Tanja Korhonen

TOOLS AND METHODS TO SUPPORT THE KEY PHASES OF SERIOUS GAME DEVELOPMENT IN THE HEALTH SECTOR
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Abstract

Health-care service providers are searching for new digital tools to support their customers, and health games can provide cost-effective and motivating means in this regard. Serious games in the health sector aim to inspire users to enhance their psychological, physical and social well-being. As the development of health games requires the involvement of many disciplines, research from a multidisciplinary point of view is needed.

This multimethod dissertation consists of six studies. Interest in the research subject was raised in a case study, followed by a systematic mapping study. Two more case studies, a design science research study and an action research study, formed the base to answer the research question of this dissertation: What kind of tools and methods are needed to support key phases of the serious game (SG) development process in the health sector?

As results, the process of developing serious games in the health sector, as well as a new serious games development tools and methods (SGTM) model is presented. The SGTM model describes four sections as tools and methods: 1) SGs rapid prototyping workshop, 2) an SG design canvas and education, 3) multidisciplinary cooperation and 4) evidence and guidelines.

This thesis proposes a new model to be used by practitioners and academics. SG designers are encouraged to select the tools and methods that fit their own design frameworks. In addition, more research is needed to explore how to support experts with cross-disciplinary backgrounds involved in SG development.

Keywords: education, game design, game development process, health games, health sector, multidisciplinary teamwork, multimethod research, serious games, SGTM model
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Tiivistelmä


Tämä monimenetelmäinen väitöstutkimus koostuu kuudesta osa-alueesta. Kiinnostus aiheeseen heräsi aiemmassa tapaustutkimuksessa ja tietoa kerättiin edelleen systemaattisessa, kartottavassa kirjallisuuskatsauksessa. Tutkimuskysymykseen ’Millaisia työkaluja ja menetelmiä tarvitaan tukemaan terveyspelikehityksen avainvaiheita?’ haettiin vastausta vielä kahdella tapaustutkimuksella, yhdellä suunnittelututkimuksella (design science research) ja toimintatutkimuksella.

Tuloksina voidaan esitellä terveyspelikehityksen prosessi ja uusi SGTM (Serious Games development Tools and Methods) -malli tukemaan kehitysprosessin vaiheita. SGTM-malli koostuu seuraavista neljästä eri alueesta: 1) hyötypelipaja, 2) hyötypelikanvas ja -koulutus, 3) monialainen yhteistyö ja 4) näytöt ja ohjeistus.

Tämä väitöskirja esittelee uuden mallin, jota voidaan hyödyntää sekä käytännön projekteissa että tutkimuksessa. Hyötypelien kehittäjät voivat poimia ehdotetuista työkaluista ja menetelmistä sellaiset, jotka sopivat parhaiten heidän tarpeisiinsa. Edelleen jatkotutkimuksissa on tärkeää selvittää, millaisin keinoin eri alojen osaajia ja heidän yhteistyökentelyään voidaan tukea monialaisissa hyötypeliprojekteissa.

Asiakirjat: hyötypeli, koulutus, monialainen yhteistyö, monimenetelmäinen tutkimus, pelikehitysprosessi, pelisuunnittelu, SGTM, terveyspeli
To my family
Preface

The motivation for launching this dissertation work arose from the practical need to understand, in more detail, serious game design and development. In 2012, as a project manager, I knew the software development process and game development practices quite well but got confused when there were no easily available supportive processes and tools for serious games. This problem was obvious – as while developing a game with a defined purpose for certain types of players, the end user had to be taken into account during the early stages of development. Also, as the nature of serious games is multidisciplinary, always having a named topic, this topical expertise is needed in the development phase. Coming from the software industry, I was familiar with taking both the end user and the customer into account during development. In the game development field, this was not the usual way – games were mostly developed for entertainment and often for a wide range of players. Also, in the health-care area, experts working with serious games needed a lot of guidance while working on projects. Thus, the foundation of this study lies in the first paper (Article I), where the serious games development model used was described. This research pointed out that the development of health games requires a multidisciplinary approach and smooth cooperation.

My PhD study path has been a little different. I started to think of the possibility of continuing my studies in 2015, after writing my first journal article. At that time, it had been eight years since my MSc degree. I wanted to deepen my knowledge on serious games (SGs), as I had been developing SGs in many projects at my workplace KAMK (Kajaani University of Applied Sciences). As Raija Halonen kindly agreed to be my supervisor, I started as a part-time doctoral student. The first year was a little overwhelming for me, being 100% at work and trying to understand how doctoral studies work, but in 2016, I took my first courses. After that, it has been quite a ride – publishing three articles in 2017, one in 2018 and another one in 2019. It feels unbelievable to be in this phase now; it has required huge work from me, support from my family and flexibility from my employer to get this thesis done in this time period. KAMK provided the empirical material and project environment for this study, and it was important to get a few months of study leave to finalise this study.

I want to thank my external reviewers, Dr. Jannicke Baalsrud Hauge and Dr. Mattia Thibault, for their valuable comments that helped me to form the final version of my thesis. I want to also thank my follow-up group: Dr. Raija Korppelainen (the Chair) from University of Oulu and Dr. Jaana Lappalainen from KAMK. They
found the time to kindly guide me and it was valuable that the follow-up group represented also different disciplinary areas. My deepest appreciation also extends to my opponent, Professor, Dr. Olga de Troyer.

I’d like to express my deepest gratitude to my supervisor, Adjunct Professor, Dr. Raija Halonen, who has patiently guided me through the study time. Her continuous support and always available advice have been the key factors to get me going forward. As being a stand-alone student without a research team, it was great that she also matched me with another PhD students. I would also like to thank my unofficial co-supervisor and valuable colleague from KAMK, Dr. Teija Ravelin, for productive co-authoring and always bringing on supporting and positive attitude. This real-life multidisciplinary co-operation and friendship is something I will highly appreciate my whole life.

I wish to thank also some KAMK colleagues, specially Jaana and Kyösti, for co-authoring, support from my managers along the way and many others that have shown interested in my studies or participated in related projects. Special thanks go also to Hanna-Leena, my one and only PhD “study buddy”. I’m very thankful that we met during a conference trip in Italy and became friends during this journey! The peer-support has been an important factor to push me further.

I am also grateful for the financial support I received as grants from Niilo Helander foundation, Miina Sillanpää foundation and from UNIOGS. These grants enabled me to reserve time to write articles and travel to present them in conferences. I would like to most humbly thank also ESF-funded projects SeGaBu and DIMMI for providing the research material.

Furthermore, many thanks to all family members and friends for your interest and support. I want specially to thank my auntie A for providing me a place to sleep during my study days in Oulu.

The support from my family during the whole time has made this journey possible. Finally, I want to thank my beloved ones, my children Saku, Emma and Roope. You give a meaning to my life. And the deepest gratitude I owe to my husband Jouni. You are my everything.

3.8.2020 Tanja Korhonen
<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>AR</td>
<td>Action Research</td>
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<td>DSR</td>
<td>Design Science Research</td>
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<td>GAH</td>
<td>Games Against Health</td>
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<td>GoML</td>
<td>Game of My Life</td>
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<td>HEP</td>
<td>Heuristics for Evaluating Playability</td>
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<td>IS</td>
<td>Information Systems</td>
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<td>PD</td>
<td>Participatory Design</td>
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<td>Persuasive Game Design</td>
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<td>RQ</td>
<td>Research Question</td>
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<td>SG</td>
<td>Serious Game</td>
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<td>SGTM</td>
<td>Serious Games Development Tools and Methods</td>
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Original publications

This thesis is based on the following publications, which are referred to throughout the text by their Roman numerals:


All the articles have been published as full papers in conference proceedings. The author of this dissertation was the primary author of Articles II–VI. For Articles II and III, the researcher was responsible for formulating the research problems and questions, gathering the theoretical bases, coordinating and collecting the empirical materials, drawing conclusions and being the primary author. The coauthor supported the work in the role of reviewer and advisor on research methods, structure and contents. For Articles IV–VI, the researcher took the lead in designing and managing, as well as authoring, the studies. The coauthors provided their expertise: R Halonen brought her experience on research methods, besides valuable reviewing and advising, and T Ravelin on mental health care and pedagogy. With regards to Article I, the researcher was responsible for the research regarding health game development and thus authoring that part in the article. For Articles I and IV, J Kemppainen brought valuable insight on the health-care sector. For Article IV, K Koskela participated in describing the developed serious games.
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Chapter 1.1 presents the purpose of and motivation for this study followed by Chapter 1.2, which presents prior research. Chapter 1.3 introduces the research questions (RQs) and methods, and Chapter 1.4 reports the main contributions. Finally, the structure of the thesis is introduced in Chapter 1.5.

1.1 Purpose and motivation

The purpose of the current study was to analyse and develop tools and methods to support key phases of serious game (SG) development in the health sector. The main motivation for this study was the ever-increasing understanding of the role of SGs as actors in the health-care sector but the lack of comprehensive existing knowledge about the process of producing such games as well. There is a need to understand, on a large scale, the benefits that health games, SGs in health care, can offer regarding empowering citizens or patients (see Primack et al., 2012).

As health-care service providers are looking for new functions to empower their customers, health games can provide a new method for maintaining and developing the health capability of different age groups. Health games can support persons’ psychological, physical and social well-being. Games can be played alone or can serve as a medium of interaction between a customer/patient and a health-care representative. Health games aim to inspire and engage users, and thus, they can provide new methods of self-help or rehabilitation (Kemppainen, Korhonen, & Ravelin, 2014).

Health game development demands multidisciplinary cooperation (Kemppainen et al., 2014). To develop effective SGs (i.e., the games fulfil their serious purpose), more education is needed (De Troyer, 2017). The current study focused on the multidisciplinary development of SGs, identified steps in the development process and proposed solutions to support this process.

1.2 Prior research

According to the World Health Organization, eHealth means using information and communication technology in support of health and health-related fields in a cost-effective and secure way (WHA58.33 Resolution, 2005). The European Union has declared that digital solutions for health and care can improve the well-being of citizens by purposeful design and cost-effective implementation. There is a strong
emphasis on developing new digital tools for citizen empowerment and person-centred care. Personalised solutions allow citizens to take personal responsibility of their health and thus improve their own well-being. Active engagement in health promotion and self-management of chronic diseases using digital tools such as wearables and mobile health applications, being easily accessible, can help people to stay healthier (Communication eHealth, 2018). Video games, being one form of digital tools, can improve health outcomes in different areas and within different sociodemographic groups (Primack et al., 2012).

Digital games have become a mainstream phenomenon, and players can be found in all demographic groups (Williams, Consalvo, Caplan, & Yee, 2009; Williams, Yee, & Caplan, 2008). Games can work as motivators and help to change players’ behaviours (Baranowski, Buday, Thompson, Lyons, Lu, & Baranowski, 2013; Ryan, Rigby, & Przybylski, 2006). Digital games create structured conflict and provide an entertaining process for players to resolve this conflict (Fullerton, 2014). Video games allow for the possibility of not just telling a story but also allowing a player to live it (Rigby & Ryan, 2011).

Various definitions of SGs exist, but it is commonly stated that the term serious game or applied game refers to using games and game technology for purposes other than pure entertainment (Djaouti, Alvarez, Jessel, & Rampnoux, 2011; Susi, Johannesson, & Backlund, 2007; Zyda, 2005). To educate, train, advertise and influence people, SGs include several subgroups – such as edutainment, advergaming, edumarket games, political games, and training and simulation games (Alvarez & Rampnoux, 2007).

