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Developing a Serious Game to Improve Collaboration in Business Ecosystems

Master's Thesis

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ABSTRACT

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The purpose of this thesis was to develop a serious game to improve collaboration in business ecosystems. First, it was necessary to recognize why collaboration fails in current business ecosystem and design a research to solve the field problem. The methodology used in this research is design science research. The developed serious game is an artefact in the design science research framework and in further field testing it will be validated to draw conclusions on its effects.

This thesis presents the development process of ECOGAME, a digital collaborative serious game and discusses ECOGAMEs capabilities in solving the presented field problem. ECOGAME bases its design choices in serious game and collaborative game theories in literature. The development process is based on software engineering and game development practices in relevant literature. The conclusions drawn are to analyze the success of the development process and application of presented theories and to discuss further development of ECOGAME and further research to be conducted with ECOGAME. The validation of ECOGAME in according to design science research is to be conducted in further research.

The value of ECOGAME is it being a rigorously created artefact to research collaboration in business ecosystems and potentially help solve challenges that other tools have not been able to solve yet. ECOGAME can be fluently adapted to different contexts and therefore might hold value yet to be recognized.

TIIVISTELMÄ

Tekijä: Matti Rissanen
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Tämän diplomityön tarkoituksena oli kehittää hyötypeli liiketoimintaekosysteemien yhteistyön parantamiseksi. Ensiksi oli tunnistettava syy miksi yhteistyö epäonnistuu nykyisissä liiketoimintaekosysteemeissä ja rakennettava ongelman ympärille tutkimus. Tämän tutkimuksen metodologiana on design science tutkimus. Kehitetty hyötypeli on artefakti annetussa viitekehyksessä ja myöhemmin suoritettavassa kenttätestauksessa tehdään sen mahdollisista hyödyistä johtopäätöksiä.

Tämä diplomityö esittää ECOGAME-pelin kehitysprosessin ja pohtii alustavasti ECOGAME:n kykyä vastata tutkimuksessa esitettyyn ongelmaan. ECOGAME on yhteistyötä painottava digitaalinen hyötypeli. ECOGAME:n suunnittelu pohjautuu kirjallisuudessa esitettyihin hyöty- ja yhteistyöpelien teorioihin. Kehitysprosessi puolestaan perustuu ohjelmiston- ja pelinkehityskäytäntöihin, jotka on myös tunnistettu kirjallisuudesta. Työn lopputuloksina esitetään analyysi kehitysprosessin onnistumisesta esitettyjen viitekehysten perusteella ja pohditaan ECOGAME:n jatkokehitystä ja ECOGAME:lla suoritettavaa tutkimusta. ECOGAME:n vahvistaminen design science tutkimuksen mukaisesti suoritetaan myöhemmin.

ECOGAME on asianmukaisesti rakennettu työkalu liiketoimintaekosysteemien tutkimukseen ja sillä voidaan mahdollisesti ratkaista ongelmia, joita muilla työkaluilla ei ole kyetty ratkaisemaan. ECOGAME pystyy muuntautumaan eri konteksteihin ja saattaa omata toistaiseksi tunnistamatonta tutkimuksellista arvoa.

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I carried out my studies as I wanted. I was allowed to make mistakes, poor choices, and I learnt from them. However, there is no need repent since every action and choice progressed my studies towards this point, the finish line.

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Finally, thank you for my family – mom, dad, Emmi. The support is always there. I do not need to ask for it because I simply know it is always there.

Lappeenranta, October 13, 2017

Matti Rissanen

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1 INTRODUCTION

1.1 Background

Moore (1993) suggests that a company is a part of a business ecosystem, which takes part in multiple industries. Much like a biological ecosystem, a business ecosystem forms naturally from companies and other stakeholders that together are able create more value to customers (Moore, 1998; Eisenhardt & Galunic, 2000; Clarysse et al., 2014). A business ecosystem is characterized by symbiosis and co-evolution between the companies in it (Moore, 1996; Li, 2009). Defining the boundaries of a business ecosystem is impossible since not all actors are working directly with each other as well as companies frequently establishing new connections and breaking old ones. **Figure 1** illustrates the structure of a business ecosystem at a given time. The small grey circles represent individual companies and the larger circles parts of the ecosystem where a group of companies works closely together. Rather than looking at a business ecosystem as whole, one should try to identify these smaller groups of companies closest to each other to draw conclusions on the functionality of the whole ecosystem (Iansiti & Levien 2004). The symbiosis in a business ecosystem means a company creating a platform to offer their services, tools or technologies for other members of the ecosystem to utilize (Iansiti & Levien, 2004). The business ecosystem companies coevolve around new and shared innovations to support the interests of the ecosystem as whole and rather than companies competing individually, ecosystems compete with each other (Moore 1993).

