasize the activities to earn reputation points quickly.

One of the emerging trends within the present body of gamification research is workplace gamification to support and motivate employees in the accomplishment of their daily tasks, specifically within enterprise systems (El-Telbany & Elragal, 2017).

However, Seaborn & Fels (2015) have identified four major issues regarding theory and applied research on gamification. Firstly, there are inconsistencies in the definition of the term "gamification" in the present body of literature. Secondly, the interpretations of theoretical foundations used within gamification studies are often contradictory. Thirdly, much of the theory lacks empirical validation, while gamification studies do not relate to any theory at all, which generally limits the growth of the gamification research stream. Fourthly, there is a lack of research on the effects of gamification features on participants' performance and enjoyment (Seaborn & Fels, 2015); the findings show a positive tendency, but the effectiveness of gamification is often mixed and highly context specific (Hamari et al., 2014).

Nonetheless, Seaborn & Fels (2015) have suggested that the success of gamification approaches may increase if the overall design is informed by the end-user's intrinsic motivators. There-

[3] `https://www.khanacademy.org/`

[4] `https://mysugr.com/en-us`

fore, the challenge is to identify the individual differences in end-users' motivations (what is intrinsically motivating) and meet the objectives and requirements at the same time. Results from their survey reveal the usage of UCD to cover a broad range of individual interests and needs and to describe individual intrinsic motivators. Consequently, the authors state that "there may not be an ideal gamified system—an optimal combination of game elements, mechanics, and dynamics that always works; instead, gamified systems may need to be selectively designed given the individual makeup of the end-user population or even designed flexibly and inclusively, allowing for personalization and customization, to accommodate individual users" (Seaborn & Fels, 2015, p. 28), which justifies the need for and focus of this doctoral thesis.

Finally, Seaborn & Fels (2015) have emphasized several topics that may improve the maturity of the present gamification research field. Firstly, there is an expectation of a more diversified playing field in terms of application domains, contexts, and elements since few game-design elements receive higher attention. Secondly, regarding the research design, the majority of gamification studies did not conduct any statistical analysis or isolate the effect of gamification. Thirdly, as mentioned previously, there is a disconnect between existing theories and applied work. Furthermore, what is currently missing is the investigation of the usefulness of specific game elements. There are several studies within the present gamification literature (e.g., Mekler et al., 2017), but more empirical studies that highlight the effectiveness of those elements are necessary.

Chapter 3

Dissertation Structure

3.1 Introduction to the research manuscripts

The corpus of this doctoral thesis is composed of four manuscripts (M1–M4) to introduce user-centered adaptive gamification and make a valuable contribution within this emerging and fast-growing research stream. Figure 5 highlights the order of the individual manuscripts and their type of contribution within this doctoral thesis. MA1 identifies existing concepts within the literature and highlights main issues and challenges for designing adaptive gamification applications. Based on the results, a design framework for adaptive gamification application has been proposed (MA2), which provides guidelines to assist the design practice. Within this framework, two out of four elements are investigated in more detail. Firstly, MA3 focuses on the development of a design theory of user-centered score mechanics and belongs to the element of adaptive game mechanics and dynamics, of which score is a sub-element. Secondly, the application and analysis of the HEXAD user-type framework is part of M4 and relates to adaptivity criteria, wherein player type is a sub-element.

The four manuscripts are discussed as along with their main characteristics and roles within this doctoral thesis. Since M2 and M3 follow the design-science research (DSR) approach, which is portrayed as a problem-solving paradigm, the overall structure of this dissertation is aligned to DSR. Consequently, this approach embodies the theoretical and practical contribution in the field of IS. Informed by MA1, the outcome or artifact of MA2 is represented by the proposed design framework, which builds the base for the following two manuscripts (MA3 and MA4).

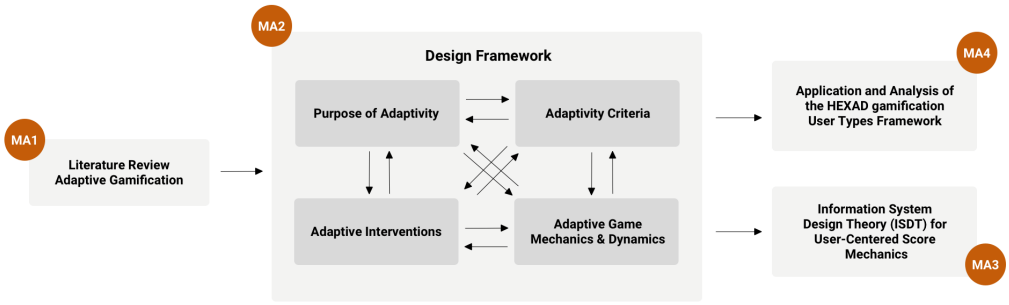

Figure 5: Overview of the four manuscripts and their interrelationships

While MA4 addresses the potential of applying user-type models, M3 proposes an ISDT with a focus on the score mechanic. Moreover, design theories "allow the prescription of guidelines for further artifacts of the same type" (Gregor and Jones, 2007, p. 322).

MA1, a structured literature review (SLR) titled "Towards Adaptive Gamification: A Synthesis of Current Developments," was presented at the European Conference on Information System (ECIS) and informs the following three studies, particularly MA2. To conduct an SLR, the methodology proposed by vom Brocke et al. (2009) and guidelines from Webster and Watson (2002) have been applied. The analysis process reveals 43 studies, which have been identified through the following search query: gamif* AND adapt* OR personal* OR contextual* OR user-cent* OR analytics.

Furthermore, results are organized into categories by considering research on adaptive education hypermedia from Specht and Burgos (2007), who have discussed a classification scheme for adaptive methods by defining the following questions: "What is adapted?", "To which feature?", "Why?", and "How?"

Taking these aspects into consideration, the following cluster criteria are defined: (1) purpose of adaptivity, (2) adaptivity criteria, (3) adaptive game mechanics and dynamics, and (4) adaptive interventions. These criteria also build the main elements for the second manuscript (MA2) and are classified by sub-elements; for instance, adaptivity criteria contains usage data

and level of knowledge.

Finally, MA1 reveals the need for adaptive gamification solutions and informs practitioners by presenting five challenges for the design of such solutions.

MA2, "A Design Framework for Adaptive Gamification Applications," presented at the Hawaii International Conference on System Sciences (HICSS), builds on the results of MA1 by creating a design framework to inform the systematic development of adaptive gamification applications. Accordingly, the four pillars identified in MA1 building the main architecture of the proposed framework, which is validated through a real-world prototype to demonstrate its applicability. Moreover, for the development of the proposed framework, the DSR approach, proposed by Hevner et al. (2004), is applied. Within this process, design principles have been derived from the literature to inform researchers and practitioners in the design of such solutions and show how scientific findings can be related to the design practice (Koppenhagen et al., 2012).

Finally, to support practitioners in the application of the proposed framework, four different design paths, representing the logical connection between each element, are suggested to highlight design possibilities with individual starting points. One single design path refers to the series of steps that could be used as guidance within the process of designing adaptive gamification solutions.

MA3, "A Design Theory of User-Centered Score Mechanics for Gamified Competency Development," develops a design theory of user-centered score mechanics, which assists both researchers and practitioners in building gamified environments to foster and support work-related competencies and employee motivation. The manuscript has been submitted to the *Journal of the Association for Information Systems (JAIS)*.

MA4, "Exploring gamified persuasive system design for energy saving," which has been submitted to the *Journal of Enterprise Information Management (JEIM)*, focuses on the exploration of UCD possibilities at the intersection of gamification and persuasive technology to foster energy-saving behaviors.