The health-care sector has strong interests in using new technologies related to health (Arnab, Dunwell, & Debattista, 2013; Haux, 2010; Moen et al., 2012). Today's increasing health-related challenges due to the aging population and increase in chronic diseases suggest SGs may be one strategy to improve health-related outcomes in the current and future generations (Arnab et al., 2013).

Play and entertainment can be effective foundations for serious interventions in health care. Nevertheless, there is a need for more studies that show a causal link between playing video games and health outcomes (Kato, 2010).

There are many different stakeholders in the health game market – such as hospitals, clinics, private-practice physicians (including therapists and personal trainers), governments, corporations, other organisations and individual consumers (Susi et al., 2007). Social security systems and health-care providers differ significantly among different countries and on a global scale, with each market area having its own methods to facilitate a healthy lifestyle (Kaleva, Hiltunen, & Latva,
2013). Significant changes should be expected, for example, in medical simulations, SGs, and mobile serious games, and an increased need for serious game analysis is already present (Loh, Sheng, & Ifenthaler, 2015).

Developing an SG requires not only game development skills and an understanding of good game design but also the ability to fix an organisational need or add to the game the defined purpose besides entertainment. SG development is seen as an interdisciplinary scene where input is needed from many domains. Client procurement skills are seen as a challenge: clients have significantly high or low expectations, and they lack knowledge of possible solutions regarding gamification and SGs (Backlund, Engström, Berg Marklund, & Toftedahl, 2017). The education and consultancy of customers could be considered a solution for this challenge. There is also need for using multidisciplinary tools during the development of SGs, for guidelines for developing SGs and for acquiring knowledge of SGs (De Troyer, 2017).

To sum up, these findings imply that the role of SGs in multidisciplinary teamwork in the SG development process cannot be overlooked. However, the possible tools and methods to support this process have yet to be specified.

1.3 Research question and methods

The current study answered the following RQ:

**RQ:** What kind of tools and methods are needed to support key phases of the SG development process in the health sector?

The RQ was answered with the help of four subquestions (SQs) using multiple research methods. Multimethod research (Mingers, 2001, 2003) means using different approaches in the research area, where the target of the research and the research process are complex and there is a multidimensional range of different approaches. The relations of the SQs, as well as where they are situated in the original articles, is illustrated in Figure 1.
To clarify the field of health games and find possible gaps in the prior studies, it was an important step to map the literature. This formed SQ1.

**SQ1:** How are SGs in health care perceived and approached in the literature?

To answer this SQ, a systematic mapping study, applying the guidelines of Kitchenham and Charters (2007), was initiated. The results are reported in Article II.

As the RQ indicates, there was a need to define the key phases of the SG development process and the role of multidisciplinary teamwork, which led to the following SQs.

**SQ2:** What are the key phases when designing and developing SGs?

To answer this SQ, constructs in the form of serious games were designed, developed, demonstrated and evaluated. The results of these case studies are reported in Articles I, III and VI.

**SQ3:** What kind of tools and methods can help a multidisciplinary team to work together when developing SGs?

To answer this SQ, a design science research (DSR) study was initiated and new constructs in the form of tools and methods were developed and evaluated. The results are reported in Article IV.
Finally, as an implication of the needed tools and methods, the last secondary RQ was formed:

SQ4: How can an e-learning course on SGs for multidisciplinary students be developed?

To answer this SQ, an action research (AR) study was initiated; the study utilised formerly developed tools and methods and developed a new e-learning course on SGs. The results are reported in Article V.

1.4 Main contribution

The main contribution of the current study is the discovery of tools and methods, needed to support the key phases of the SG development process in the health sector. The phases of this research – covering activities, studies, articles and contributions – are illustrated in Figure 2.

Article I defined the terminology and development methods that are used in SG development. It also raised the interest towards this subject and helped to identify the RQ for this thesis. Article II mapped the area of serious games, conceptualised SGs as a research phenomenon and defined how they are used in different areas of interest. In Articles III and VI, the emphasis was on the conceptualisation and demonstration of an iterative SG development process through case studies. Article IV conceptualised multidisciplinary expertise and demonstrated new tools and methods that support the development phase of SGs. In Article V, these new methods were demonstrated in a multidisciplinary environment.
Figure 2 illustrates the overall layout of the thesis. The activities included defining the objectives of the solution, the design and development phases and the demonstration and evaluation phases. The multimethod research consisted of using multiple case studies, a DSR study and an AR study. The multimethodology enabled different viewpoints of the main RQ and supported a process-like orientation regarding the research.

1.5 Thesis structure

This dissertation, consisting of six individual articles, reports the SG development process to identify the key phases and clarify tools and methods that can support this process (Fig. 2).

The structure of this dissertation is as follows. Section 2 presents the essential related literature relevant to this dissertation. Section 3 presents the research methodology – comprising of the research objectives, approach and research methods. A summary of the studies included in the dissertation and their findings is presented...
in Section 4. A discussion of the results related to previous works is presented in Section 5. Finally, the conclusions, limitations and future research possibilities are presented.
2 Related research

This chapter presents the related research. Chapter 2.1 starts with defining the computer games, and Chapter 2.2 continues with exploring affective computing and games. Chapter 2.3 defines SGs; Chapter 2.4 presents the related research on game design and development. In Chapter 2.5, the focus is on developing SGs, including the definition of health games. Chapter 2.6 presents the concept of multidisciplinary teamwork, including tools and methods that can support it. Finally, Chapter 2.7 describes the pedagogical approach.

In this doctoral thesis, the theoretical background is based on computer games and game design and development, including the affective computing viewpoint. The related research regarding SGs and their development, especially in the field of health, is grounded on this knowledge. To go further into the field of tools and methods to support the multidisciplinary approach, a pedagogical theory is included. Figure 3 illustrates this positioning.

![Fig. 3. Positioning the related research.](image)

The small icons in Figure 3 illustrate different aspects and diversity within computer game research areas that are related to this doctoral thesis.
2.1 Computer games

Computer games are becoming an inevitable part of Western life – as according to the Entertainment Software Association (2019), over 164 million adults in the United States play video games and 75% of all Americans have at least one gamer in their household. About 20 years ago, Aarseth (2001) declared computer games are, to some extent, even more important cultural phenomena than movies or sports. He also noted that computer game researchers enter this field from somewhere else (i.e., different research disciplines – such as anthropology, sociology, narratology, semiotics and film studies). An interdisciplinary approach helps to understand how games work and why they look the way they do (Egenfeldt-Nielsen, Smith, & Tosca, 2013, p. 3).

Computer games are basically software applications and, thus, an interesting domain for research in software engineering techniques and technologies. The core of computer games are a compound of human–software–platform interactions that cause emergent gameplay behaviours (Cooper & Scacchi, 2015). On the other hand, it is suggested that game development differs from other software development processes, even being an important part of it (Murphy-Hill, Zimmermann, & Nagappan, 2014). Behind this difference can be the multidisciplinary nature of the game development process – combining sound, art, control systems, artificial intelligence and human factors (Aleem, Capretz, & Ahmed, 2016a).

Juul (2011) defined a video game as a game played using computer power and a video display that can be a computer, arcade, console or any other digital game. Fullerton (2014) described a digital game as a system in which the whole is greater than the sum of its parts. In this digital game, a structured conflict is created and when a player resolves that conflict, it creates an entertaining environment. In the early 2000s, Rollings and Adams (2003, p. 201) defined gameplay as ‘One or more causally linked series of challenges in a simulated environment’, and Adams (2013) later described gameplay as the challenges and actions that players are presented and permitted to take in the game world while enjoying the feeling of overcoming the offered challenges and performing other activities. Video games not only can tell stories but also allow players to live them (Rigby & Ryan, 2011).

2.2 Affective computing and games

Affective computing aims to close the communicative gap between human emotions and computers by applying systems that recognise and adapt to the user’s
affective states. Computer games usually provide very dynamic forms of human–computer interaction, as they are designed to offer affective experiences that are influenced by player feedback (Iovane, Salerno, Giordano, Ingenito, & Mangione, 2012; Yannakakis & Togelius, 2011). In 1995, Picard (2010, p. 11) defined affective computing as ‘computing that relates to, arises from, and deliberately influences emotion’.

Computer games provide a valuable research setting for human–computer interaction research – particularly with respect to their design, interfaces and design processes. As games often offer emotional experiences, they are good examples of affective computing (Yannakakis & Togelius, 2011).

It is also suggested that computer games can best realise affective interaction. The rich content of games – consisting of music, sound effects, audio, virtual graphics and game mechanics – provides obvious triggers for raising the emotions of players (Yannakakis, Isbister, Paiva, & Karpouzis, 2014).

Research on player motivation attempts to establish the psychological needs that games satisfy and how different games fulfil these needs. This provides information about both positive and negative experiences within games (Rigby & Ryan, 2011).

Malone and Lepper (1987) identified four major factors that make a learning environment, such as a gaming activity, intrinsically motivating: challenge, curiosity, control and fantasy. These individual factors motivate a player when playing alone, while interpersonal factors such as cooperation, competition and recognition motivate a player when interacting with other players.

The player experience of need satisfaction model details the satisfaction that hooks players to games. This model is based on the fact that video games are considered most engaging when they satisfy specific intrinsic needs: competence, autonomy and relatedness (Rigby & Ryan, 2011). The player experience of need satisfaction model grounds on the self-determination theory, a well-established theory of motivation. Extrinsic motivation means performing an activity to get some deliberate outcome, and it contrasts with intrinsic motivation, which refers to doing an activity just to get satisfaction of the activity itself. Contexts that support a person’s autonomy, competence and relatedness can motivate an individual in a way that leads to commitment, effort and high-quality performance (Deci & Ryan, 1990; Ryan & Deci, 2000). Competence refers to our desire to grow abilities and gain mastery of new situations and challenges. Digital games easily provide highly engaging experiences in rich virtual worlds – which brings immediacy and can satisfy motivational needs, such as competence and mastery. Autonomy refers to our desire
to take actions based on our own decisions and not be controlled by others. There is a certain consistency in games: once a player learns the rules, the outcome will consistently reflect the player’s actions and expectations. Relatedness reflects our need to have meaningful connections with others. Density refers to the ability of games to deliver competence and the other needs at a high tempo and with a well-built feedback system. (Deci & Ryan, 1990; Rigby & Ryan, 2011; Ryan & Deci, 2000.)

2.3 Defining serious games

SGs, having an intentional educational purpose, are not intended to be played just for amusement (Abt, 1970). The concept of SGs was introduced in the 1970s, when it referred to an activity among two or more independent decision-makers seeking objectives in a limited context. During that time period, SGs were focused on educational functions (Abt, 1970; Ricciardi & De Paolis, 2014). The concept involves a digital game whose main purpose is something other than pure entertainment and is designed to be used in training, education and health care (Loh et al., 2015). Stokes (2005) defined SGs as digital games whose principal goal goes in addition to entertainment to education, outreach or training. Breuer and Bente (2010) pointed out the possibility to use digital games as motivators or generators of interest beside as a learning tool. On the other hand, Klabbers (2018) presented a contradictory view to abandon the term serious game as a whole, as he pointed out that the term excludes play and thus SGs might not be playful. Clapper (2018, p.375) answered to this with a comment stating that a game can be playful while having serious consequences, pointing out that ‘serious games are not at all serious’. Hence, as expression serious games can be seen questionable and as a contradiction (Breuer & Bente, 2010).

In addition to the above definitions, two widely used definitions can be pointed out as follows. Zyda (2005, p. 26) defined an SG as ‘a mental contest played with a computer in accordance with specific rules that use entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives’. In this definition, pedagogical features are considered to be one major part differentiating SGs from entertainment games. It is however emphasised that the entertainment activities are always a priority.