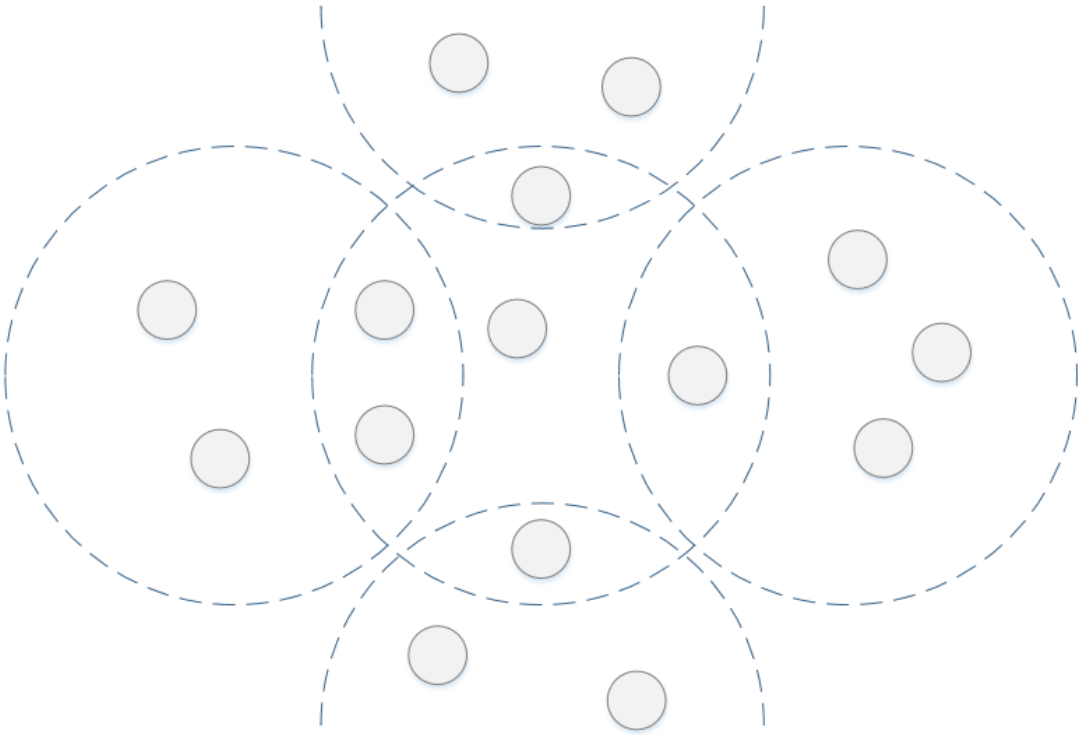

Figure 1. Structure of a business ecosystem.

By acting in a networked environment such as a business ecosystem, and making decisions collaboratively, companies can lower their individual costs (Li et al., 2012). Open communication is required for every individual company in the ecosystem to gain additional benefits (Levery, 1998; Kulmala, 2002; Tenhunen, 2006; Reinartz & Ulaga, 2008). Inter-organizational sharing of technical knowledge has been recognized as a way to reach higher profits than individually possible (Dyer & Singh, 1998) and to improve innovation within the companies (Du & Ai, 2008; Hung et al., 2008; Feller et al., 2009). When it comes to exchanging technical knowledge, business ecosystems appear to work in symbiosis and coevolve together but when it comes to sharing cost information within the ecosystem, the companies are not as open for collaboration (Sinkkonen et al., 2013). Hallikas et al. (2004) recognize that sharing information in a network causes additional uncertainty and risk and propose that developing systems to manage the sharing of information can potentially help to manage those risks. The risk of sharing cost information seems to be too high even while the ecosystem is

collaborating in other ways. It is unclear how the necessary level of trust and communication in an ecosystem can be reached so that the companies feel comfortable to share even the high valued individual cost information – or if there even is any level of collaboration that allows a company to trust their ecosystem with this information.

1.2 Objectives and research questions

This thesis presents the development process of ECOGAME, a collaborative serious game. Games are known to be used for either entertainment or learning purposes (Garris et al., 2002) but serious games are an approach to combine these two (Zyda, 2005; Dörner et al., 2016, p. 2). Serious games are used for education (Gonen et al., 2009; Hwang et al., 2012) and employee training (McLeroy, 2008; Kuipers et al., 2016). The motivation for the design of ECOGAME is to attempt to increase the level of collaboration in business ecosystems to a level where the participating companies feel comfortable enough to share their cost information and seek cost advantages from this further collaboration. The collaboration within business ecosystems draws a line between sharing technical knowledge and cost information. Companies are comfortable sharing technical knowledge (Feller et al., 2009; Li et al., 2012) to their ecosystem partners but are not ready to attempt to gain cost advantages through sharing detailed cost information (Kajüter & Kulmala, 2005; Windolph & Möller, 2012; Sinkkonen et al., 2013). ECOGAME presents the companies a tool to play a game that resembles real decision making situations in business ecosystems but is not a pure simulation. ECOGAME attempts to engage the ecosystem partners to a playful experience where they have to improve their communication skills during a game session to reach their self-set goals. In addition to improving communication, the players are expected to relate the decision making situations in the game to real ones and see that it is necessary to collaborate as closely as possible, including the sharing of cost information, to reach the highest possible benefits.

This thesis seeks to answer the following research questions:

RQ1: Why does collaboration fail in business ecosystems?