To explore design-related possibilities in this specific application domain, the relationship between HEXAD gamification user types (Socializers, Philanthropists, Free spirits, Achievers, Players, and Disruptors), proposed by Tondello et al. (2016), and selected persuasive strategies (Self-monitoring and feedback, Goal setting and suggestion, Competition, Simulation, Personalization, Reward, and Social comparison) is investigated. Generally, MA4 investigates how different user types perceive various persuasive strategies to then design user-centered adaptive gamification applications. Furthermore, the role of existing energy-saving behaviors (e.g., turning off the lights when leaving a room) and their mapping concerning the proposed player types and strategies are investigated in a second step.

3.2 Research objectives and questions

The objective of this doctoral thesis is to explore how to systematically design user-centered adaptive gamification solutions by identifying main categories and challenges that define the architecture of design solutions within this emerging and fast-growing research stream. Research questions of the four manuscripts are summarized in Table 2.

Generally, MA1 and MA2 build the base of this doctoral thesis. Firstly, MA1 identifies existing concepts and approaches that contain a high degree of personalization and adaptivity in the present body of gamification literature. Secondly, MA2 proposes a framework that contains the major elements (purpose of adaptivity, adaptivity criteria, adaptive interventions, and adaptive game mechanics and dynamics) identified in MA1 to inform the systematic development of such solutions.

Table 1: Overview of manuscripts

Manuscript No.	1	2	3	4
Title	"Towards Adaptive Gamification: A Synthesis of Current Developments"	"A Design Framework for Adaptive Gamification Applications"	"A Design Theory of User- Centered Score Mechanics for Gamified Competency Development"	"Exploring Gamified Persuasive System Design for Energy Saving"
Authors	Böckle, Martin; Novak, Jasminko; Bick, Markus	Böckle, Martin; Micheel, Isabel; Bick, Markus; Novak, Jasminko	Böckle, Martin; Novak, Jasminko; Bick, Markus	Böckle, Martin; Novak, Jasminko; Bick, Markus
Outlet	*European Conference on Information Systems*	*Hawaii International Conference on System Sciences*	*Journal of the Association for Information Systems*	*Journal of Enterprise Information Management*
VHB Ranking	B	C	A	C
Associated Points	0.66	0.37	1	0.5
Publication Status	Published	Published	Passed desk reject	Revise and resubmit (third round)
Research Method	Query scientific databases (ACM Digital Library, Scopus, etc.)	DSR	DSR, cluster analysis, descriptive statistic UTAUT questionnaire	Visual storyboards, partial least squares structural equation modeling (PLS- SEM), one-way and repeated measures (ANOVA)
Applied Frameworks and Theories	Five phases for conducting a structured literature review (vom Brocke et al., 2009)	DSR process model (Peffers, 2007), Unified theory of acceptance and use of technology (UTAUT)	Components of an ISDT (Gregor and Jones, 2007), knowledge space theory (KST), self-determination theory (SDT), UCD, goal-setting theory (GST), meaningful gamification and engagement UTAUT	HEXAD gamification user types framework (Tondello et al., 2016)

Table 2: Research questions and hypotheses within the individual manuscripts

Manuscript	Research question
MA1	What are the main objectives, elements, and challenges of current research regarding the development of adaptive gamification approaches?
MA2	What are the main elements and challenges that must be addressed for the design of adaptive gamification applications?
MA3	Which elements must be considered for the definition of the main constructs of an ISDT that aims to support user-centered score mechanics for gamified competency development? Defined Hypotheses: **H1:** The overall gamification approach of the proposed ISDT fosters the accomplishment of tasks within the platform alpha and, therefore, supports the competency development process. **H2a:** The design of the score classes motivates end-users to carry out more of the active contribution tasks (e.g., creating a medical case, commenting on a case). **H2b:** The design of the score classes prevents the possibility of outsmarting the scoring system. **H3:** The defined competency thresholds (levels) should motivate physicians to accomplish more tasks to move up to higher levels. **H4:** The gamified competency visualization tool of the alpha platform is well received by the end-users.
MA4	**RQ1:** To which extent do the different HEXAD user types respond to various persuasive strategies when these are applied to the design of a persuasive system for energy saving? **RQ2:** How do users' existing energy-saving behaviors influence perceived persuasiveness of different persuasive strategies for energy saving?

Furthermore, in MA1, the identified studies (n = 43) are clustered and classified in an iterative process, resulting in a conceptual matrix. The main goal of this matrix is to provide a holistic overview of existing approaches by highlighting which sub-categories are most prominent; for instance, recommendations and suggestions comprise the highest quantity in the category of adaptive interventions. MA3 and MA4 go into more detail of specific element criteria from the proposed framework—score mechanic and user-type models, respectively—and reveal how to apply these in a meaningful way.

Moreover, this thesis, specifically within MA1, provides an overview of current challenges and future research directions when designing for such solutions. Additionally, in MA3, practitioners receive valuable insights into how to apply the score mechanic in a user-centered way by putting the focus on the mapping process between the virtual tasks and the real-world competencies. Finally, the potential of applying user-type models and existing energy-saving behaviors, which has a high practical relevance, has been demonstrated.

Table 2 summarizes the research questions and hypotheses within the individual manuscripts. To state it in a more detailed way, the objective of MA2 is to provide a framework for the systematic development of adaptive gamification application. This should not be misunderstood to mean that the proposed framework represents the entire design process but rather an approach that provides guidance for researchers and practitioners in designing such solutions. Specifically, the practice of designing gamification solutions often involves the enhancement of already existing systems since the concept of gamification aims to increase overall engagement. Although only two elements of the proposed framework are investigated in more detail, the application within the health domain reveals the high degree of flexibility when defining the gamification model. Finally, the identified challenges in MA1 have been integrated in the design framework and aim to inform system designers about design aspects that should be considered. Generally, the proposed framework aims to flexibly and easily support the development of novel gamification solutions but also focus on the enhancement of standard gamification applications,

which may reveal a decline of end-user engagement.

MA3 proposes a design theory for the application of user-centered score mechanics. Objectives are the development of a theory that supports the actual competency development process while motivating end-users in solving virtual tasks on the platform, tested by the first hypothesis (H1).