On the other hand, Susi et al. (2007, p. 5) defined SGs as ‘games that engage the user and contribute to the achievement of a defined purpose other than pure entertainment (whether or not the user is consciously aware of it)’. They proposed
how SGs can be applied to many areas, but they are categorised in different ways: 1) pedagogical, idealistic, political or societal games, 2) educational, health care, national security or corporate management games or 3) educational, health, public policy, science, government or corporate training games. In addition, Michael and Chen (2006) proposed categorisation into markets – such as military games, government games, educational games, corporate games, health-care games and political, religious and art games. Breuer and Bente (2010) outlined that SGs can be used on different platforms in diverse settings such as professional training, school education or political campaigns, having different topics and subject matters. Michael and Chen (2005) pointed out the debate within SGs, whether ‘fun’ is a needed or desirable element of SGs. According them, if these games, seeming to provide an appealing learning environment, are too close to a classroom setting, with continuous assessment, it reduces interest towards them. On the other hand, it is pointed out that SGs can fulfill entertainment needs to a certain point (Shen, Wang, & Ritterfield, 2009).

2.4 Aspects of serious games design

Research on player motivation is founded on knowing what psychological needs games satisfy and how different games fulfil those needs. Player motivation also relies on immersion, in which a player is transported to a fictional world through storytelling. In video games, where people actively participate in the action, immersion enables emotional experience as if the events were really happening to the players (Rigby & Ryan, 2011). Immersion in gameplay experience can be divided into sensory, challenge-based and imaginative dimensions in which all players’ interpretation of playing influences personal and social contexts of their lives (Ermi & Mäyrä, 2005).
Fig. 4. Aspects of serious games design (article II, published by permission of the Association for Information Systems).

Figure 4 illustrates some aspects of SGs design. Designing digital games involves psychological aspects (Rigby & Ryan, 2011), as well as mechanical and artistic aspects (Fullerton, 2014). Game designers empathise with players, and their main task is to ensure that the game is entertaining (Adams, 2013). According to Rollings and Adams (2003), game design is a process that includes imagining a game, defining how it works, describing its elements and transmitting all this information to the game development team. A common element in digital game design is to design systems of actions and outcomes where the game responds easily to a player’s input (Salen & Zimmerman, 2004).

The process of video game design involves designing the content and rules in the preproduction stage and designing the gameplay, environment, storyline and characters in the production stage (Bethke, 2003; Fullerton, 2014). Adams (2013) divided the game design process into three parts: the concept stage, which is performed first; the elaboration stage, where most of the design details are added and refined; and finally, the tuning stage, which involves polishing the game.

Fullerton (2014) proposed a v-shaped game development model – where the main phases are concepting, preproduction, production, Quality Assurance (QA)
and maintenance after the launch. Petrillo and Pimenta (2010) described a modification of the waterfall process regarding game development—consisting of the analysis, project and test/quality phases. On the other hand, several agile methods have been suggested and reported to be used in game development (Koutonen & Leppänen, 2013; Petrillo & Pimenta, 2010). The most commonly used Agile method in Finnish game development companies is Scrum—followed by XP, Lean and Kanban methods (Koutonen & Leppänen, 2013).

2.5 Developing serious games

This chapter focuses on the development of SGs. After rationalising the need and challenges of SGs design, Chapter 2.5.1 presents different categorisations of health games, and Chapter 2.5.2 focuses specially on the design and development of SGs in the health sector.

In the development of SGs, one main challenge is finding a way to make a game that is both appealing, fun and engaging and achieves its serious goal (De Troyer & Janssens, 2014; Mader, Levieux, & Natkin, 2016). A good serious game should also to solve a specific organisational need (Backlund, Engström, Marklund, & Toftedal, 2017). On the other hand, a SG has failed in its mission, if the player learns to master the game, but cannot apply the learning in the real world (Michael & Chen, 2006). Sanford, Starr, Merkel, and Bonsor Kurki (2015) studied how adolescents see serious games compared to entertainment games. Their research implicate that it is necessary to take on account the experiences, expectations and perceptions of gamers in serious game design, to develop effective educational tools for children and youth. As Sanford et al. (2015) stated, it is very common that serious games are more simplified and not so immersive as mainstream commercial games immersion is seen as the right feature to label a game ‘good’. To make an acceptable and playable SG, the implementation needs to surpass expectations regarding technological capacity, aesthetic presentation and game design elements. Super fun factors, such as narrative-related elements, humor and social interaction, contribute to a higher level of enjoyment also with serious content. (Shen, Wang, & Ritterfield, 2009.) To motivate the player, SG needs to find a balance between information and enjoyment so that the player/learner does not experience the learning element as detached from the game (Breuer & Bente, 2010).

The SG development process can follow any existing system development models from the traditional waterfall model to iterative, incremental and agile pro-
cesses (Avison & Fitzgerald, 2006; Backlund et al., 2017). Braad, Zavcer and Sand-
over (2016) suggested that many development processes regarding SGs follow the
ADDIE model (see Molenda, 2015). This model consists of the analysis, design,
development, implementation and evaluation phases and is supported by the Scrum
methodology.

Persuasive Game Design (PGD) aims to create ‘a user experienced game world
to change the user behavior in the real world’ (Visch, Vegt, Anderiesen, & van der
Kooij, 2013, p.2). This approach can be seen completing SGs design methodology
although it is more focused on user experience than game design mechanics. A
method called PGD cookbook presents a very practical guidance to PGD develop-
ment. The planning initiates the development: the wanted transfer effect is de-
scribed, and it continues with investigating the user’s world. This is followed by
concept design, game design, and ends with evaluation of effects. (Siriaraya, Visch,
Vermeeren, & Bas, 2018.)

2.5.1 Health games

SGs in the health sector can be divided into games for game-based education of
health professionals and games for improving the therapeutic outcomes of patients
(Arnab et al., 2013). The Games for Health taxonomy categorises health games by
the area of the health activity, being preventive, therapeutic, assessment, educa-
tional and informatics (Sawyer, 2008). Wattanasoontorn, Hernandez, and Sbert
(2014) described three main purposes for health games:

1. Games that are designed originally for entertainment and in which a health
   purpose is secondary but can be found in the games.
2. Games that include a health topic to pass on knowledge or skills.
3. Training games with medical purposes, including simulations
Figure 5 illustrates the health game classification as whole, combining different aspects. The used classifications can divide health games by player: as an in-patient player (focusing on health monitoring, detection, treatment, rehabilitation, and/or education for self-care) or a nonpatient player (focusing on wellness or simulation games). Health games can also be classified by their main purpose, functionality or the stage of disease of patients. The stages of disease of patients include the stage of susceptibility (healthy nonpatients with the possibility of certain illnesses), the presymptomatic stage (patients feeling healthy but with a specific illness), the stage of clinical disease (patients or professionals) or the stage of recovery or disability (patients or professionals) (Wattanasoontorn et al., 2014). Furthermore, health games can be classified by focus areas: physical fitness; education in health, training and simulation; rehabilitation (recovery and therapy); diagnosis and treatment of mental conditions; cognitive functioning; and self-control (Susi et al., 2007).

It should also be noted that “games for health” ideology has also inspired research on “games against health” (GAH) that reacts to it with demonstrating the use of dark game design patterns. This GAH movement emphasises the player agency over health games that aim to correct the players. (Linehan, Harrer, Kirman,
Furthermore, Vandenberghe and Slegers (2016) developed the satirical tone of Linehan et al. (2015) to more focused conclusions on how designing for others can be unintentionally harmful: outcome can serve more commercial goals than the best interest of end-users.

### 2.5.2 Serious games in the health sector

The reported development processes of SGs in the health sector have been quite similar as presented in Table 1 (Braad, Folkerts, & Jonker, 2013; Deen, Heynen, Schouten, van der Helm, & Korebrits, 2014; Friess, Kolas, & Knoch, 2014). These similarities include a strong research and analysis phase at the beginning. Involving different stakeholders is also considered essential. An iterative development process or prototyping is used, along with user-group testing and an evaluation or validation phase at the close of the game development process.

<table>
<thead>
<tr>
<th>Authors</th>
<th>SGs development process</th>
<th>Possibilities</th>
<th>Limitations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Braad et al., 2013</td>
<td>Phases: analysis, design, development and evaluation</td>
<td>Iterative intervention functioning in practice.</td>
<td>Gap between design decisions and development execution.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Monitoring design specifications.</td>
<td>Opportunities for focused improvement in next iterations can be missed due available budgets and time is limited.</td>
</tr>
<tr>
<td>Deen et al., 2014</td>
<td>Phases: Analysis = Ethnographic research, connecting to existing therapies, Design = Game Jamming, Design, Development = Prototyping and Evaluation = User testing and validation</td>
<td>Creating prototypes that are tested with the target audience and domain-experts.</td>
<td>An experimental description of a certain case.</td>
</tr>
<tr>
<td>Friess et al., 2014</td>
<td>Phases: Requirements engineering, concepiting, designing, prototyping and evaluating</td>
<td>Involving target group in the process.</td>
<td>Merely a description of the planning and designing phase.</td>
</tr>
<tr>
<td>Vanden Abeele et al., 2010</td>
<td>Phases: Concept Design, Game Design, Game Development (P-III framework)</td>
<td>Player-centred design model.</td>
<td>Validation not so strongly in focus.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Iterative and incremental development with user testing.</td>
<td></td>
</tr>
</tbody>
</table>
Vanden Abeele et al. (2010) presented the P-III framework (see Table 1) as a method of designing and developing SGs. This model is based on player-centred design, iterative development, interdisciplinary teamwork enhancement and integration of play and learning. The P-III framework consists of the concept design, game design and game development phases.

In health game design, supporting players’ motivation and enhancing behavioural change are key points (Rigby & Ryan, 2011). It is essential to use game elements such as surprise and simulation to engage players and enable immersion (Adams, 2013). In addition, developing a health game needs a multidisciplinary team, with team members working together successfully (Kemppainen et al., 2014). It is also important to

1. define both the target group and the main objective;
2. design a game, accordingly, using sound game design principles;
3. utilise design elements to enhance learning and persuasion;
4. collaborate with health professionals from an early design stage; and
5. involve patients, especially to improve usability. (Brox, Fernandez-Luque, & Tollefsen, 2011).

Iterative design is a play-based design model. It emphasises playtesting and prototyping, which allows players to be part of the game design. In iterative design, a rough model of the game – a rapid, interactive prototype – is created as early as possible. This may have placeholder graphics, but it can be played and evaluated. The user comments and evaluations influence the game’s further design (Salen & Zimmermann, 2004).

When designing SGs in health care, the target group should be taken into account during the development process (Braad et al., 2013; Brox et al., 2011; Deen et al., 2014; Friess et al., 2014). Professional knowledge is an essential part of the development (Merry et al., 2012).

SGs achieve their consequences through experiential and behavioral effects on the player (van der Kooij, Hoogendoorn, Spijkerman, & Visch, 2015). It is important to include an assessment of SGs’ usefulness and effectiveness in the development process (Graafland et al., 2014). When the effectiveness of SGs is assessed, the entertainment value should always be included. Besides final outcomes, also the learning and training process should be assessed. SGs should be assessed further from the point of ‘possible negative effects such as media-induced reduction
of invested mental effort, the learning of socially undesirable content, and misconceptions in learning due to reductions and ‘simulation shortcuts’ (Michael & Chen, 2006) in games’ (Breuer & Bente, 2010, 21.)