RQ2: How can a game improve collaboration in business ecosystems?

RQ3: How does ECOGAME improve collaboration in business ecosystems?

This thesis does not go into detail on game or software development practices that are used by development teams greater than two people since this particular development project was carried out by two people, one concentrating on the design of ECOGAMEs concept and one on the development of ECOGAME. The thesis does not consider any other choices for development platforms than the one chosen since it includes all the necessary functionalities for building a working prototype. As this thesis is written before the planned beta test phase, this thesis does not provide any results that would hold proof on the effectiveness of ECOGAME in the context of the presented field problem.

1.3 Design science research

Design science research (DSR) concentrates on improving practical matters in present time. It is used when a stakeholder presents a real field problem that should be improved. The field problem is turned into a design problem that asks for a design, an artefact, which can solve the problem in the field (van Aken, 2014). DSR then aims to produce generic knowledge, generic designs, that can be transferred to contexts other than the one it has been made for and tested in. The design cannot be logically concluded from the field problem (van Aken et al., 2016). The generic design produced is a field-tested and validated option, rather than normative statement, for practitioners to use in their own design of instruments for problem solving (van Aken, 2014). The ultimate goal of DSR is to generate knowledge, which can be used by professionals in creating designs to resolve practical problems (van Aken, 2004).

Hevner et al. (2004) presents DSR in three cycles. Relevance cycle connects the context of the research project to the design science activities and through field testing in the

relevance cycle the effect of the artefact is evaluated. Rigor cycle connects the knowledge base and tools to the design science activities and ensures the innovation of the research project (Hevner, 2007). Thorough research of the knowledge base is necessary in order to guarantee that the design artefacts produced are not based on already known applications (Hevner et al., 2004). The design cycle in the center of the research produces and evaluates a design artefact or artefacts. Design cycle draws requirements from relevance cycle, and methods and theories from rigor cycle to conduct evaluation (Hevner, 2007). The three cycles of DSR are presented in **figure 2**. Van Aken (2004) divides the DSR process in three designs: an object-design, a realization-design and a process-design. These designs are comparable to Hevners three cycles but since the approach of Hevner comes from information systems research and this thesis presents a software design in the form of a game, this thesis considers Hevners approach the most suitable for the design of the research.

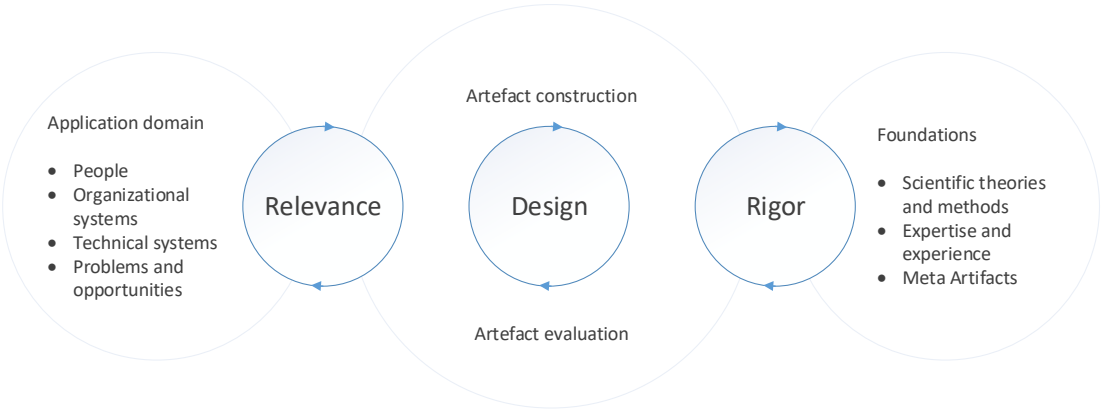

Figure 2. Three cycles of design science research. (Hevner, 2007)

To understand the context of the design problem and to know the tools to be used – DSR is greatly based on the explanatory paradigm. However, the design artefacts are more application-oriented compared to the results of explanatory sciences (van Aken, 2004). The differences between description- and prescription-driven research are presented in **table 1**. Explanatory research is used to find and understand causal mechanisms for example in physics whereas DSR attempts to find solutions to real

problems recognized in practice (van Aken, 2014). In prescription-driven research, the researcher has to find parties having the problem in question and interested in solving it. If an organization deems the problem worth fixing there is a possible win-win situation for both the researchers and the organization (van Aken, 2004).