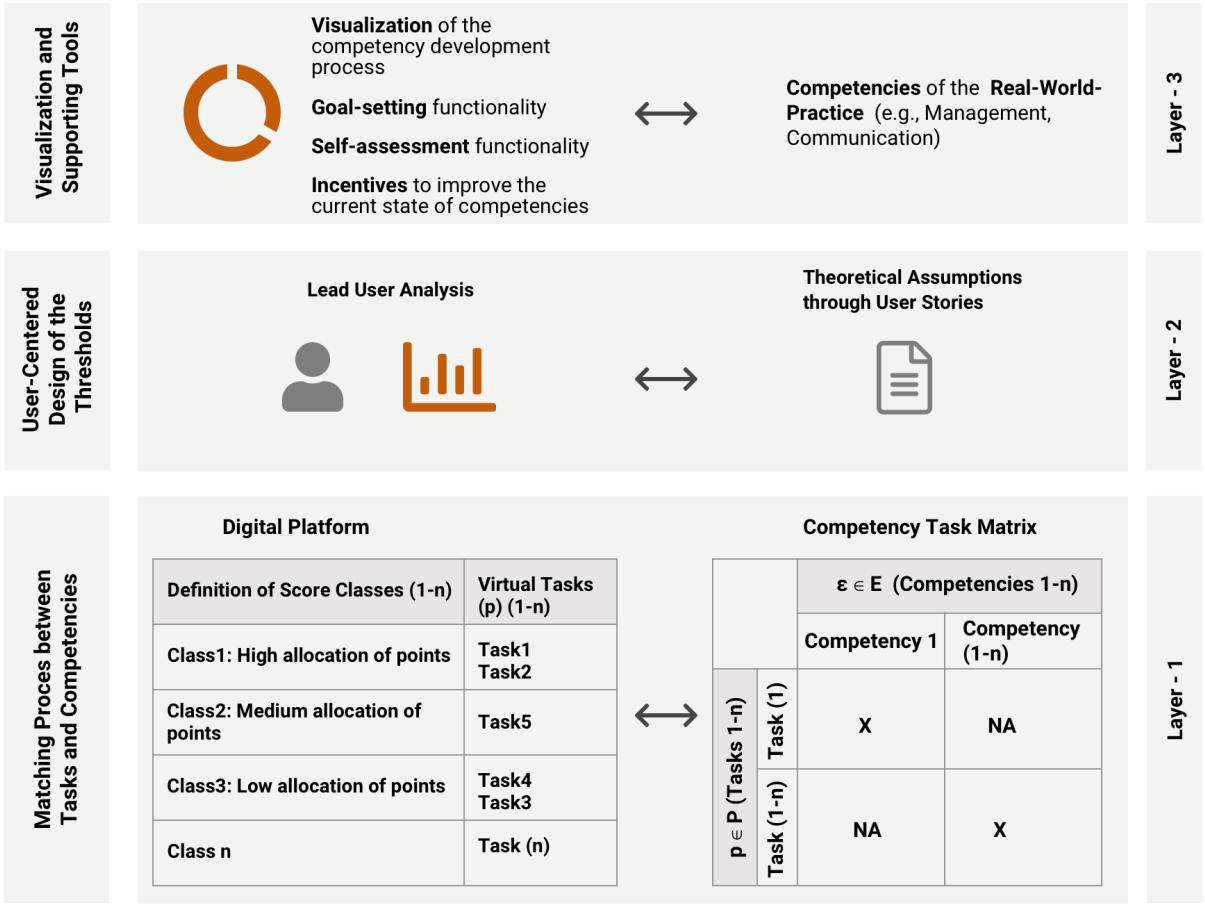

Figure 6: Constructs defined in the design theory

Furthermore, the defined constructs of the design theory are divided into three layers, visualized in Figure 6.

The first layer attempts to ensure a successful mapping process between the virtual tasks and the real-world competencies, including the definition of score classes, which classify each task regarding its relevance to the incentive design, tested by H2a. These classes should also prevent the end-users from outsmarting the defined incentive scheme, tested with H2b.

While the first layer organizes tasks and related competencies, the second layer enables the definition of the competency thresholds (e.g., low, medium, and high) based on a lead-user analysis. The objective of the defined levels is to motivate different types of end-users (e.g., active, passive, and lead users) to accomplish more tasks to move to the next higher level, tested by H3.

Layer three provides visualizations that inform the end-users about their current competency status, including goals and adaptive incentives (H4), to actually suggest missing competency elements by carrying out certain tasks. Finally, the theory has been applied within the health domain for the support of physicians in post-graduate education. The digital platform enables knowledge exchange regarding their workplace practice through sharing medical cases. Consequently, the overall goal of the design theory is the application in different domains where the development of competencies plays a crucial role. Generally, the proposed design theory is developed by following the eight components of Gregor and Jones (2007).

The objective of MA4 is to highlight the potential of user-type models and how they can be applied in practice by considering existing behaviors at the same time. This is particularly important since every end-user may come with different pre-existing behaviors related to the application context before using the application, in this case, energy saving. The first research question (RQ1) aims to understand how different user types perceive selected persuasive strategies, followed by the second research question (RQ2), which investigates to which degree existing behaviors influence the perceived persuasiveness of the selected strategies.

3.3 Research design and methods

To conduct research, answer the defined questions, and confirm the hypotheses, the manuscripts within this doctoral thesis follow a research design and apply selected methodologies and theories, described in Table 1. For instance, MA1 applies the framework proposed by vom Brocke et al. (2009) for conducting a structured literature review. Defining the scope and topic conceptualization involves the definition of the search terms, described in Table 3:

Table 3: Defined search terms

gamified	adapt	personal	contextualized	user-centered	analytics
gamify	adaptive	personalized	contextual	user-centred	
gamification	adaptivity	personalised	contextualised		
gamifiable		personalization			
gamifying		personalisation			

Furthermore, after the definition of the exclusion criteria (e.g. serious games), the search query was applied to scientific databases. Based on an iterative process (e.g. title screening, abstract screening, etc.) the actual corpus of 43 studies was defined and visualized in Table 4.
The composed corpus of 43 papers is analyzed and synthesized by establishing challenges and a research agenda regarding the design of adaptive gamification applications.
MA2 follows the DSR approach and applies the process model, proposed by Peffers (2007). Firstly, the model starts with problem identification and motivation and is based on the structured literature review of MA1, as well as the identified challenges (what is possible and feasible), which refers to the second phase, the objectives of a solution. Secondly, the artifact, which represent the proposed design framework, is defined in the phase of design and development. Thirdly, the demonstration phase highlights the application of the defined artifact (design

Table 4: Database search results and final review results

Library	Number of Results
Scopus	435
Proquest	93
EBSCOHost	25
ScienceDirect	506
ACM Digital Library	45
AISel	14
IEEE-Xplore	107
WebOfScience	145
SUM	1370

Review Task	Number of Papers
Keyword search	1370
Title screening	430
Abstract screening	126
Full-Text screening	35
Forward and Backward searches	+8

framework) to a specific domain, where the artifact informs the design and implementation of a real-world prototype. Finally, the prototype is evaluated, including the communication of the results. The questionnaire, which aims to assess the user acceptance of the proposed gamification approach, received 20 responses and is based on UTAUT.

Furthermore, MA3 consists of eight components to specify a design theory, proposed by Gregor and Jones (2007). Firstly, within the component of purpose and scope, meta-requirements have been derived, for instance, in MR1, the scoring mechanic should connect to and gamify the available tasks within the digital platforms in a meaningful way and should foster the development of work-related competencies. Secondly, based on the justificatory knowledge, which represents kernel theories and frameworks, six design requirements (DR) are defined. Built upon these requirements, several constructs (Figure 6), which serve as an abstract blueprint or architecture describing an IS artifact, are introduced. Thirdly, followed by the definition of the design principles, known as the principles of form and function and the principles of instantiation, the developed artifact is applied to a real-world prototype, which highlights the physical instantiation. The testable propositions represent the defined hypothesis in MA3 and try to reveal "truth statements about the theory" (Gregor and Jones, 2007, p. 43).

Table 5: Research design and methods

MA1	Framework for conducting an IS SLR, proposed by vom Brocke et al. (2009): • Definition of review and scope • Conceptualization of the topic • Literature search • Literature analysis and synthesis • Research agenda
MA2	Research Design: DSR—Process model by following the six phases, proposed by Peffers et al. (2007): • Problem identification and motivation (results from the SLR–MA1) • Objectives of a solution (defined based on the main challenges of the identified studies) • Design and development (definition of the design framework) • Demonstration (framework has been applied into a specific domain to inform the design and implementation of a real-world prototype) • Evaluation (quantitative and qualitative analysis) • Communication (participants have been informed about results) Methods: Quantitative analysis of usage data through descriptive statistic Theories: Unified theory of acceptance and use of technology (UTAUT)
MA3	Research Design: For the development of the ISDT, the eight components proposed by Gregor and Jones (2007) have been considered: • Purpose and scope include meta-requirements and goals that specify the type of artifact to which the theory applies, including boundaries. • Constructs represent the entities of interest in the theory. • Principles of form and function serve as the abstract "blueprint" or architecture for the IS artifact. • Artifact mutability represents the degree of artifact change induced by the theory. • A testable proposition should be made about the system to be constructed. • Justificatory knowledge represents the underlying knowledge that explains the design and its links with goals, processes, and materials.