Desurvire, Caplan and Toth (2004) outlined a set of design heuristics which are guidelines that serve as an evaluation tool specific to video games. According to their definitions, the Heuristics for Evaluating Playability (HEP) categories include evaluating game play, game story plot and character development, game mechanics and game usability. Especially, HEP is recommended for use in the early design phase. On the validation, van der Kooij et al. (2015) suggested using the change catalyst (independent variable), that means using a placebo SG which is equal to the researched SG in all other aspects except the change catalyst. Graafland et al. (2014) provided framework for the assessment of health games. This framework consists of five main themes: game description, rationale, functionality, validity, and data safety.

2.6 Multidisciplinary teamwork

The term multidisciplinary expertise refers to the gathering of professionals and nonprofessionals from multiple academic disciplines to collaboratively solve a defined problem (Nancarrow et al., 2013).

The terms multidisciplinary teamwork and collaborative or participatory design (PD) process refer to the same phenomenon, just from different angles. Software game development is a multidisciplinary activity, where team configuration and management are a big challenge. Game development teams have quite different types of people working on them, from computer scientists to illustrators and business managers, and several factors have been identified that have an effect on successful collaborations among such diverse groups. There are interpersonal factors such as trust between team members and communication skills, willingness to collaborate and mutual respect, as well as organisational factors such as having suitable protocols and supporting collaboration (Aleem, Capretz, & Ahmed, 2016b; Fullerton, 2014).

Tran and Biddle (2008) described three main factors that contribute positively to the collaborative process in SG development: respecting others’ roles, participating in iterative development and having a shared vision for the game product. Other factors mentioned were a collaborative spirit and a supportive technical environment.
A PD process is a design approach in which the users participate in and oversee the making of design decisions through the entire design process. In that approach, the users are one of the many actors involved in the PD process; other actors include designers and other experts (Gulliksen, Lantz, & Boivie, 1999). Participation in this sense is meant to improve the design process so a meaningful game is developed (Lukosch, van Ruijven, & Verbraeck, 2012).

Computer game development needs a multidisciplinary team that consists of game designers, writers, programmers and so forth. Pedagogical competence is also needed in educational games, and end users should be involved (Brox, Heggelund, & Evertsen, 2009). Health professionals are needed from an early design stage to validate the content and validate the game from a clinical viewpoint. Patient involvement is also needed to improve usability (Brox et al., 2011). Health game development is motivated by the need to support professionals or patients and game design experts, health-care professionals and end users all participating in developing the game concept. The game implementation process includes design, production, graphics, programming, sound and testing, and health-care experts provide support through their professional knowledge (Braad et al., 2013; Deen et al., 2014; Friess et al., 2014). Due to the many different potential applications of SGs (see, for example, Ricciardi & De Paolis, 2014; Zyda, 2005), their development requires the involvement of experts who present a variety of disciplines (Kemppainen et al., 2014; Merry et al., 2012).

There are frameworks to guide SG development, but those are aimed at developers and, thus, do not help other experts, such as health professionals, working within SGs. In the analysis phase, several issues regarding an SG has to be decided, and this involves all stakeholders. These issues can include, for example, the context of the SG, definition of the target group characteristics, allocated resources and game aspects. By providing a list of explained issues in the form of a tool, the nondevelopers can also follow the process (De Troyer & Janssens, 2014).

SG development is interdisciplinary by nature, and it can be challenging for the developer to get input from many domains. Another issue concerns clients, who do not know what to ask for and do not understand the nature of iterative development. Also, expectations of clients regarding visual realism in an SG may be high, as well as possibilities to maintain and use the SG (Backlund et al., 2017).

Lukosch et al. (2012) described using computer-mediated brainstorming sessions for the PD of their simulation game. After the brainstorming sessions, they role-played scenarios, conducting interviews with experts in the field and review-
ing the literature on SGs involved in the subject area. Kayali et al. (2015) used design workshops as the participatory game design method for the development of a health game for children with cancer. They concluded that user-centred and PD methods are helpful in the early stages of a project, as they provide a general direction for the design. In a play-centric design, the key point is ideas are prototyped and play-tested early, so a playable version of the game idea is needed immediately after brainstorming ideas (Fullerton et al., 2008).

A business model canvas is presented as a tool to quickly combine design thinking with a user-centric approach. This canvas gathers all needed information – such as partners, activities, resources, value propositions, customer relationships, channels, customer segments, cost structure and revenue streams regarding the targeted business (Osterwalder & Pigneur, 2010). The Game Design Canvas has been developed for professional game designers and is supported by game design workshops (Carey, 2017).

![Game Design Canvas](https://example.com/game-design-canvas.png)

**Fig. 6. The Game Design Canvas (Carey, 2017).**

As illustrated in Figure 6, the game design canvas guides the game designers to start thinking about the players and the intention of the game and then progresses to game design elements and, finally, to other considerations, such as development and marketing (Carey, 2017).
Zavcer, Mayr and Petta (2014) developed the Serious Games Design Pattern Canvas to assist in a bottom-up approach to designing SGs. Their canvas is a visual chart that breaks larger game design problems into smaller pieces. The descriptions in the canvas (Fig. 7) can be complemented with detailed descriptions and visual representations.

**Fig. 7. The Serious Games Design Pattern Canvas (Zavcer, Mayr, & Petta, 2014).**

Figure 7 presents the Serious Games Design Pattern Canvas – which gathers information on related research, the purpose, key data, patterns, mechanics, channels, ethics, desired outcomes and users into a visual form (Zavcer, Mayr, & Petta, 2014).

### 2.7 Pedagogical approach

This chapter presents the aspects regarding the concept of e-learning and the Carpe Diem learning design method. These aspects create a base for developing a tool to support the SGs development in form of an e-learning course.

The internet and rapidly developed information and communication technology have built new methods of education and learning. Especially, the role of e-learning has grown as part of the acquisition of new skills and knowledge, and thus, more participants can be educated simultaneously. Despite e-learning’s technical requirements, the pedagogical aspects should be noted as well. To evaluate the effectiveness of e-learning, a framework, from the perspective of pedagogy, was proposed. The framework consists of five aspects: the individual, knowledge, learning,
content, and the relationship between the instruction and the learner (Yunus & Salim, 2008).

The social constructivism approach has been applied in online courses (Shaikh, Karim, & Asif, 2017). Online learning and self-study are considered possible in the social constructivism context because the learner has ‘inherited evolved cultural tools deliberately devised for intentional learning’ (Marsh & Ketterer, 2005, p. 7).

The tension between the synchronous and asynchronous delivery of online courses is recognised. Shared deadlines result in improved motivation, and asynchronous delivery gives students more freedom and ease (Shaikh et al., 2017). Asynchronous discussion forums using the collaborative learning method is proposed to assess students’ knowledge level (Durairaj & Umar, 2015).

Considering the dropout rate, Onah, Sinclair and Boyatt (2014) noted that in most massive open online courses, less than 13% of students finished the course. In online courses, it is challenging to provide individual help to students and guarantee that the course outcomes have been achieved. Crowdsourcing has been noticed to have a possibility to answer these questions. Crowd formation in an online setting related to specific knowledge domains can connect students and make interacting and collaborating with knowledgeable individuals possible (Shaikh et al., 2017).

Kali, Levin-Peled and Dori (2009) reported about challenges to design courses that promote collaborative learning in higher education. According to them, teachers willing to adopt socioconstructivist pedagogies often face challenges related to fulfilling their objectives without the thorough application of carefully planned design methods. They also encouraged teachers to formulate and refine guidelines to fit with the objectives and to find sensible methods in the design.

The Carpe Diem learning design method describes a team-based, collaborative online learning design process that typically comprises two or three academics (Salmon, Gregory, Dona, & Ross, 2014; Salmon & Wright, 2014). This method is suitable for designing new courses. Carpe Diem focuses on learning design needs for specific units of study. The basic process is delivered in a two-day workshop, and the basic idea is that people design something that could be put into immediate use with participants. By the end of the workshop, a unit or module should be partly built in the online environment and an action plan designed to support it (Salmon & Wright, 2014).

The Carpe Diem design method has been used for entirely digital and blended learning and mobile learning. It is a way to design new student-centred and engaging courses for higher education (Salmon & Wright, 2014). The design method can
be considered as a toolkit: rather than following the process step by step, it is possible to select only the steps needed (Usher, Macneill, & Creanor, 2018).
3 Research objectives, approach and methods

This chapter describes the research objectives – including RQs, the chosen research approach and research methods.

3.1 Research objectives, questions and approach

The main objective in this study was to identify the steps in the multidisciplinary development process of SGs and propose solutions to support this process. The current study answered the following RQ with the help of four SQs (SQ1–SQ4) using multiple research methods.

**RQ:** What kind of tools and methods are needed to support key phases of the SG development process in the health sector?

**SQ1:** How are SGs in health care perceived and approached in the literature?

**SQ2:** What are the key phases when designing and developing SGs?

**SQ3:** What kind of tools and methods can help a multidisciplinary team to work together when developing SGs?

**SQ4:** How can an e-learning course on SGs for multidisciplinary students be developed?

3.2 Research approach and methods

This chapter presents used multimethod research approach and methods – including a systematic mapping study, DSR, AR and a case study.

3.2.1 Multimethod research

The area of SGs is multidimensional; hence, multimethod research, as advocated by Mingers (2001, 2003), was adopted as the path of the study. Mingers (2001) stated that multimethod research, using a range of different research approaches, is justified on the grounds that the research process and research target are complex and multidimensional. A multimethod work can answer demands of complex real-world situations (Mingers, 2003).
Using more than one research methodology, in whole or in part and possibly from different paradigms, is seen to make the most effective contribution. Multi-methodology can be defined as partitioning methodologies and combining parts. Research is described as a process, not a single event, that brings different problems in phases to the agent. The multidimensional work favours multimethodology. (Mingers & Brocklesby, 1997.)

The research process iterates idea generation and refinement (i.e., working back and forth between design possibilities and RQs). The design processes result in a set of decisions that directs the study (Rossman & Wilson, 1994). Greene, Caracelli and Graham (1989) defined five different purposes that involve the use mixed-method evaluations: triangulation, complementarity, development, initiation and expansion. Development is defined as the process by which the results from one method help to inform the development of the other method, while expansion aims at extending the breadth and range of inquiry by using different methods (p. 259). Mixed-method research covers research involving both quantitative and qualitative methods development (Rossman & Wilson, 1994).

Brewer and Hunter (2006, p. 4) stated multimethod approach’s strategy is to ‘attack [a] research problem with an arsenal of methods that have nonoverlapping weaknesses in addition to their complementary strengths’. Mingers (2001) proposed frameworks for designing multimethod research methodologies. This proposal covers 1) the research context (deciding which methods to use and how those are linked) and 2) a framework for mapping methodologies and the generic research design. He pointed out the example of an AR in designing an information system (IS)/IT. This used a variety of methods and also parts of methodologies that fit that certain situation.

Fig. 8. Methodological choices (Saunders, Lewis, & Thornhill, 2016, p. 167).
Figure 8 illustrates the differences between methodological choices, mainly between mono and multiple methods. Mono methods restrict methodology to either qualitative or quantitative studies. On the other hand, multiple methods can be divided between mixed-methods and multimethod research. Multimethod is described as being branch of multiple methods that uses more than one qualitative or quantitative method without mixing both (Saunders et al., 2016).

3.2.2 Systematic mapping study

A standard systematic literature review is usually conducted over a specific RQ. A mapping study, on the other hand, aims to provide an overview of a topic area through multiple RQs (Kitchenham, Budgen, & Brereton, 2011). Mapping questions are about ‘what we are knowing with respect to a specified topic’ (Petersen, Vakkalanka, & Kuzniarz, 2015, p. 9). The results of a systematic map presented as a visual summary helps to determine in which areas to conduct a conventional systematic literature review (Kitchenham et al., 2011; Petersen, Feldt, Mujtaba, & Mattsson, 2008).