Table 1. Differences between description- and prescription-driven research. (van Aken, 2004)

Characteristic	Description-driven research programmes	Prescription-driven research programmes
Dominant paradigm	Explanatory sciences	Design sciences
Focus	Problem focused	Solution focused
Perspective	Observer	Player
Logic	Hindsight	Intervention-outcome
Typical research question	Explanation	Alternative solutions for a class of problems
Typical research product	Causal model; quantitative law	Tested and grounded technological rule
Nature of research product	Algorithm	Heuristic
Justification	Proof	Saturated evidence
Type of resulting theory	Organization theory	Management theory

The motivation for DSR emerges from the desire to improve environment with new artefacts and processes for building the artefacts. Design is the process of taking action to change existing situation into a preferred one (Simon, 1996). Klabbers (2003b) calls the aim to change the situation to a preferred one design-in-the-large and the construction of an artefact design-in-the-small. Klabbers (2003b) adds that the purpose of design-in-the-large is to see the design broader than the material artefacts. Especially in cases of complex social systems, for example operation management systems, where human agency makes predicting the behavior of the system difficult, whereas material systems are expected to behave as designed (van Aken, 2014). Design oriented research

in social systems is more complicated than in material systems because the links between the artefact and outcomes are more shallow and generalizing the artefact in social systems is much more difficult (van Aken, 2004). Generalizing in social systems is difficult because there are no mechanisms to detect the behavior of social systems (van Aken, 2014). In the case of social systems, those in the position of design-in-the-large design artefacts beyond their control and merely attempt to enhance the particular properties of the system presented in the design problem (Klabbers, 2003a). The contents of the artefact are communicated to the target group and they are motivated to learn to use it as designed (van Aken et al., 2016). DSR produces the artefacts used to deal with the field problems but also possible extensions to original theories and methods used in defining the context and developing the artefact. Field tests and evaluation of the artefacts also provide experience in performing research in the application environment (Hevner, 2007).

DSR artefacts are typically studied and tested by using multiple case studies in the intended context. Series of similar problems in similar settings are attempted to be solved by applying the design artefact to the problem. The cases can include influence of factors that are not well studied as they improve the quality of the test (van Aken, 2004). Field testing can be divided into two parts, alpha and beta testing. Alpha testing is carried out by the artefact designers and after the artefact is ready to be applied to the intended context, it is beta tested by third-party stakeholders. Beta testing requires generating a number of context-variant instantiations (van Aken et al., 2016). In beta testing, the interest should be in finding both successes and failures. Both kinds of findings help in generalizing the design (van Aken, 2004).

The purpose of testing is to produce input for redesign of the artefact. First to optimize the performance and later to generalize the design. In testing, the aim should be in testing short causal relations between artefact and outcomes rather than ultimate causation (van Aken et al., 2016). Hevner (2007) considers field testing to only be the testing activities along the relevance cycle and preceding the field tests are laboratory

tests. Regardless, alpha testing conducted by designers precedes the beta testing in intended context and field testing in the relevance cycle is the process which determines when the design artefact is completed and how scientifically rigor the research is (van Aken et al., 2016).

Van Aken (2004) concludes with requirements for relevant social system artefact: validation by multiple case studies, relevance of goals in practice, operational validity, non-obviousness and timeliness. In social systems where human agency impact is substantial, validity of an artefact can only be justified based on strong practical evidence provided by multiple case studies. The validity of a generic design depends on whether it can provide the same results in other contexts (van Aken et al., 2016). Hevner (2007) states that the synergy of relevance and rigor to design and contributions from design to relevance and rigor are the factors that define good DSR rather than simple practical utility. It is necessary to have a balance between constructing and evaluating the artefact during the design.

Games are examples of artefacts (Klabbers, 2003b). Serious games are designed to educate or train the players and can be used to reflect a real situation. Any game represents a certain tradition of knowledge and contains characters with their respective characteristics. The social system of a game is controlled with a set of rules that must be communicated to the players. The resources and rules of a game provide a frame for interactions, which form the resulting knowledge (Klabbers, 2003a). In social systems as well as in games, the participants or players may not be aware of the reasons why they act how they act. Computer as an interface between the player and the game can hide the structure of the game and further encourage instinctual action. The designer of a game artefact should not only be aware of this factor of design-in-the-large but also use it in the design-in-the-small by shaping the elements of the game accordingly (Klabbers, 2003a).

1.4 Research design

The DSR conducted to research the behavior of business ecosystems and to solve problems in collaboration and information sharing is presented in **figure 3**. This thesis is located mainly inside the design cycle, which is presented in **figure 3** with the game development process. This thesis draws its theories and background from the knowledge and environment bases through rigor and relevance cycles but does not contribute anything to the bases. The contribution to environment and knowledge relies on further research.

The background and context of the research are brought from environment into design through the relevance cycle. Environment describes a real field problem and it is turned into a design problem that asks for a design, an artefact, which can solve the problem in the field (van Aken, 2014). DSR then aims to produce generic knowledge in the form of designs that can be transferred to contexts other than the one it has been made for and tested in. The design cannot be logically deduced from the field problem (van Aken et al., 2016). The theories and tools required to produce an artefact are brought into design from knowledge through the rigor cycle. A serious game was chosen as the type of an artefact to be used to solve the field problem. Serious games are lately being used more for skill acquisition and corporate training rather than interchangeably using the term with educational games, which have a pure pedagogical purpose (Boyle et al., 2016).