	• Principles of implementation describe the implementation process of the theory. • Expository instantiation refers to that to which the theory will be applied, represented by a physical implementation of the artifact. Methods: • Cluster analysis • Descriptive statistics Theories: • Knowledge space theory (KST) • Self-determination theory (SDT) • Goal-setting theory (GST) • UTAUT
MA4	Research Design: • Survey that includes a storyboard for each persuasive principle (S1–S7) • Perceived persuasiveness measured with a Likert scale. • Collection of responses (n = 480) through Amazon Mechanical Turk (MTurk) • HEXAD user types identified through survey questions proposed by Tondello et al. (2016). • Existing energy-saving behavior scale, proposed by Markle (2013) Methods: • Visual storyboards • Partial least squares structural equation modeling (PLS-SEM) • One-way and repeated measures ANOVA

MA4 uses visual storyboards to represent the selected persuasive strategies. For the identification of the HEXAD user types, the questionnaire by Tondello et al. (2016) is applied. Finally, partial least squares path modeling is conducted to identify the relationships between user types and the perceived persuasiveness of the selected strategies, visualized in the PLS-SEM model in Figure 7.

For the identification of pre-existing saving behaviors, the subscale conversion of the pro-environmental behavior scale (PEBS), proposed by Markle (2013), is applied.

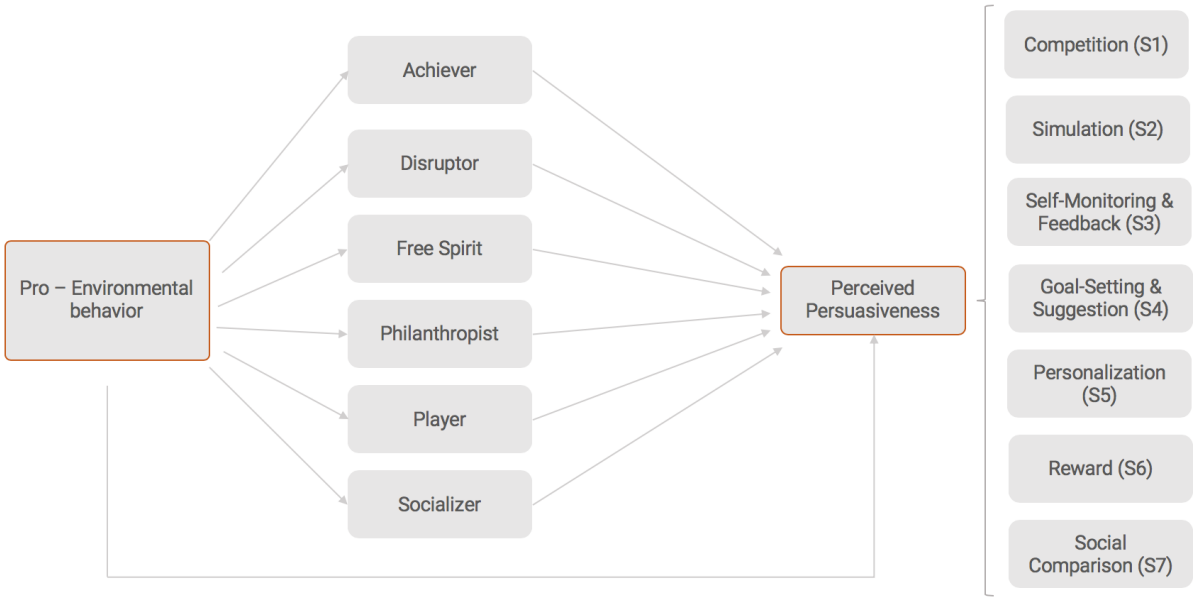

Figure 7: PLS-SEM model

Chapter 4

Research Manuscripts

4.1 Manuscript 1 - Towards Adaptive Gamification: A Synthesis of Current Developments

Manuscript No. 1

This manuscript is published as:

Böckle, M., Novak, J., and Bick, M. (2017). "Towards Adaptive Gamification: A Synthesis of Current Developments," *Proceedings of ECIS*, Guimarães, Portugal.

Manuscript available in the AIS library: `https://aisel.aisnet.org/ecis2017_rp/11/`

ISBN 978-989-20-7655-3

4.2 Manuscript 2 - A Design Framework for Adaptive Gamification Applications

Manuscript No. 2

This manuscript is published as:

Böckle, M., Novak, J., Micheel, I., and Bick, M. (2018). "A Design Framework for Adaptive Gamification Applications," *Proceedings of the 51st Hawaii International Conference on System Sciences*, Waikoloa, Hawaii, USA.

Manuscript available in the ScholarSpace library: `https://scholarspace.manoa.hawaii.edu/handle/10125/50038`

ISBN 978-0-9981331-1-9
DOI 10.24251/HICSS.2018.151

4.3 Manuscript 3 - A Design Theory of User-Centered Score Mechanics for Gamified Competency Development

Manuscript No. 3

The manuscript is currently under review (status: passed desk reject).

Böckle, M., Novak, J., and Bick, M. "A Design Theory of User-Centered Score Mechanics for Gamified Competency Development," *Journal of the Association for Information Systems (JAIS)*.

4.4 Manuscript 4 - Exploring Gamified Persuasive System Design for Energy Saving

Manuscript No. 4

This manuscript has the status of revise and resubmit (third round)

Böckle, M., Novak, J., and Bick, M. "Exploring Gamified Persuasive System Design for Energy Saving," *Journal of Enterprise Information Management (JEIM)*.

Chapter 5

Discussion and Conclusion

5.1 Key findings and major contributions

This doctoral thesis aimed to provide a holistic overview of how to systematically design user-centered adaptive gamification applications and highlighted two examples for a deeper understanding of how to design such solutions, including their challenges and limitations.

The major contribution of MA1 is threefold. Firstly, a conceptual matrix highlights the main dimensions of adaptive gamification approaches and how often they appear in the identified studies. Secondly, results of the matrix have been clustered into the following themes, visualized in Figure 8, which emphasizes existing approaches and frameworks related to this emerging research stream. Thirdly, research challenges within these themes have been identified and synthesized into a research agenda, which provides information about future research directions.

Overall, adaptive Approaches plus gamification summarizes research on adaptive environments that only use gamification to support and influence adaptive functionalities, for instance, meeting individual needs of students within intelligent tutoring systems, where gamification has been used to increase engagement within the environment (Vandana and Venkatesh, 2015). Furthermore, Vassileva (2012) has discussed the role of adaptive environments and their connection to incentive design since the system environment focuses more on the adaptation of the actual system to the end-users' needs, in contrast to adaptive gamification design, which aims to provoke behavior change (goals, motivations, beliefs, etc.) through personalized incen-

tive design. Moreover, within adaptive gamification design, the balance of adaptivity must be considered as well. Thus, the first challenge (C1) has been defined as finding the right balance in the design of adaptive gamification environments, in either putting more weight on the individual user (micro level—personalize standard gamification elements to support individuals, e.g., by showing personal recommendations) or on the community (macro level—e.g., enticing users to commit to a common goal).