![Fig. 9. The systematic mapping process (Petersen et al., 2008).](image)

Figure 9 illustrates the systematic mapping process defined by Petersen et al. (2008) – which consists of the following process steps: defining RQs, conducting the search for relevant papers, screening of papers, performing keywording using abstracts and performing data extraction and mapping. The categories used in a mapping study are usually based on publication information such as authors’ names, authors’ affiliations, publication source, publication type, publication date and/or information about the research methods used (Kitchenham et al., 2011).
Mapping questions are often formulated around a specified topic and include questions regarding venues, research methods and trends (Petersen et al., 2015). The search is conducted in relevant databases for all papers in the research field, and, as recommended by Kitchenham and Brereton (2013), the use of IEEE (Institute of Electrical and Electronics Engineers) and ACM (Association for Computing Machinery), as well as two indexing databases, is sufficient. A search string is defined based on the RQs (Petersen et al., 2008).

The third step in the systematic mapping process is the screening of papers. Inclusion and exclusion criteria are needed to find relevant papers that answer the RQs (Petersen et al., 2008). Inclusion and exclusion criteria can be related to the relevance of the topic of the article, venue of publication, period considered, requirements for evaluation and restrictions with respect to language. The selection of papers is performed on titles and abstracts, thereby building a classification scheme first, and then later, reading is extended to introductions and conclusions (Petersen et al., 2015).

For classifying the type of research, Kitchenham et al. (2011) and Petersen et al. (2008, 2015) recommended using a classification system with six categories developed by Wieringa, Maiden, Mead and Rolland (2006):

1. Validation research, which concerns evaluating novel techniques not yet deployed in the industry
2. Evaluation research, which concerns evaluating industrial practices
3. Solution proposals, which discuss new or revised techniques
4. Philosophical papers, which structure the field in new ways, such as taxonomies
5. Opinion papers
6. Experience papers, which discuss how someone did something in practice.

In the data extraction phase, relevant articles are sorted into a scheme, such as an Excel spreadsheet. The mapping process ends with a presentation on the frequencies of publications for each category using maps for visualisation (Petersen et al., 2008).

### 3.2.3 Design science research

Systems development from the research domain point of view, as described by Nunamaker and Chen (1990), offers a fruitful base for seeking new solutions to an identified problem. They listed eight ways to find these solutions:
1. build a prototype,
2. construct a method,
3. develop a theory,
4. formulate a concept or a framework,
5. conduct an empirical laboratory test,
6. conduct a real-world test or a survey,
7. describe a case and
8. declare the ‘truth’.

Fig. 10. A research process of systems development research methodology (Nunamaker & Chen, 1990).

A research process of systems development follows a systems building process, as illustrated in Figure 10. In the first phase, constructing a conceptual framework, research issues cover stating a purposeful RQ, studying the relevant subjects for new approaches, investigating and understanding needed functionalities and processes. In the development of a system architecture, systems component’s functionalities are defined. After this, the system is designed and built while learning of design, concepts and framework and gaining experience about problems of the system. Finally, system use is observed (a case or a field studies) and evaluated (laboratory or field experiments), thus developing new models or theories based on the information (Nunamaker & Chen, 1990).
3.2.4 Problem identification

Figure 11 illustrates the problem identification process in DSR. A literature review helps to identify the problem, clarifies the existing state of art in this area and helps to notice possible obstacles and difficulties for its solution (Offermann, Levina, Schönherr, & Bub, 2009). Vaishnavi and Kuehler (2015) pointed out that finding an interesting research problem may result from multiple sources and the output of the phase called ‘awareness of [the] problem’, which may result in a proposal. This is followed by a suggestion phase (which can be seen as a creative step), where the first tentative design is conducted (Vaishnavi & Kuehler, 2015). Offerman et al. (2009) mentioned expert interviews that can be conducted to identify relevant problems. Peffers et al. (2007) defines the objective of the solution as part of the problem identification process.

3.2.5 Solution design

After problem identification, Offermann et al. (2009) described the phase of developing the artefact as a ‘solution design’ and proposed doing a second literary research process. A DSR is used to produce an artefact to solve a real-life problem. Artefacts, in this regard, can be models, systems, prototypes or other constructs (Hevner, March, Park, & Ram, 2004). Peffers et al. (2007) added that the outputs of DSR can include social innovations and new characteristics of existing technical, social or knowledge-intensive systems. Hevner and Chatterjee (2010) delineated DSR as a research method that focuses on problems related to human beings, develops innovative artefacts and promotes new knowledge in a particular discipline.
They especially noted that the developed artefacts should be functional and useful in their contexts and should help people solve problems.

![Diagram of IS research framework](image)

**Fig. 12. The information systems research framework (Hevner et al., 2004).**

Figure 12 presents an IS research framework. The environment offers business needs that people in organisations have, thus offering the problem to be solved in the research. The knowledge base serves as a container for foundations such as prior research, theories and frameworks. Methodologies provide guidelines such as data analysis techniques, formalisms and validation criteria to be used in the justifying and evaluating phase. In the development phase, DSR addresses unsolved problems in new, innovative ways or existing solutions in more effective or efficient ways. Research, answering these problems, is addressed through building and evaluating artefacts. The contributions of research return as additions in the knowledge base and is found in use in appropriate environments (Hevner et al., 2004).

DSR is mostly a problem-solving process, and seven guidelines are proposed to be followed during this process:

1. Designing a purposeful IT artefact (a construct, a model, a method or an instantiation) that solves a given organisational problem.
2. Designing a relevant, innovative technology-based solution for a given problem domain.
3. Evaluating the artefact from the aspect of utility, quality and efficacy.
4. Providing verifiable research contributions in design foundations, design methodologies or the design artefact (novelty, generality or significance).
5. Using rigorous methods in the construction and evaluation of the design artefact.
6. Using an iterative process to search for an effective solution to the problem.
7. Communicating the DSR both to technology- and management-oriented audiences (Hevner et al., 2004).

3.2.6 Evaluation

The evaluation phase in DSR can consist of a case study or AR by arranging a broad expert survey and by laboratory experiments or simulations. It is also possible to iterate back to the problem identification or solution design phase (Offermann et al., 2009). The evaluation of the artefact provides a better understanding of the problem used in order to improve the process and quality of the product (Hevner et al., 2004).

3.2.7 Action research

AR aims to solve current practical problems while expanding scientific knowledge, typically using an iterative research process where researchers are part of the study (Baskerville, 1999; Baskerville & Myers, 2004). As a concept, AR was introduced by Lewin (1946), who studied workers’ intergroup relations and actions, as well as the barriers the workers met at work.
Susman and Evered (1978) described the cycle of AR, as illustrated in Figure 13 – starting with a diagnosing phase, followed by action planning, action taking, evaluation and, finally, learning specification. These phases can be repeated. The number of phases that are carried out in AR projects between the action researcher and the client system can differ. In experimental AR, the researcher and client system are involved in all, or almost all, phases.

Specifically, AR is an effective research method in cases that include active participation in organisations that are in the process of changing and that raise research interest among researchers. In practice, the change can be carried out by professional researchers who want to develop their work processes and practices in their environment. AR appears as a cyclical process, and it is collaborative in nature (Coghlan & Brannic, 2014).

3.2.8 Case study

Myers (2013, p. 73) asserted case studies offer fruitful approaches for learning how to act or what is to be built. This is because of their special nature of showing that the theory can be applied and that the subject matter has a meaning in life. The use of case studies is a well-known approach that aims to help understand the process
taking place in defined settings, and it often combines several data collection methods—such as observation and the use of interviews, archives and questionnaires (Eisenhardt, 1989).

A case study is defined as a targeted study of a single unit for the purpose of understanding a larger phenomenon. A unit means a spatially bounded instance observed during some delimited period or at certain time (Gerring, 2004, p. 342). Multiple case studies help researchers understand the differences and similarities between cases (Baxter & Jack, 2008; Yin, 2003). At the same time, a multiple case study can require more resources and time than a single-case study (Yin, 2003).

**Fig. 14. The case study research process (Eisenhardt, 1989).**

Eisenhardt (1989) presented a guide to conduct the case study process, as illustrated in Figure 14. The first steps are to define the RQ, specify possible constructs (getting started) and select cases. In the selection phase, the definition of population is essential. Crafting instruments and protocols can combine multiple data collection methods— including quantitative with qualitative methods, if needed. The combination of data types is considered synergistic. It can be usable to also have multiple investigators. Entering the field starts building the theory from case studies and data analysis goes simultaneously with data collection, with field notes being a good tool. The data are then analysed using within-case analysis and a cross-case pattern search using divergent techniques. Shaping hypotheses consists of measuring constructs and verifying relationships. Finally, it is time to compare results with the existing literature and reach closure.
4 Research implementation

This chapter presents a summary of original papers as Articles I–VI that were published between 2014 and 2019. Each chapter presents research objectives, RQs and main results.

4.1 Summary of the research implementation

The first article (Article I), written in 2014, raised interest in the research area. The main focus of Article I was defining the terminology and development method of SGs through a case study. Article II conceptualised the area of SGs in health care by applying a systematic mapping study. In Article III, the conceptualisation of iterative development process of SGs continued in a case study. Articles IV and V concentrated on the conceptualisation of multidisciplinary expertise, which is needed in SG development, and demonstrating developed tools and methods to support the SG development process via an action study and applying DSR. Finally, Article VI aimed at demonstrating the SG development process model via a case study. This progress of the studies is illustrated in Figure 15.

![Fig. 15. The progress of the studies on serious games.](image)

The main RQ addressed by this study was:

What kind of tools and methods are needed to support key phases of the SG development process in the health sector?

Table 2 presents the summaries of the articles’ contribution and the author’s role in them. In the following subsections, the contribution of the author of this dissertation is specified at the end of each summary.
Table 2. Summary of the articles’ contributions and author’s role in them.

<table>
<thead>
<tr>
<th>Article</th>
<th>Contribution</th>
<th>Author’s role</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Defining the terminology and development methods that are used in SGs development and identifying interest in the subject and the research question for this thesis.</td>
<td>Being responsible for the research part regarding health game development and thus authoring also that part in the article.</td>
</tr>
<tr>
<td>II</td>
<td>Mapping the area of serious games and conceptualising SGs as research phenomenon and how they are used in different areas of interest.</td>
<td>Being responsible for formulating the research problems and questions and conducting a systematic mapping study. Served as the primary author.</td>
</tr>
<tr>
<td>III</td>
<td>Conceptualising and demonstrating the iterative SG development process through a case study.</td>
<td>Being responsible for formulating the research problems and questions, gathering the theoretical bases, coordinating and collecting of empirical material, drawing conclusions, and being the primary author.</td>
</tr>
<tr>
<td>IV</td>
<td>Conceptualising multidisciplinary expertise and demonstrating new tools and methods that support the SG development.</td>
<td>Leading the design and executing the study presented with a research team and served as the primary author.</td>
</tr>
<tr>
<td>V</td>
<td>Demonstrating use of the new tools and methods to support SG development in a multidisciplinary environment.</td>
<td>Responsible for the research conducted with a multidisciplinary team. Served as the primary author.</td>
</tr>
<tr>
<td>VI</td>
<td>Conceptualising and demonstrating the iterative SG development process through a case study.</td>
<td>Responsible for the research conducted with co-authors and being the primary author.</td>
</tr>
</tbody>
</table>

All the articles have been published as full papers in conference proceedings. The author of this dissertation was the primary author of Articles II–VI.