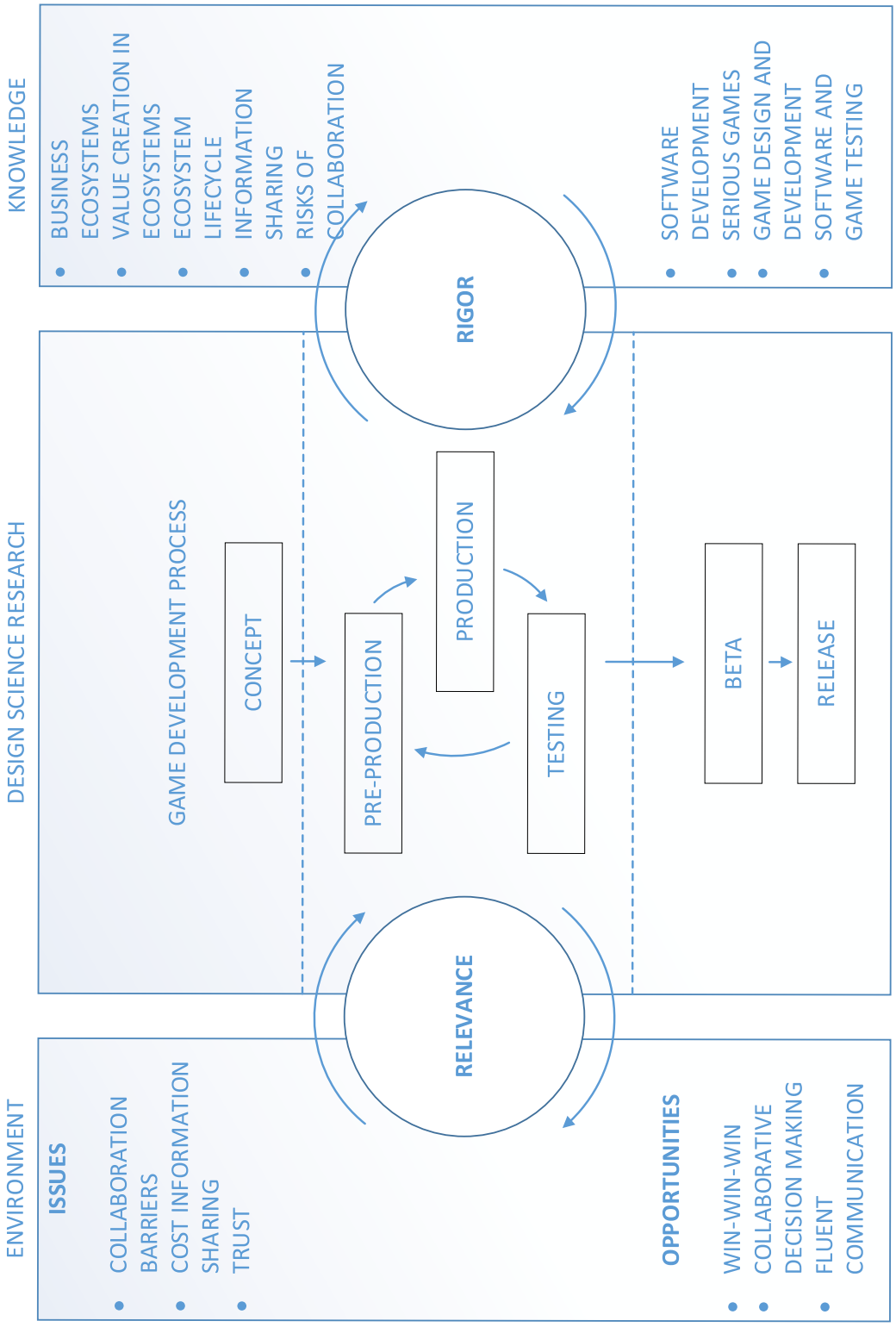

Figure 3. Three cycle design science research for ECOGAME. (adapted from Hevner, 2007)

This thesis is grounded on research and literature in software development, serious game design and development, and software and game testing practices. Traditionally software development has mostly followed a non-iterative waterfall model (Rucker, 2002, p. 37) but the creatively more demanding process of game development requires an iterative production process. The development process of ECOGAME is presented in **figure 4**. Due to the cyclic production in game development, the development process fits well into DSR. Design cycle requires a continuous evaluation of the artefact and that is allowed by the development process (**figure 4**). Relevance cycle connects to the concept of the game, rigor cycle connects to the production cycle, and the produced artefact, serious game, is rigorously tested in the field and the implications are brought back to research environment through the relevance cycle.