The next layer in Figure 8 summarizes contributions related to adaptive gamification research and represents major elements in the present gamification research stream, for instance, the relationship between personalities and game-design elements including frameworks for player and user-types models. A strong contribution comes from research by Codish and Ravid (2014b, 2015), which extends the existing MDA framework with variables like gender, personality, and age. Thus, the challenge within this theme is to understand the relationship between the mechanics and their effects on different individuals to react accordingly (C2). To meet this challenge, gamification scholars are focusing on the investigation of those connections using the HEXAD framework proposed by Marczewski (2015). This framework consists of the following six user types: Philanthropists, Disruptors, Socializers, Free spirits, Achievers, and Players - and has featured prominently in this doctoral thesis since MA4 focuses on the relationship between user types and selected persuasive principles within the energy-saving domain. Furthermore, the interplay between player types and game-design elements has already been investigated by Gil et al. (2015), Tu et al. (2016), and Ferro et al. (2013), but there is a lack of research that actually shows how to apply them in practice, including the contextual factors of certain application domains. Thus, the challenge (C3) is defined as examining and understanding the difficulties of the development and application of different types of users (e.g., user types, player types, personality types) inside gamified environments, especially considering how they emerge and connect to the gamification layer in a meaningful way as needs and demands change. Finally, the last two layers of Figure 8 summarize existing adaptive

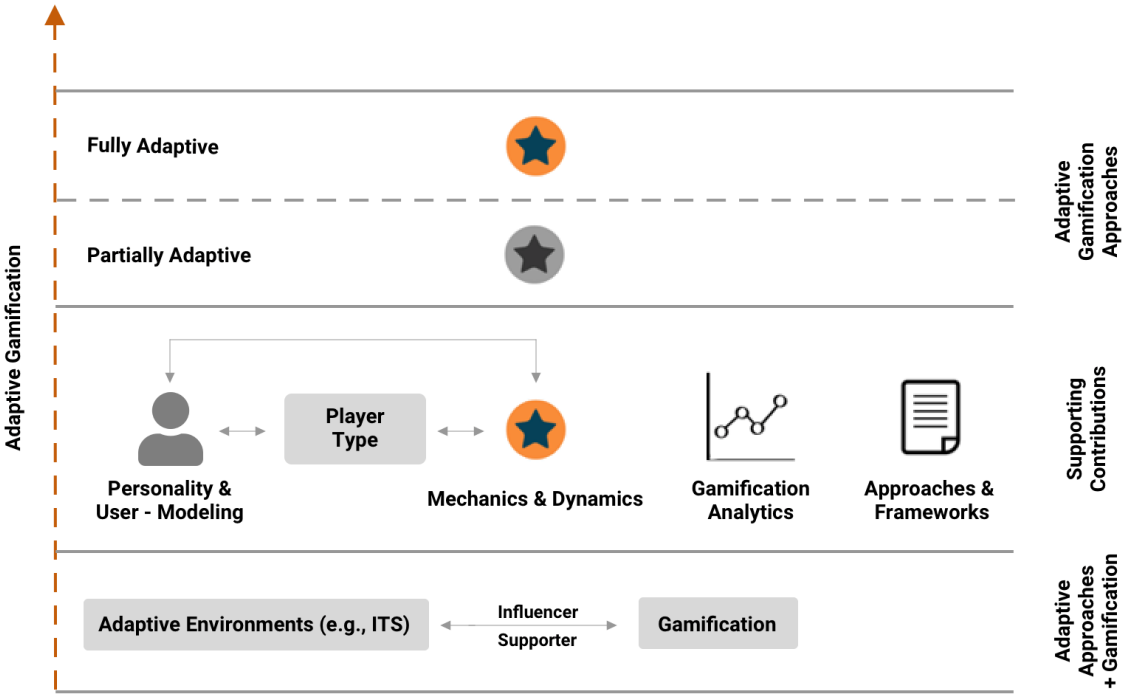

Figure 8: Overview of adaptive gamification research

gamification approaches as fully adaptive and partially adaptive, even though it is challenging to draw a full distinction between both themes.

Generally, studies with the common goal of increasing personalization with a set of contextual and motivational gamification strategies, based on SDT, are considered partially adaptive. Examples include research by Vaezipour et al. (2016) and Shi and Cristea (2016), who have propose different motivational gamification strategies based on the three basic needs of SDT: autonomy, competency, and relatedness. While these strategies can positively inform the design of adaptive gamification applications, the challenge (C4) of how to balance the degree of adaptive gamification approaches based on SDT focuses on the degree of adaptivity.

As shown in the top layer of Figure 8, the strongest contributions regarding adaptive gamification applications have been made by Monterrat et al. (2015a), Gonzalez et al. (2016), Cheng

and Vassileva (2005), and Paiva et al. (2016). While Monterrat et al. (2015a) have proposed a novel solution that calculates the relevance score for displaying the appropriate gamification mechanics and dynamics, Paiva et al. (2016) have created interaction profiles to personalize game-design elements. Although several adaptive gamification solutions are being discussed within the present body of gamification literature, the fifth challenge (C5) is defined as how to design a meaningful adaptive gamified reinforcement strategy to sustain the long-term motivation and prevent effects like declining enjoyment and usefulness. Finally, the methodology for conducting an SLR proposed by vom Brocke et al. (2009) suggests the definition of a research agenda that synthesizes the identified research challenges (C1–C5) and provides appropriate methods with which to address them.

The major contribution of MA2 is a design framework (Figure 9) to explain the systematic development of adaptive gamification applications. Based on the results of MA1, the framework provides design paths (depending on the application context) and principles to assist with the design practice. Moreover, the proposed framework also considers the identified challenges of MA1 and, therefore, provides a holistic approach for designing such solutions. For the development of the framework, the DSR approach proposed by Hevner et al. (2004) has been applied. This approach also embodies the theoretical and practical contributions within the IS field. By doing so, based on the associated sub-elements of the framework, for instance, feedback and points, visualized in Figure 9, design principles are defined that represent concrete guidelines for the design practice, illustrated in Table 6:

Table 6: Design principles of MA2

MR1: Consider the Purpose of Adaptivity (1)	
DP1:	Ensure to support learning and provide a gamified personal learning experience
DP2:	Ensure to create a meaning between the end-user and the activity to support long-term engagement
DP3:	Ensure to efficiently support participation to increase the quality and quantity of end-user contributions
DP4:	Overcome the "one size doesn't fit all" problem with adaptive incentives for individual users/user types
MR2: Define the Adaptivity Criteria (2)	
DP5:	Include user information (e.g. gender, usage data, personality, user type, preferences for certain gamification elements etc.) as criteria for adaptive gamification design
DP6:	Consider the context (e.g. levels, reputation, user goals, self-assessment, domain specific values etc.) as criteria for adaptive gamification design
MR3: Design the Adaptive Gamification Mechanics & Dynamics (3)	
DP7:	Add adaptivity to standard gamification mechanics in a meaningful way (e.g. adaptive levels, customized challenges, personalized feedback etc.)
DP8:	Consider persuasive reinforcement strategies to sustain long-term engagement
DP9:	Design adaptive gamification mechanics and dynamics which are seamlessly connected to adaptive criteria and follow the defined purpose of adaptivity
MR4: Design Meaningful Adaptive Interventions (4)	
DP10:	Design clear, personal adaptive interventions which inform the end-users about their current behavior or status and behavior improvements
DP11:	Design multiple paths (choices) to achieve end-user goals and support their believes and motivation
DP12:	Ensure to define time and location of the intervention and connect it to the gamification layer
DP13:	Visualize end-user contributions and show possible next steps to achieve personal goals (e.g. skills, status etc.)

Table 7: Design paths

P1	Purpose of Adaptivity → (**C1**) → Adaptivity Criteria → (**C2-C5**) → Adaptive Game Mechanics & Dynamics → (**C3**) → Adaptive Interventions
P2	Adaptive Game Mechanics & Dynamics →(**C3**) → Adaptive Interventions → (**C4a-C4b**) → Adaptivity Criteria → Purpose of Adaptivity
P3	Adaptive Interventions → (**C4-C5**) → Purpose of Adaptivity → (**C1**) → Adaptivity Criteria → (**C2-C5**) → Adaptive Game Mechanics & Dynamics
P4	Adaptivity Criteria → (**C1**) → Purpose of Adaptivity → Adaptive Game Mechanics & Dynamics → (**C3**) → Adaptive Interventions

Finally, the design paths consider the logical connection between the main elements and provide different starting points depending on the application context since design opportunities in practice are often restricted to a certain degree, shown in Table 7.