4.2 Article I: Developing health games requires multidisciplinary expertise

Article I targeted defining the main concepts of SGs and describing a health game development process involving different stakeholders. The objective was to explore *key phases of the SG development process* through multiple case studies. These case studies included a dance game for the elderly, a rehabilitation game for stroke patients, a virtual training and rehabilitation environment and a game to support the development of youth life management skills. The latest, Game of My Life, was used as an example in proposing a health game development process as presented in Figure 16.

**Fig. 16. The proposed health game development process.**

The results suggest SG development in the health sector needs a multidisciplinary team – with its members efficiently working right from the planning phase, after the need for a game is realised. As Figure 16 illustrates, the development process continues through the implementation and testing phase and finalises in the commercialisation and marketing phase.

*The author of this dissertation* participated in the planning of the research and gathering empirical evidence regarding health game development and thus was responsible of authoring that part in Article I.
4.3 Article II: Serious games in healthcare: A systematic mapping study


A systematic mapping study was chosen as the method to get a broad overview of the SGs. The study applied the guidelines of Petersen et al. (2008), Petersen, Vakkalanka and Kuzniarz (2015) and Kitchenham, Budgen and Brereton (2011). The evaluation phase utilised the criteria of research approaches by Wieringa et al. (2006).

The main RQ was *How are SGs in health care perceived and approached in the literature?* To get the answer, three SQs were presented:

- Which journals include papers on SGs in health care?
- What are the most investigated areas of SGs in the health sector and how have these changed over time?
- What research types and methods are most frequently applied?

As results, a total of 408 studies from 2005 to 2016 were found, and after screening and exclusion, 83 studies were analysed. Most of the included papers were published in conference proceedings, the IEEE SeGAH (International Conference on Serious Games and Applications for Health) conference being the most popular forum. The systematic mapping study found only a few papers published before the year 2009; after that the number of papers increased until 2014. In 2015, there was a slight gap, and then in 2016, the number of papers increased again.
The most common target groups of SGs described in the included papers were children, the elderly and patients with certain diseases. Educating professionals or patients and informing healthy people (preventive approach) was one of the top topics – followed by exergaming, cognitive rehabilitation, psychology and physical rehabilitation. The most frequent approach was to use a case study to describe the development or design of an SG – as seen in Figure 17, which illustrates the most investigated areas of SGs. Many of the studies used participatory, user-centred or collaborative methods, which supported earlier research on involving different stakeholders in SG development (Braad et al., 2013; Brox et al., 2011; Deen et al., 2014; Friess et al., 2014). Only a few of the studied papers focused on providing general guidelines for SG developers in health care.

The results indicate the next focus might be on validating SGs and developing general guidelines for SG developers in health care, including maturity models, and future studies should further integrate the gaming industry and health-care professionals.

The author of this dissertation was solely responsible for formulating the research problems and questions and conducting a systematic mapping study. The author also served as the primary author of Article II.
4.4 Article III: On the development of serious games in the health sector – a case study of a serious game tool to improve life management skills in the young


In this study, the means of the case study (Myers, 2013) were applied. The case focused on the development of Game of My Life (GoML), an online visual novel-type game that aims to support the life management skills of young people aged 16 to 19 years old. The main RQ was What are the key phases when designing and developing SGs? The SQ was raised based on the interest in affective computing: How does the SG design take into account affective computing? The study described the development of this SG in two phases.

In the first phase, designing the game started with gathering user needs, deciding on the theoretical framework to be used and analysing existing similar games in the market. A framework of a young person in the process of becoming independent could be used as a theoretical base. A background qualitative research was launched, where data was gathered in six individual, semi-structured interviews to find out how young people understood life management and what challenges they had with it. The study also gathered their expectations regarding a game that could support life management issues. This framework, together with qualitative data, provided the background for the game’s storylines.

The development of GoML continued with the game concept design, where a visual novel was selected as a game genre. For content creation, the development team was mixed with nursing students and a lecturer. Ideas were also presented to different experts, from psychiatry to game development professionals.

An iterative Agile game development process enabled prototypes to be tested by different stakeholders. The test feedback mainly covered feedback and suggestions for the improvement of the game. Reasonably, an external and unbiased evaluation of the GoML was also provided. This evaluation used a modified version of the HEP (see Desurvive et al., 2004).

The second phase of development continued by utilising all previously gathered testing and feedback data. The new aim of the game for the young was to evoke new thoughts and ways of thinking, considering daily-life decision-making
and problem solving. The choices that the visual novel genre provided would make it possibility to face the consequences of the choices made in the game. After similar Agile game production cycles, evaluation of the GoML was conducted in two ways: first, via constant testing through on the website, with a request at the end of the game to provide feedback anonymously and, second, through a qualitative study with nine young people aged 18 to 22 years that were interviewed after playing GoML. Evidently, the game provoked and eased discussion about very difficult areas of life management.

![Fig. 18. The iterative serious game development process.](image)

Figure 18 illustrates the key phases that were discovered in this case study. The study suggested the analysis phase starts SG development. It is essential to involve different experts and other stakeholders, such as end users, as early as possible in the process. This enables active collaboration and makes it easier to understand user needs. Understanding the user helps in finding the right triggers in stories to raise emotions in players – thus, perhaps, leading to an effective outcome.

A game concept helps in communication regarding both game content and technical issues. It is also important to make necessary exclusions in game features
when considering the budget. Iterative development with frequent playable content that can be tested helps to consider if the SG is working in the planned manner. The whole iterative SG development process can continue for as many rounds as needed or resources can be made available to improve the outcome.

Fig. 19. Game of My Life user interface, differences between the first (left) and second (right) versions.

The case also indicates SG design takes, at least in the case of the visual novel, into account affective computing: the game design intentionally influences emotions in order to engage players. Regarding the serious use of the game, GoML’s second version, as illustrated in Figure 19, was reported to work as a discussion tool to evoke conversations between patients and professionals, and the game was provided with a protocol for its use.

**The author of this dissertation** was responsible for formulating the research problems and questions; gathering the theoretical bases; coordinating, collecting and analysing empirical materials (not participating in the qualitative interviews); drawing conclusions; and being the primary author of Article III.

### 4.5 Article IV: A multidisciplinary approach to serious games development in the health sector

DSR techniques were adopted in this study to identify the role of versatile expertise in the health-care context. The main RQ was *What kind of tools and methods can help a multidisciplinary team work together when developing health games?*

![Fig. 20. The applied design science research approach.](image)

The framework introduced by Hevner et al. (2004) was applied in the study, as illustrated in Figure 20. The literature review provided background, and the development of a series of SGs in the health sector in the near past produced context-dependent information and new knowledge upon which to build the framework. Next, relevant tools and methods were developed and evaluated. Kajaani University of Applied Sciences provided the environment for this study. Game development teams that focused on SGs and worked with external experts from different disciplines and end users provided an excellent ground for the study.

To find an answer to the research problem of how to work collaboratively around a defined problem, an applied DSR approach was used. In this study, the environment consisted of people coming from several disciplines – such as health care, education, and software or game design. The knowledge base included literature research, expert interviews and existing knowledge containing six SG projects. These projects were evaluated from the perspective of cooperation in multidisciplinary teams. The main result was that a lack of communication or
limited understanding about others’ work was noted in many projects. On the other hand, the differences among team members were also noted as a positive remark.

IS research is about implementing a solution to help designers and developers to get context-related knowledge and develop ways on how to communicate the emerged ideas. The solution included a rapid prototyping workshop and an SG design canvas (see Appendix 1) as *artefacts*.

The artefact design was a creative and iterative process. The implementation required inputs from the environment and knowledge base before the solution was built, and it required evaluation, iterations and collaboration. As theoretical implications, this study proposed involving different disciplines in the designing and development of SGs. Regarding practical implications, the study suggested SG development process education for health-care professionals and the introduction of the above artefacts to the developers and other professionals in the analysis phase.

The author of this dissertation led the design of the DSR and, together with a research team, execution of the study and served as the primary author of Article IV.

### 4.6 Article V: Developing an e-learning course on serious games


In this study, the author was involved as one actor in the multidisciplinary team developing an e-learning course on serious games. The overall process of developing the course – as well as participating in practical work as a developer, which is one typical feature of AR – was observed (Coghlan & Brannic, 2014). The main RQ in this study was: *How can an e-learning course on SGs for multidisciplinary students be developed?* Three SQs were raised to answer this question:

- How can an e-learning course with social constructivism theory as approach be designed?
- What kind of content is needed regarding SGs when designing a course for multidisciplinary students?
- How gamification be utilised to motivate students?
Findings are shown in Figure 21. The **planning** phase started with research on the state of the art in SGs courses and it was followed by applying the Carpe Diem learning design methodology (see Salmon et al., 2014; Salmon & Wright, 2014). Next is the **acting** phase, which involved content selection and creation in the Moodle learning management system. Gamification was utilized in the course structure and tasks. The **observation** phase was done by three implementations from where all feedback was gathered and analyzed, which were **reflected** and used in the iterative development of the course.

The study proposed nine attention points, which are available in Appendix 2, as a recommendation. Regarding the social constructivism approach, it was attained through the social interaction and enabling dialogue between students in the learning management system. Constructing knowledge in social setting was one main point in the course, as well as using peer feedback. The course content was largely a compromise, considering the heterogeneous student group. On the other hand, more advanced students could utilize their expertise in discussions and propose new ideas to their peers. Finally, gamification was considered motivating if integrated into the course structure as use of levels and a progress bar. Gamification without connection to the content could be seen as irritating.
On the whole, the iterative development and improvement according feedback was shown to be a good approach to develop an e-learning course.

The author of this dissertation was responsible for planning the AR, which was conducted with a multidisciplinary team. The author also served as the primary author of Article V.

4.7 Article VI: Development of a serious game as a method to support youth work: A case study


This study continued the research started in Article III, focusing on utilising all developed knowledge on SGs to further develop GoML to be used in youth work. The main RQ in this case study was How do we develop an SG in the social and health-care sector that aims at enhancing the life management skills of young people? The three phases of development of GoML could be seen as multiple case studies that helped researchers to understand the differences and similarities between cases.

The earlier phases in this study could be described as

1. A prephase that focused on analysing the existing games and created a concept of a visual novel. This was continued with a demo phase that utilised an iterative development process and multidisciplinary teamwork.
2. A book-like version played online through a web-browser, where the aim was achieved through stories to evoke new thoughts and ways of thinking concerning daily-life decision-making and problem-solving situations. This second version of GoML was thoroughly tested and evaluated.

In the third phase, the focus was on developing a mobile game that had story-driven content. These stories were written by young people themselves, and a multidisciplinary team developed the game to promote positive mental well-being. GoML’s impact on the mental well-being of the young players was evaluated using the Short Warwick–Edinburgh Mental Well-being Scale questionnaire in pilot groups, and at the moment this thesis was being written, this evaluation was still ongoing.

The study results imply the development of an SG starts with getting familiar with the subject and target area. This phase covered also observing if similar games
on the topic already exists. The target group and the changed aim of the game had to be defined. It was important to include specialists from the target area in the process. When the technical issues and graphical appearance, as well as the look and feel in general, regarding the game were set, the game development could be launched. It was essential the game designers understood the theoretical background of the game, even the stories came from external members. Finally, profound testing and impact measurement would make validation of the SG possible. It is essential to provide guidance and a protocol or handbook on using the SG for end users and their supporters.