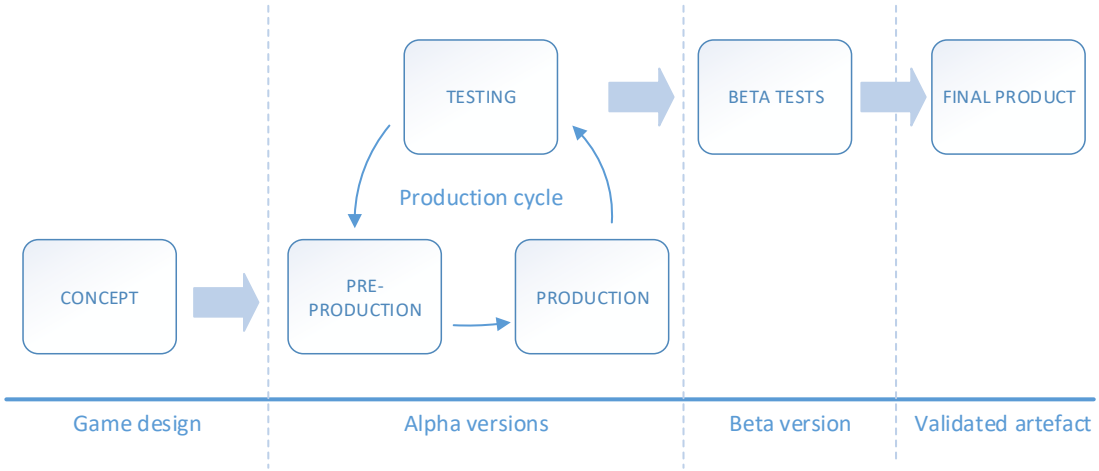

Figure 4. Development process of ECOGAME. (adapted from Rucker, 2002, p. 39; Ramadan & Widyani, 2013)

The testing stages of ECOGAME are presented in **figure 5**. The purpose of testing in DSR is to produce input for redesign of the artefact (van Aken et al., 2016). Developer tests and first gameplay tests revolve around the alpha versions of the game and are located inside the production cycle of development process. Alpha versions concentrate on the technical functionality of the game and are part of the design cycle in DSR. Beta version of the game is formed after three alpha tests conducted within a research team.

Beta version is tested with students to preliminary test the capabilities of the game to solve the field problem and test the amount of fun and enjoyment present in the game.

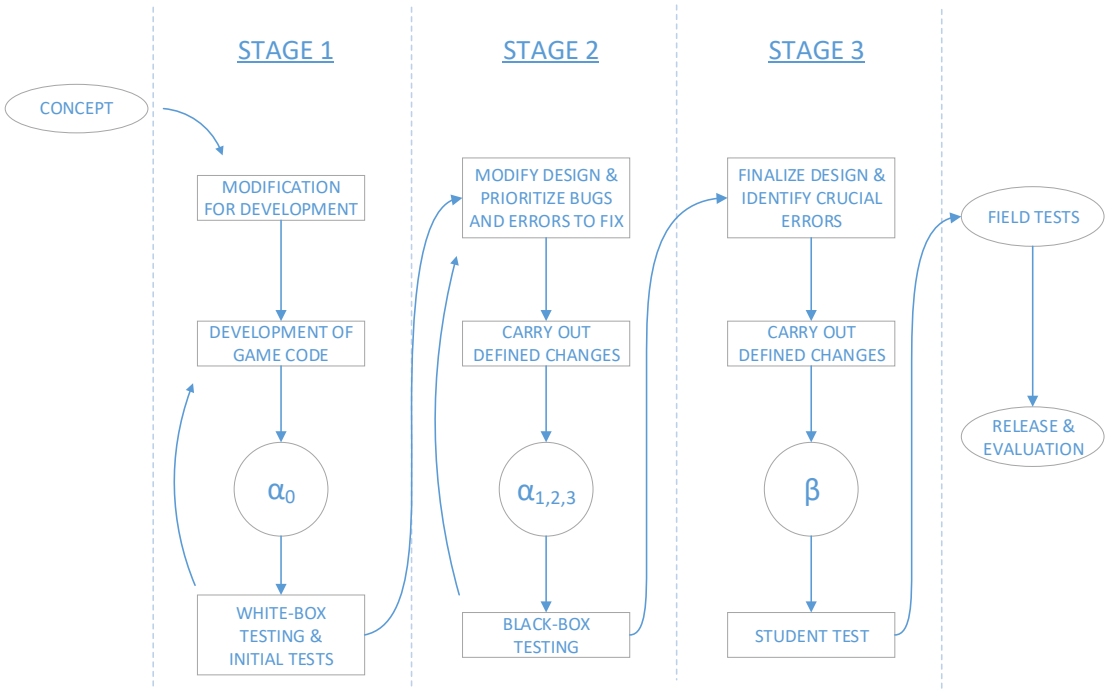

Figure 5. Testing and development stages of ECOGAME.

1.5 Structure of the thesis

This thesis in first chapter presents the methodology and the design of the research of which development of ECOGAME is a part. Chapters two and three review the literature for theories and frameworks necessary to design and produce a collaborative serious game. Chapters four and five discuss the development process of ECOGAME in detail. Chapter six is dedicated for the discussion on further research to be conducted with ECOGAME and for the conclusions of the thesis. The thesis is finished with a short summary in chapter seven. The structure of the thesis is presented in **figure 6**.