To validate the developed artifact, the proposed framework has been applied in a real-world prototype, an online platform for knowledge exchange in postgraduate medical training. Results are based on a mixed-method approach. The quantitative analysis of usage data highlights the end-user activities six months after the introduction of the gamification prototype, compared to user activities in the project period, where no interventions were performed to stimulate the usage of the online platform. The main results show that the overall system activity (number of active users per month) increased after the application of the gamification model.

For other forms of active end-user interaction (e.g., creating a patient case, adding new comments on an existing case), only minor effects have been observed. For the amount of passive system usage (e.g., opening patient cases), a multiple increase has been found. In addition to overall positive user acceptance (e.g., usefulness, usability) of the integrated gamification concept, specifically for the adaptive incentives (perceived as useful for utilizing the platform more efficiently), results also indicate the potential of adaptive gamification elements in this

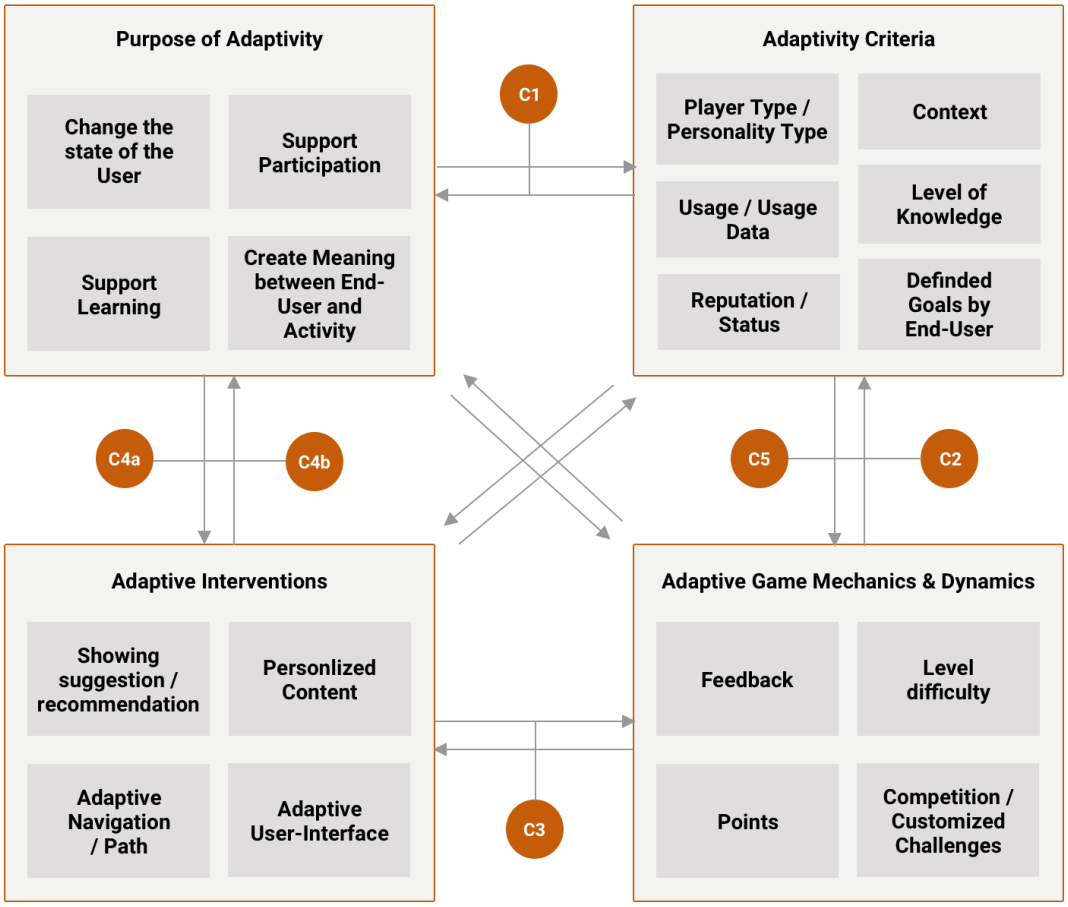

Figure 9: Framework for adaptive gamification design

specific application context. Generally, the results show that for more time-consuming tasks with larger barriers to overcome, different incentives with more specific behavior profiling must be considered.

MA3 contributes to the adaptive gamification research stream by providing design knowledge of how to systematically apply game-design elements in a user-centered way, specifically the score mechanic. Since design knowledge of meaningful score design is currently missing, the aim of MA3 is to develop a design theory of user-centered gamification mechanics in work-related

settings. The developed design theory provides reasonable knowledge through prescriptive statements that inform researchers and practitioners in building gamified environments to support the development of employee competencies in their daily practice. Furthermore, score design forms the backbone of most of the gamification approaches by enabling other mechanics, for instance, levels, badges, and leaderboards. Thus, it is important to provide design knowledge of how to apply the score mechanic in a meaningful way since best practices in the present body of gamification literature are scarce. Key findings are highlighted through the constructs and principles of form and function, shown in Table 8:

Table 8: Match between design requirements and principles (MA3)

DR1: Tasks and competencies need to be matched within the digital platform and the level of relevance identified for every single task involved in a set of competencies.	DP1: Ensure that the competency-task matrix considers possible dependencies, prerequisites and conditions between competencies and tasks, explained through the surmise function, with the aim of providing a meaningful competency development process. DP2: Ensure that the application of weights, which represent the level of relevance of tasks in relation to competencies, leads to a balanced score distribution within the digital platform, supports the end-users (e.g. employees) through appropriate competencies, and leads them in the right direction (e.g. as dictated by business needs). DP3: Ensure that the degree of difficulty of a task is well targeted to the competencies, in order to support a broad range of end-users (e.g. employees).
DR2: The level of gamification support of each individual task within the digital platform needs to be defined.	DP4: Ensure that the score classes provide a hierarchy for the available tasks within the digital platform, and consider the relations and dependencies among them.

	DP5: Ensure a meaningful balance between the different types of tasks (e.g. active and passive) in the process of assigning tasks to score classes by considering their significance, complexity and frequency of occurrence in regard to the competency development process, in order to provide an effective and motivating score design. DP6: Ensure that a meaningful score base is chosen for each class (e.g. 10x for the highest class, 2x for the lowest class, with the goal being a balanced distribution of possible achievements and the prevention of opportunities to exploit the scoring system.
DR3: The design of the competency threshold (e.g. high, medium, low) for the digital platforms should take into consideration the various different types of users.	DP7: Ensure that the distance (difference in scores) between each level takes into consideration the goals and expectations of the competence development process, the desired user journey and the types of competency that will be accomplished within a defined period of time. DP8: Ensure that when gamifying existing information systems (IS), the clustering of users into different types, including an analysis of their tasks over a given timeframe, delivers useful insights for the first application of the new scoring model in order to identify suitable thresholds by considering the application context, such as user goals and business needs.
DR4: The design of the competency thresholds (scores) within the digital platform should also include a theoretical understanding of the user tasks, with a focus on UCD.	DP9: Ensure that theoretical assumptions about possible end-user contributions are defined, and map these through a lead user analysis to create new perspectives on the most suitable thresholds for use in the competency development process.

	DP10: Ensure that there is an increasing level of difficulty between each threshold associated with the goals and expectations of the competency development process, in order to prevent a decline in engagement over time.
DR5: The visualization concept of the competence development process within digital platforms should include incentives to collect more points and improve the current state of competencies aligned to gamification design guidelines by considering SDT.	DP12: Ensure that the visualization of achieved competencies can be shared with other users and can support the provision of various tools for interaction and discussion within the digital platform, in order to foster relatedness. DP13: Ensure frequent decision making and optimal challenges are involved, thus fostering competence by providing incentives in the form of feedback and recommendations in order to motivate end-users (e.g. employees) to earn more points and perform the next logical tasks within their individual competency development process, including possible achievements towards their personal goals.
DR6: The visualization concept of the competency development process within digital platforms should follow gamification design guidelines by considering GST.	DP11: Ensure that personal competency goals defined by the end-users can be achieved in multiple ways through the performance of tasks, in order to support autonomy.