Iterative game development enables learning from previous phases and improving a game further in each iteration. Developing SGs in the social and health-care sector
requires a thorough understanding of the topic and players. This can be accomplished by using multidisciplinary teams. The developed, third iteration of GoML, as illustrated in Figure 22, can be used in youth work or nursing as a discussion tool to provoke conversation and inspire thoughts on difficult issues.

The author of this dissertation was responsible for planning and conducting the research with coauthors and served as the primary author of Article VI.

### 4.8 Findings

The summary of the SG development process, as presented in this dissertation, is illustrated in Figure 23. The process starts with customers having an idea or perceiving a need for an SG. This initiates an analysis phase.

![Fig. 23. The process of developing serious games as presented in this dissertation.](image)

During the **analyse** phase, customers can be helped to further form their SG idea by organising an SG rapid prototyping workshop and/or by providing education on SGs. In this phase, a facilitator and/or educator are needed. Forming an SG design canvas can also help the customers, end users and development team members to cover needed aspects, considering the development, and understand one another better. The aim of the analyse phase is to create a concept for an SG.
When the concept is detailed enough, the development team, as part of the development and test phase, starts its own analysis process to gather more information and knowledge related to the SG’s subject area. Active participation from customers in this phase would be recommendable. This also initiates multidisciplinary cooperation, which is needed throughout the process. The development and test phase itself are iterative by nature, and the testing of playables should involve both end users and customers. Also, validation of the developed SGs is a continuous part of the process. This dissertation does not position any development method over another. The proposed development and test phase can also have an Agile approach.

In the final phase, the validate phase, it is better to provide evidence regarding the developed SG in a suitable form. It is also important to provide guidelines for both the customers and end users. The next iteration of the development process can also be initiated after validation and restarted from the analyse phase.

4.9 The serious games development tools and methods model

The proposed serious games development tools and methods (SGTM) model follows findings illustrated by Figure 23. It has been intentionally formulated in a way that it also fits other existing frameworks for the development of SGs.

Figure 24 presents the main elements of the SGTM model. Designers of SGs are encouraged to select the tools and methods that fit their own design framework.
The SGTM model consists of four primary tools or methods that can be utilised during the SG development process: 1) an SGs rapid prototyping workshop, 2) an SG design canvas and education, 3) multidisciplinary cooperation and 4) evidence and guidelines. Table 3 presents these elements in more detail.

An SGs rapid prototyping workshop is intended for multidisciplinary audiences. It includes an introduction to SGs and basic concepts such as gamification and game design principles. An SG design canvas that guides the process with questions is explained. The 2–4 hours lasting workshop consists of a discussion and group work (including three to four people) to create an idea of an SG according to a given assignment. The idea is formulated into a SG design canvas and finally introduced to other groups. At the end of workshop, the best idea is voted on.

An SG design canvas aims to gather ideas and thoughts regarding an SG into a one sheet of paper that is easily understood by different stakeholders. This canvas consists of three different areas with the following details:

1. The goal, the experience, the target group and the player, a genre and the basic game concept.
2. The wanted influence/change and graphics, game mechanics, interaction and feedback mechanisms.
3. The needed resources, budget, platforms, distribution channels and business model.
Table 3. The serious games development tools and methods.

<table>
<thead>
<tr>
<th>Tool / Method</th>
<th>Actor / Stakeholder(s)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>SGs rapid prototyping workshop</td>
<td>a Facilitator, Customers, the Development Team, (End users)</td>
<td>A facilitated model for a 2–4 hour workshop on selected topic regarding SGs. See Appendix 2.</td>
</tr>
<tr>
<td>SG design canvas and education</td>
<td>Customers, the Development Team (End users, a Facilitator)</td>
<td>A summary of needed information and features regarding an SG. See Appendix 1. Recommendation to use education such as e-learning courses to improve customers understanding of SGs.</td>
</tr>
<tr>
<td>Multidisciplinary cooperation</td>
<td>the Development Team, Customers, End users</td>
<td>Suggestions to enhance multidisciplinary cooperation.</td>
</tr>
<tr>
<td>Evidence and guidelines</td>
<td>The Development Team, (Customers, End Users)</td>
<td>Recommendation to emphasise validation and provide clear protocols and guidance.</td>
</tr>
</tbody>
</table>

The development of SGs in the health sector requires a profound understanding of the game’s topic and players. Including customers and end users as early as possible in the process is important, as there is a need to find a common understanding and efficient multidisciplinary cooperation. Hence, it is suggested that

- Game development teams name one person to handle communications between other stakeholders and shares information with all stakeholders.
- The customers should be able to define wanted outcomes and understand game development limitations, needed resources and their own role and tasks in the process.
- To improve the aforementioned, education regarding SGs is recommended to the customers. This can be provided to multidisciplinary audiences through dedicated e-learning courses.
- The use of tools such as an SG workshop and an SG canvas is introduced to game developers and other professionals.

Profound testing and measurement of the impact of the SG is recommended to improve validation. Providing guidance for end users and a protocol regarding the use of the SG for both the end users and customers is important.
5 Discussion

This chapter discusses the contributions of this dissertation (including theoretical and practical implications), comparing them with previous work’s contributions. Finally, the implications and limitations of this study are addressed.

5.1 Research contributions

The use and role of SGs in the health sector is increasing, and multidisciplinary teamwork during the development process evidently needs new supportive tools and methods. This study examined the multidisciplinary development of SGs in the health sector, thus answering the RQ: **What kind of tools and methods are needed to support key phases of the SG development process in the health sector?**

The main contribution of this work settles in between the research fields of the information processing science and health or medical informatics. SG development requires the knowledge and skills of game development that can be broadly seen as a creative software development process (Zyda, 2005). As SGs are systems developed for a certain function, several similarities in the development process can be seen with any utility software system (Backlund et al., 2017). Many system development models exist – from the traditional waterfall model to iterative, incremental and Agile processes (Avison & Fitzgerald, 2006; Backlund et al., 2017).

This doctoral study has pieced together the SG development process, which is presented in Figure 23. The key phases of the process are also illustrated in Figure 25. As Braad et al. (2016, p. 111) mentioned, the documentation of design guidelines within SGs can help in the knowledge transfer between professionals and different communities and can be a ‘key factor for structured research built upon best and proven practices’. The documented SG development process (see Fig. 23) has similarities with previous works (Braad et al., 2016; Vanden Abeele et al., 2011), and it is applicable with different development approaches. Nevertheless, this work has a holistic approach and provides a new model, the SGTM model, to support SG development processes, as proposed in Figure 24. The SGTM model adds new tools, recommendations and methods to support the SG development process.
5.2 Comparison with prior works

The SGTM model consists of 1) an SGs rapid prototyping workshop, 2) an SG design canvas and education, 3) multidisciplinary cooperation and 4) evidence and guidelines. In the following, these are compared with prior works’ recommendations.

An SGs rapid prototyping workshop is aimed at a multidisciplinary audience, and it is preferable to have customers, the game development team and end users as participants. The workshop also needs a facilitator to run the process. The aims and execution of the workshop has roots in the PD process. Using PD methods is beneficial at the early stages of a project, and it can guide the direction for the design (Kayali et al., 2015). Workshops and other participatory sessions enhance mutual learning and can be seen as the initial stage of PD (Bødker, Dindler, & Iversen, 2017). Guliksen et al. (1999) pointed out that in workshops with the users, the designers and IT team tend to take over. In an SGs rapid prototyping workshop, the emphasis is on letting the customers and end users bring their ideas to the table – the game development team acts more in the background, or even in the role of facilitator, without interfering with the developed ideas.

An SG design canvas has its original roots in a business canvas (Osterwalder & Pigneur, 2010) and the Game Design Canvas (Carey, 2017). Also, Zavcer, Mayr and Petta (2014) developed their own canvas, the Serious Games Design Pattern Canvas. A canvas as a tool both guides and documents the game design process, while stimulating and documenting the creative process (Oleksandr & Luhova, 2018). These all inspired the design of SG design canvas. It gathers the needed and relevant topics into a form of one sheet of paper, and with instructions, anyone is able to participate in designing a SG.

The need for education, especially targeted at customers and other stakeholders to increase successful collaboration, was brought up by Backlund et al. (2017) and De Troyer (2017). There are requirements to find multidisciplinary tools, guidelines, methods and knowledge to assist in the development of SGs (De Troyer, 2017). The SGTM model contains the aspect of SGs education that answers the knowledge requirement. An e-learning course targeted at a multidisciplinary audience covers the main aspects of SGs design. It guides the student through the analysis phase and gives enough information about the development and test and validation phases. After completing this “Basics of Serious Games”-course, it can be assumed that the acquired knowledge on SGs can ease multidisciplinary teamwork.
The SGTM model, first, suggests that to improve multidisciplinary cooperation, a named (one) person should handle communications and share information between all stakeholders. This kind of findings has not been found in other literature. It might be that this issue is taken for granted and, thus, not put as priority. Second, the model suggests providing education regarding SGs so the customers are themselves able to define wanted outcomes and understand game development limitations, needed resources and their own role and tasks in the process. Third, the aforementioned SG workshop and SG canvas can work as tools.

Considering the evidence and guidelines section of the SGTM model (see Figure 24 and Table 3), profound testing and measurement of the impact of the SG is recommended to improve validation. According to Baranowski (2014), it is important to design health games that aim at longer-term change regarding behaviour and health changes. As stated by De Troyer (2017), a variety of SGs has been developed, but there is not enough information on if they have achieved their purpose – that is, being effective as well as in the sense of transferring the effects to reality. Kato (2013) provided a practically oriented guide to address the observed research gap regarding the efficacy of SGs for health, and the first issue is also to engage research experts early into the game development process. In the field of health care, more randomised controlled trials are needed to determine the effectiveness of serious games regarding health issues (Lau, Smit, Fleming, & Riper, 2016; Primack et al., 2012). The SGTM model emphasises the importance of providing evidence in a suitable form regarding the developed SG. Nevertheless, the validate phase needs more focus in future research and more detailed, practical instructions on how to measure the effectiveness of SGs.

The SGTM model also suggests providing guidance for end users and a protocol regarding the use of SGs for both end users and customers. Especially in the health sector, a protocol and guide on how to use the SG is expected. This supports Duncan, Hieftje, Culyba and Fiellin’s (2014) assertion – stating that a document with a logic model, including intervention manual-style content, is needed to provide the foundation for the development and testing of a video game intervention.

5.3 Implications

Article II rooted the dissertation more theoretically in the sense of the conceptualisation of SGs, especially health games, and charted the use of SGs in different topics in the health sector. The systematic mapping study revealed gaps in the re-
search area – such as the need to develop general guidelines for health game developers, research on validation of SGs and SG maturity models to improve the level of development. The study also noted that future studies should integrate the gaming industry and health-care professionals.

**Article I** started with defining SG terminologies and conducting a case study to understand the key phases in the development of SGs in the health sector. This case study also helped to identify the RQ of this dissertation, as it was noted that the development phase needs smooth cooperation among multidisciplinary team members.

**Article III** focused on further conceptualising the iterative development process, and **Article VI** continued this conceptualisation and demonstrated the use of the developed tools and methods. Together, these articles (I, III and VI) demonstrate the evolvement of the model of the key phases in the development of SGs in the health sector (see Fig. 16 and Fig. 18), and a combination of the results is illustrated in Figure 23 and Figure 25. This model of the key phases in SG development process is presented as one practical implication of this dissertation.