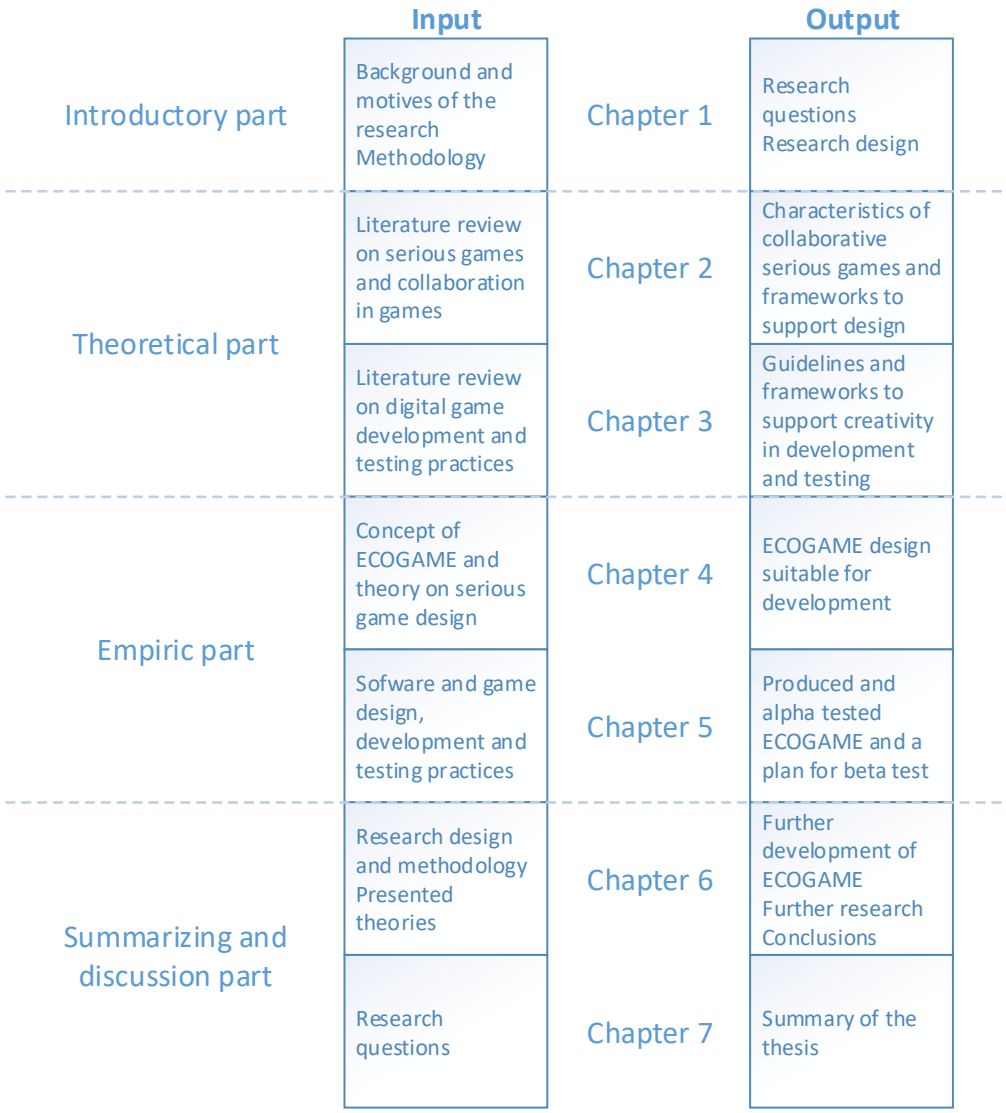

Figure 6. Input-output chart of the thesis.

2 SERIOUS GAMES AND COLLABORATION IN GAMES

2.1 Games as instructional tools

Playing a game is voluntary action of the player to engage in joy and amusement. A player forced to play a game is not playing at all but rather constrained from their freedom to choose an activity of pleasure (Caillois, 1961, p. 6). Games can be used as effective instructional tools to improve learning (Whitehall & McDonald, 1993; Ricci et al., 1996) and adoption of skills (Kuipers et al., 2016), or at least raise interest in the subject matter (Druckman, 1995; Connolly et al., 2012; Girard et al., 2013; Sedano et al., 2013; Wouters et al,. 2013) but like any form of learning, games are not an effective way of learning for all people (Garris et al., 2002). Garris et al. (2002) reviewed literature on how games are characterized and came up with six dimensions that describe a game and help designing the elements of the game for instructional purposes. These dimensions are presented in **table 2**.

Table 2. Six dimensions to describe a game. (Garris et al., 2002)

Game dimension	Descriptor
Fantasy	Imaginary or fantasy context, themes, or characters
Rules/goals	Clear rules, goals, and feedback on progress toward goals
Sensory stimuli	Dramatic or novel visual and auditory stimuli
Challenge	Optimal level of difficulty and uncertain goal attainment
Mystery	Optimal level of informational complexity
Control	Active learner control

Fundamentally, playing a game is making changes to the games states. The game state represents the states of all components in the game (Björk & Holopainen, 2005, p. 8). States change every time a player makes an action. Actions in a game can be for example moving with a character, answering a question with pre-determined answer or giving a numerical input. Game states can also change over time when a player makes a choice or triggers a mechanic that does not only give instant feedback but affects the

games states for longer period of time. It is common to include random effects in games to increase unpredictability and complexity but too much randomness can diminish the purpose of the game, as the player will not feel to be in control (Westera et al., 2008).