For each layer, visualized in Figure 6, design principles have been defined. Finally, the developed artifact has been applied as a physical instantiation to validate the prescriptive statements and demonstrate practicability (Gregor and Jones, 2007) with promising results. The first hypothesis (H1), which relates to the efficiency of the approach to gamify the competency development process, is supported by the results. Since the user-centered gamification approach increased the motivation of physicians to carry out certain tasks, the applied theory had a positive impact on the end-user activities and, therefore, on the overall competency development

process. More specifically, H1 is supported by the increase of passive tasks (e.g., opening a patient case) but only partially supported due to the low increase of active contributions (e.g., creating a comment), which are essential and important for competency development.
To test the second hypothesis (H2a), which focuses on whether the overall score design leads to a higher end-user motivation and engagement in the creation of more active contributions on the online platform, the number of different types of tasks in each of the defined score classes are analyzed in Table 9:

Table 9: Overall number of achieved tasks in relation to the score classes

Score – Classes	**Types of task within each class**	**Number of achieved tasks within each score class in %**
40x base – highest reward scores	Share case with group (28), Publish case (7)	35 (0.4%)
16x base – high reward scores	Add comment to case (362), Add comment to media file attached to case (3), Add article or comment to forum (140), Add keywords to case (19), Create medical case (33), Invite new users to platform alpha (5)	562 (6.9%)
4x base – low reward scores	Edit case (56), Create group (6), Send group invitations (24), Read information regarding CanMEDS competencies (10), Update personal profile (26)	122 (1.5%)
2x base – bonus class	Periodic usage of the platform (1393)	1393 (17.1%)
1x base – lowest reward scores	Explorative search in matrix browser (515), Read article in forum (805), Visit group (557), Visit profiles of other users (777), Open medical case and view discussion (3231), Join group (121)	6006 (73.9%)

During the evaluation period (April 2016–2017), a total of 8,118 tasks were performed by 227 users. Although the frequency of passive tasks was generally higher and the accomplishment of

tasks such as sharing a new medical case within the community would reward end-users with the highest individual score (40x score base), the results presented in Table 9 do not support H2a. As discussed with H1, a major increase in passive tasks was revealed that received the scores of 2x and 1x, while the tasks with a higher score base (e.g., 16x) were only slightly increased for regular users. Only a few lead users, who achieved the most scores through the whole evaluation period, gained the greatest proportion through tasks and were members of the score class 16 (16x).

Furthermore, the second part of the hypothesis (H2b) investigated whether the designed score classes protect the system from exploitation. To test this, a lead-user analysis (three user profiles) was performed, and results reveal that it is not possible to achieve a high score through simply clicking (e.g., opening a medical case or visiting groups) since those tasks were on the lowest score level; therefore, this supports H2b.

The third hypothesis investigates whether the defined thresholds actually stimulate competition and motivate the end-users in carrying out more tasks. Results show that 2.3% of the active users (n = 215) reached the second level, while only 0.9% crossed level two and reached the last level (4800–12000 points). Since a very low number of end-users moved to the second level, there is a lack of support for H3. This could have several reasons: Firstly, passive tasks predominated and were put into the lowest score class to prevent exploitation effects. Thus, to move to the second or third level, end-users were forced to accomplish more active tasks (e.g., create a new medical case) that may conflict with the daily routine. Consequently, H3 is only supported by certain types of users.

To test the last hypothesis (H4), the perceived usefulness and ease of use of the gamified competency development approach was investigated through a questionnaire and showed rather positive results (n = 20). The competency monitor to visualize the present competency status was perceived as simple and clear, as well as easy to use.

Key contributions of MA4 highlight the relationship between the identified HEXAD user types

Persuasive Strategies	PHI	SOC	FRE	ACH	PLA	DIS
Competition	-	0.33** (5.56)	-	-	0.18* (3.15)	-
Simulation	0.15* (2.03)	0.29** (4.15)	-	-		-
Self-monitoring and feedback	0.25** (3.94)		-	-	-	-
Goal setting and suggestion	0.14* (2.04)	0.21* (2.86)	-	-	0.10* (2.03)	-0.08* (2.01)
Reward	-	0.36** (5.71)	-	-	0.15* (2.84)	-
Social comparison	-	0.31** (5.60)	-	-	0.13* (2.41)	-
Personalization	0.16* (2.21)	0.31** (5.51)	-	-	-	-

PHI = philanthropist, SOC = socializer, FRE = free spirit, ACH = achiever, PLA = player, DIS = disruptor Path coefficient beta () and the level of significance (p) between player types and persuasive strategies (**coefficient p <.001, *coefficient p <.05, '-' no significance, t-statistics in bold)

Table 10: Relationship between persuasive strategies and player typologies

and persuasive strategies, illustrated in Table 10. Findings show that the user types *Socializers*, *Players*, and *Philanthropists* felt highly perceived persuasiveness of the selected strategies. The social component is especially highlighted by the *Socializer* user type, who shows a high tendency toward most of the persuasive principles, whereas *Players* prefer *Competition*, *Goal setting* and *suggestion*, *Reward*, and *Social comparison*. While the user type *Philanthropist* shows a high tendency toward *Simulation*, *Self-monitoring* and *feedback*, *Goal setting* and *suggestion*, and *Personalization*, a negative relationship was identified, as Table 10 illustrates, between the user type *Disruptor* and *Goal setting* and *suggestion*. Finally, these results confirm H1 since the relationship between the HEXAD gamification user types and the selected persuasive strategies for energy saving is revealed.

Furthermore, the repeated measure ANOVA (RM-ANOVA) shows that the strategies are perceived differently, whereby *Self-monitoring* received the highest preference, followed by *Goal setting* and *suggestion*, *Personalization*, *Simulation*, and *Competition*.

Furthermore, since those results show similar characteristics, as indicated in Orji et al. (2018), the role of existing energy-saving behaviors was investigated. First results revealed a signification relationship between the existing energy-saving behavior and three of the persuasive

strategies. This is a key finding of MA4 and highlights that people with a high value of existing energy-saving behavior are persuaded by *Goal setting and suggestion*, *Self-monitoring and feedback*, and *Simulation*. Moreover, these results show that the perceived persuasiveness is influenced by existing energy-saving behaviors and, therefore, confirms H2. Further analysis also shows that there is a significant difference between the younger (15–25) and older age groups (26–35, $p = 0.04$; 36–45, $p = 0.032$; over 45, $p = 0.24$). These key results suggest that designers and practitioners must consider age as a factor for the design of such solutions and also contribute to the direction of further research.

5.2 Implications for research and practice

The four manuscripts discussed in this doctoral thesis revealed several implications for research and practice. Firstly, MA1 represents a structural literature review by conceiving a conceptual matrix of adaptive gamification design that contains major dimensions used in current approaches. This matrix provides a holistic overview of the current developments in the field and supports gamification scholars in the identification of research gaps. Although MA1 has more of a theoretical character, practitioners can benefit from these results since the matrix offers information about what has been done so far and how the problem has been addressed. Furthermore, five research challenges including a research agenda provide possible future research directions. The proposed agenda highlights sub-areas (e.g., community modeling, user modeling for C1) related to the identified challenges and selected research methods, for instance, experiments, field studies, and case studies.

Secondly, the implications of MA2 are of a more practical nature. The proposed framework informs about the systematic development of adaptive gamification applications. Specifically, the different design paths support system designers in a real-world setting by offering four starting points, depending on the application context. For example, the classical path would

always start at the purpose of adaptivity and continue clockwise toward adaptivity criteria, but contextual dependencies (e.g., existing IS to be gamified) force system designers to think about alternative solutions that may focus on existent adaptivity criteria (e.g., if usage data are available). Furthermore, the proposed design principles contribute design knowledge to the field of IS. Thus, theoretical and practical implications also support further developments in the field by informing scholars and system designers on how to design adaptive gamification applications.