![Fig. 25. The key phases of the serious game development process.](image-url)
The results can be used also as a **theoretical implication**, being consistent with previous works. The results point out the importance of a strong research and analysis phase at the beginning of development and emphasising that a good understanding between the different stakeholders is essential in serious game development (Braad et al., 2013; Brox et al.; 2011, Deen et al., 2014; Friess et al., 2014; Kemppainen et al., 2014; Merry et al., 2012). Additionally, Articles I, III and especially VI point out, as a theoretical implication, the validation phase of an SG is as important as the analysis or development phase. It is important to provide guidance and even a protocol on how to use the developed SG for both end users and their (possible) supporters. Measuring the impact of the developed SG could prove the its effectiveness to potential decision-makers in the supply chain.

**Article IV** focused, first, on the conceptualisation of multidisciplinary expertise. It showed, as a **theoretical implication**, supportive results for previous studies (Kemppainen et al., 2014; Merry et al., 2012) on many disciplines to be involved when designing and implementing SGs. The study emphasised that education and knowledge increase fruitful collaboration in multidisciplinary projects, which supports Backlund et al.’s (2017) and De Troyer’s (2017) assertions.

Second, Article IV introduced a DSR study that developed new tools and methods that can be used to support the SG development process as **practical implications**: a serious game design canvas and a rapid prototyping workshop concept.

The need for education for health-care professionals regarding the SG development process was raised in Article IV. Thus, it led to an AR study described in **Article V**, which focused mainly on the educational aspect of developing an e-learning course on SGs. Together, Articles IV and V provided tools, methods and education to enhance multidisciplinary teamwork. This answers to the demand of further education (De Troyer, 2017).

Regarding research methodologies, the dissertation suggests that using multiple research methods can provide a more comprehensive understanding of the research phenomenon. Approaching the same RQ using different methodologies, as in this dissertation (case studies, DSR and AR), can offer new ways to answer it.

### 5.4 Limitations

Besides contributions, there are also several limitations. First, the main part of the articles referenced prior research involving IS, health informatics or educational journals and conference proceedings can leave out possible studies in another fields of study (such as medical or health related). Also, as SG development is a quick
expanding, cross-disciplinary research field, this might result in leaving out some essential previous studies. Even the five years between Article I and Article VI provided a vast amount of new information on the research subject.

Multimethod research requires know-how in multiple methods and amenity with several styles of arrangements (Mingers, 2003). In this research, the used research methods have been selected to suite according the research topic and studied along the way. This has been time consuming, but also provided richness to the research as enabling looking the research problem from multiple angles.

The systematic mapping research (Article II) has its own limitations. Petersen et al. (2015) classified validation types as descriptive validity, theoretical validity, generalizability and interpretive validity and defined that descriptive validity focuses on how accurately and objectively observations are described. Using a data collection form minimized the threat in this research. Furthermore, theoretical validity consists of confounding factors such as biases and selection of subjects (Petersen et al., 2015). In this research, the study was planned and conducted by one author, which creates a main threat to validity. This could occur such as the eventual omission of papers and bias in the extraction data. Also, the used terminology in the search string and exclusion/inclusion criteria could leave some useful papers out. Possible threats to the validity of the research can also occur in the generalizability of the results of the mapping. Additionally, interpretive validity is reached when the conclusions drawn are acceptable “given the data, and hence maps to conclusion validity. A threat in interpreting the data is researcher bias.” (Petersen et al., 2015, p.5.) The repeatability was enabled in this study by reporting and documenting phases carefully.

The SG design canvas presented in Article IV has some similarities with the Serious Games Design Pattern Canvas (Zavcer et al., 2014). Both aim to break larger game design issues into smaller pieces and assist in a bottom-up approach to form a serious game idea. There are though also differences in their contents (see Fig. 7 and Appendix 1).

Case study research (Articles I, III and VI), being constructivist with an involved researcher, can cause subjective threats to reported results, such as misinterpretation or misunderstanding. The same also applies to DSR (Article IV) and AR (Article V), limiting the generalisability of the findings before further research.

Regarding the applicability and transferability of proposed implications, it is stated that even if this study is about SGs in the health sector, the research has been focusing on certain type of health games. This can imply that the presented results are applicable only among same type of games. On the other hand, the presented
model of the key phases in SG development process (see Fig 25) and proposed tools and methods in the form of a canvas and workshop, could be applicable also more widely within SGs in general.

Finally, even the used research methods (case study, action research and DSR) do not require bigger sample sizes, it is evident that since the research subject is limited, this also limits the generalisability of the findings.
6 Conclusions and future work

This study focused on the multidisciplinary development process of SGs in the health sector. A series of case studies was initiated to define the key phases of the SG development process and a systematic mapping study unearthed the landscapes of SGs in health care. In an Agile way, learning along the studies, the focus was shifted to examine tools and methods that could support this process. This launched a DSR study to develop and demonstrate these tools and methods and, finally, an AR study to develop education that utilises these developed tools and methods.

The findings discussed in this thesis provide a model of the key phases in SG development process (see Fig. 23 and Fig. 25). This model can be seen as a simplified guide to be followed. Regarding tools and methods to support the SG development process, the SGTM model (see Fig. 24) was presented. The SGTM model consists of four elements: 1) an SGs rapid prototyping workshop (see Appendix 2), 2) an SG design canvas (see Appendix 1) and education, 3) multidisciplinary cooperation and 4) evidence and guidelines.

Education on SGs is needed to enhance the multidisciplinary teamwork. In summary, the results point out that education and knowledge increase fruitful collaboration in multidisciplinary projects.

There are many potential future avenues in this research field. First, the systematic mapping study could be re-executed with modern, up-to-date information. This could verify the research gaps and focus for needed research. Are there still gaps in research regarding general guidelines for SG developers in health care and focusing on validation of SGs? Are any SG maturity models available to improve the level of development?

Second, the proposed model of the key phases in the SG development process could be used as a theoretical background in future SG projects. These projects could also utilise the proposed SG design canvas and rapid prototyping workshop as part of the process.

Launching a new case study or a DSR study to validate the SGTM model would provide valuable insight. Also, as the validation phase of SGs is considered as valuable as the analysis and development phase, more research on that aspect is needed in the field.

Finally, the emphasis on educational aspect regarding SGs and its influence on SGs’ quality need further investigation. How can we support the experts with cross-disciplinary backgrounds by SG education?
References


Baranowski, T. (2014). The five most important research issues in effective game for health design (from a behavioral scientist’s perspective). In Proceedings of the 2014 ACM International Workshop on Serious Games (SeriousGames ’14). Association for Computing Machinery, New York, NY. (pp. 1–2).


Myers, M. D. (2013). Qualitative research in business and management. Ch. 7. *Case study research* (pp. 73-91). UK: SAGE.


## Appendix 1 Serious game design canvas

<table>
<thead>
<tr>
<th>NAME OF THE GAME</th>
<th>Think what name would describe or market the game best</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOAL, AIM</td>
<td>Why this game is needed? What is the aim of this game?</td>
</tr>
<tr>
<td>EXPERIENCE</td>
<td>What is the genre? What is the player aiming at? What is the game concept? Story, narrative? How do you create flow in the game?</td>
</tr>
<tr>
<td>PLAYER, TARGET GROUP</td>
<td>Describe the typical player: age, type, gender. Is the game played alone or in team? Does the player have some restrictions? What is the target group like? Is the buyer of the game same as the player?</td>
</tr>
<tr>
<td>INTERACTION</td>
<td>Describe controls</td>
</tr>
<tr>
<td></td>
<td>Settings</td>
</tr>
<tr>
<td></td>
<td>How is the game played?</td>
</tr>
<tr>
<td></td>
<td>How does it progress?</td>
</tr>
<tr>
<td>FEEDBACK, REWARD</td>
<td>Describe levels, points, achievements. How does the player see her progress?</td>
</tr>
<tr>
<td>GAME MECHANICS AND CHOICES</td>
<td>Choices, decision paths</td>
</tr>
<tr>
<td></td>
<td>Turns, rules, limits</td>
</tr>
<tr>
<td></td>
<td>AI, randomness</td>
</tr>
<tr>
<td>GRAFICAL STYLE, ART</td>
<td>Look &amp; Feel What does the game look like?</td>
</tr>
<tr>
<td></td>
<td>Learning results</td>
</tr>
<tr>
<td></td>
<td>Behaviour change</td>
</tr>
<tr>
<td></td>
<td>How does the game influence the player?</td>
</tr>
<tr>
<td>RESOURCES</td>
<td>What partners do you need to develop this game? What knowledge or skills?</td>
</tr>
<tr>
<td>BUDGET, FUNDING, TIMETABLE</td>
<td>Budget How do you fund this development? What is the schedule?</td>
</tr>
<tr>
<td>BUSINESS MODEL</td>
<td>Who is the buyer/customer? How much they would pay for this game? BtoB /BtoC?</td>
</tr>
<tr>
<td>PLATFORMS AND DISTRIBUTION CHANNELS</td>
<td>What platform and devices will this game be played at? How do you sell/distribute it?</td>
</tr>
</tbody>
</table>
Appendix 2 Serious games rapid prototyping workshop content

1. Introduction of facilitators and subject, followed by discussion:
   a) What are serious games / applied games?
   b) Have you played them?
   c) What kind of serious games have you seen others play?
   d) What is gamification?
   e) Where is gamification used?

2. The very basics of serious games
   a) Concepts: serious games, applied games, gamification
   b) Game design principles
   c) Why people play games? The player experience of a need satisfaction model.
   d) Examples of serious games

3. Serious games rapid prototyping workshop
   a) Instructions: presenting a serious game design canvas, supporting questions, a game genre list and game design principles (all printed and ready in tables).
   b) Groups and subjects: forming groups according to previously handed colours or legos. An assignment (subject) can be given according to the host’s wishes.
   c) Gamestorming ideas: writing / drawing ideas on an A2 paper.
   d) Follow the serious design canvas’s questions and fill it.
   e) Extra: Do your own serious games (paper) prototype
   f) Extra: Document your prototype

4. Pitch (1–3 minutes) and vote for the best serious game idea (coloured Post-it notes or legos). Rewarding the best serious game idea.

5. Summary
   a) Short summary and feedback of some serious game ideas.
   b) What happens next? What it takes to continue into the development phase?
   c) Thanks.
Original publications


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Original publications are not included in the electronic version of the dissertation.

731. Mylonopoulou, Vasiliki (2019) MAD: designing social comparison features in health behaviour change technological interventions

732. Shevchuk, Nataliya (2019) Application of persuasive systems design for adopting green information systems and technologies

733. Tripathi, Nirnaya (2019) Initial minimum viable product development in software startups: a startup ecosystem perspective


735. Salman, Iflaah (2019) The effects of confirmation bias and time pressure in software testing

736. Hosseini, Seyedrebvar (2019) Data selection for cross-project defect prediction

737. Karvonen, Juhani (2019) Demography and dynamics of a partial migrant close to the northern range margin

738. Rohunen, Anna (2019) Advancing information privacy concerns evaluation in personal data intensive services


740. Santos Parrilla, Adrian (2020) Analyzing families of experiments in software engineering

741. Kynkäänniemi, Sanna-Mari (2020) The relationship between the reindeer (Rangifer tarandus tarandus) and the ectoparasitic deer ked (Lipoptena cervi): reindeer welfare aspects


743. Honka, Johanna (2020) Evolutionary and conservation genetics of European domestic and wild geese

744. Alasaarela, Mervi (2020) Tietojärjestelmän käytön vaikutus laatauun ja tuottavuuteen sairaalaorganisaatiossa palveluhenkilöstön kokemana

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TOOLS AND METHODS TO SUPPORT THE KEY PHASES OF SERIOUS GAME DEVELOPMENT IN THE HEALTH SECTOR