Thirdly, MA3 provides several implications for theory and practice. Although the literature contains controversial opinions about whether or not design theory is an outcome of DSR, Gregor and Jones (2007) have highlighted the importance of the way in which design knowledge is being expressed in terms of a theory. Therefore, one implication for practice is the development of practical knowledge, which can take several forms like reusable design patterns and principles, to inform the design of different classes of IS initiatives (Gregor and Jones, 2007; Carlsson, 2007; Walls et al., 1992). This knowledge aids researchers and practitioners in the design of a scoring system that explains the mapping process of individual scores and virtual tasks to support the development and achievement of the desired work-related competencies. Furthermore, since research on score design within the present body of gamification literature is relatively fragmented, with mixed results, one implication for researchers and practitioners is that the proposed design theory will show how to manage the overall score design to reach a certain goal, in this case, the development of work-related competencies. This discussion is currently missing since existing approaches reveal general and standard characteristics on how to apply scores for behavioral change. Moreover, the developed theory may indicate future approaches to focus on the personalization of gamification through the score mechanic. Further implications for practice reveal the development of real-world applications to engage employees in their daily tasks and support their competencies at the same time. Several applications for workplace gamification already exist (source), but most of them mainly emphasize

performance through the provision of transparency or simple badges and leaderboards or by providing incentives to work harder.

Fourthly, the results of MA4 can be applied in manifold ways. Since the relationship between gamification user types and persuasive principles was investigated, system designers may apply the outcome for the development of conceptual prototypes, with a strong focus on the personalization of gamified IS within the energy-saving domain. Results showed that self-monitoring and feedback received the highest preference among all the assessed strategies, which may be used and tested further within the prototyping phase of the user experience (UX) design process. Furthermore, results of MA4 confirm (Orji et al., 2018) and extend previous research on the personalization of persuasive strategies by investigating the impact of existing energy-saving behaviors with factors such as age. Thus, MA4 suggests that pre-existing energy-saving behaviors should be considered when gamification user-types models are applied. Finally, further implications are future research directions that focus on personalized gamification design by simultaneously considering the application of player types and existing behaviors.

5.3 Limitations and future research directions

The conceptual matrix in MA1 represents the results of an iterative analysis conducted through an SLR. Although the proposed categories (purpose of adaptivity, adaptivity criteria, adaptive game mechanics and dynamics, adaptive interventions) were derived from the literature, few publications properly fit into them since these studies rather focus on related topics of adaptive gamification design. However, the categories still represent a valuable contribution to this emerging research stream. Consequently, it its challenging to draw a distinction between supporting and non-supporting contributions, which underscores the major limitation of MA1. Generally, the majority of these studies are identified through a backward search by reviewing the references of the selected literature, identified through the SLR. Moreover, no acceptance

criteria for supporting contributions have been defined, which limits the overall perspective of the SLR but adds important insights regarding the general idea of adaptive gamification design. Furthermore, six out of the 25 identified studies do not include any evaluation or focus on theoretical framework and approaches, which may lower the degree of empirical results but may contribute with novel discussions and ideas related to adaptive gamification design. The second limitation refers to the idea of grouping the identified studies by their degree of adaptivity. In many cases, the term "adaptive gamification" is not mentioned, but a similar approach has been applied, which lowers the relevance of any classification. Finally, future research directions are highlighted by the proposed research agenda, which includes the five identified challenges and suggested methods to address them.

In MA2, two limitations are discussed. Firstly, the evaluation is highly context-specific (doctors in postgraduate medical training) and, therefore, limits the relevance of the results regarding the general validity of the design framework. Secondly, the very small sample of survey responses, including the limited six-month trial, may cause rebound effects. Therefore, longitudinal studies in different application domains are necessary to demonstrate validity, which suggests directions for future research. Further directions involve the application on existing systems that may have been gamified already since the demonstration of different design paths in practice will lead to other challenges.

The proposed ISDT in MA3 is also subject to several limitations. Firstly, the theory aims to support real-world competencies by connecting them to virtual tasks. Since the literature on workplace competencies is highly fragmented, it is challenging to build upon a solid base of literature related to the support of the competency development process. Furthermore, the assessment of the developed competencies and their representation through single scores reveal major limitations since several aspects are neglected, like participants' attitudes or job performance. Secondly, the evaluation highlights that several testable propositions (hypothesis) have only been partially supported, which implies that further research is necessary to understand

how and in which ways the selected competencies may have been improved or developed in practice. Finally, to leverage competencies through gamification, the right conditions must be provided to stimulate the competency development process.

In MA4, several limitations are discussed. Firstly, the assessment of the perceived persuasiveness through static screenshots represents one limitation since the evaluation through an interactive prototype would be more realistic and may reveal the strengths and weaknesses of each persuasive principle in a more meaningful way. Furthermore, gathering end-user feedback through Mechanical Turk (MTurk) has become a standard for large-scale studies, but it does not represent an optimal solution due the lack of information about the participants and their habits and needs. This becomes highly relevant since the study measure the role of existing energy-saving behaviors, which often differs in cultures and regions around the world.

Future research endeavors are discussed in a recent article by Orji et al. (2018), who have claimed that there is still little knowledge on how to effectively personalize persuasive technology. Furthermore, the age, gender, and personality of the participants are suggested as promising dimensions, which are addressed in MA4. Future research directions should investigate the same study design in similar context, like water management, to investigate the transferability of the findings to other application domains. Furthermore, since existing user-type models are limited to motivational perspectives on certain game-design elements, the pro-environmental behavior scale may be used as an extension to propose gamification user types for a specific application context, in this case, energy saving.

Finally, current research trends reveal the importance of data-driven gamification approaches by constantly analyzing and modeling end-user profiles based on behavioral data (e.g., task completion time, number of clicks on certain pages). These profiles may be defined through daily consumption rates by updating present player profiles to dynamically personalize game-design elements like feedback, challenges, and level of difficulty based on user-type models.

Chapter 6

Final Remarks

This doctoral thesis consists of several manuscripts that show that gamification research is clearly moving toward an adaptive gamification approach to better support long-term engagement. The future of gamification is bright since the concept reveals manifold opportunities, specifically in emerging domains where game-design elements play a crucial role by keeping the end-users engaged to collectively solve large challenges or provide a richer end-user experience. Finally, games are successful because they are fun, exciting, and challenging at the same time. Gamification puts those elements into serious contexts to increase end-user motivation, which has been identified as a need within several domains like education, health, and crowdsourcing. Overall, service designers must consider an end-user analysis, which requires understanding the end-users' needs, motivations, behaviors and preferences before starting to define the gamification model. Generally, the existing gamification research stream provides valuable knowledge on a broad spectrum in the UX domain but is still unknown to many in practice.

On a personal note, at the University of Technology Graz (TUG), I participated in a research project wherein game-based learning was successfully applied for the first time in the educational domain (Ebner et al., 2011). Since then, I have been following with great interest the different approaches where game-design elements are being used. Exciting research projects at the social innovation lab in the Humboldt-Viadrina School of Governance gave me the opportunity to apply gamification within the health domain, where user-centered gamification models have been tested and validated with general practitioners. Furthermore, research (parts of EU projects) at the European Institute for Participatory Media (EIPCM) helped me to un-

derstand the potential and effects of gamification within crowdsourcing. Finally, my time as a PhD student gave me the chance to investigate the different layers of gamification, specifically from a theoretical perspective. I am happy to apply this valuable experience in my current job as an UX Designer at BCG Platinion.

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