2.2 Serious game definition

Zyda (2005) defines serious game as ”a mental contest, played with a computer in accordance with specific rules, that uses entertainment to further government or corporate training, education, health, public policy, and strategic communication objectives.” He further emphasizes that the entertainment comes before the pedagogical part in importance even though the pedagogy is what makes the game serious by definition. Dörner et al. (2016, p. 3) considers even wider approach to defining serious games. They conclude that serious games have to be intended by developers to include training or pedagogical goals but it does not matter if the game achieves those goals or not. These definitions have not strayed far from the first use of the term serious game in this context by Abt (1987, p. 10) who considered serious games to include educational purpose and the intent to play would not be entertainment. However, he adds that despite the intent, serious games can be entertaining. Combining the definitions from Zyda (2005) and Dörner et al. (2016), this thesis considers a game serious when it includes learning of skills or acquisition of knowledge, which are useful in another context outside of the game itself. It does not matter if the game is mainly entertaining as long as the game has potential to educate or train the player.

Another term similar to serious games is gamification. Gamification is the use of elements characteristic to game design in non-game contexts (Deterding et al. 2011). Gamification can be used to develop applications and processes to aid learning but gamified applications are not necessarily games (Dörner et al., 2016, p. 4), which creates the distinction between gamification and serious games.

This thesis emphasizes digital serious games even though games are played in other ways as well (e.g. yard games, board games). Zyda (2005) and Dörner et al. (2016)

differentiate video games from serious games by defining video games as digital games that exclusively promote entertainment as the purpose of the game. The position of serious games according to the presented definitions is shown in **figure 7**. Gaming itself is not well defined and therefore establishing a general framework to implement educational or training content in a digital game is difficult (Giessen, 2015).

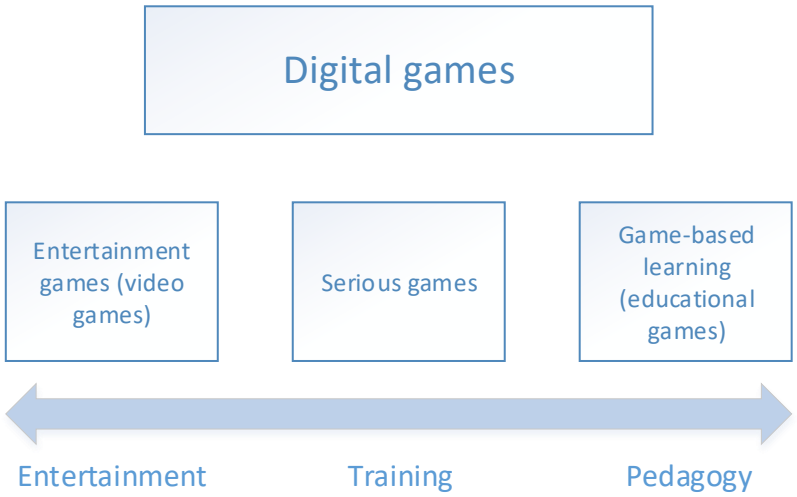

Figure 7. Positioning serious games under digital games by the purpose.

2.3 Serious games in practice

Boyle et al. (2016) updated the systematic literature review of Connolly et al. (2012) regarding serious games and found out that after review period of Connolly et al. the term "serious game" has entered mainstream. The term is used interchangeably with games-based learning, which results in much of the serious games literature to be concentrated on creating games to support knowledge acquisition rather than training skills (Boyle et al., 2016). Many researches (Druckman, 1995; Connolly et al., 2012; Girard et al., 2013; Sedano et al., 2013; Wouters et al,. 2013) note that serious games seem to increase motivation and engagement compared to traditional learning methods. This results in more time spent with the learning material in the context of the serious game but it does not confirm the assumption that serious games would be better for learning than traditional methods (Annetta et al., 2009; Connolly et al., 2012). Wouters

et al. (2013) suggest that the learning from serious games leads to good knowledge base from where the player can continue on learning. The benefits from serious games are long term and in comparison to traditional learning methods, multiple serious game playing sessions benefit learning more (Wouters et al., 2013).

Serious games are mostly used as an approach to learning in curricular areas such as health, business or social issues (Connolly et al., 2012). In addition to curricular areas, Boyle et al. (2016) found out that lately serious games are successfully being used for example for skill acquisition in town planning (Poplin, 2012), behavior change in substance abuse (Verduin et al., 2013) and for supporting collaborative interactions (Hannig et al., 2011; Sánchez and Olivares, 2011). Zyda (2005) states that serious games are used to carry out government or corporate objectives. Even though the uses for serious games are indeed serious, the games can also be fun and entertaining. Many serious games try to fulfill their purpose without introducing fun gameplay, which might make motivating players difficult. To form a balance the serious game design should be an appropriate mixture of serious and positive experience. (Marsh & Costello, 2012)

The most common game genre to present a serious game in is simulations (Boyle et al., 2016). Simulation games can reflect reality better than other forms of training and education (Newbery et al., 2016). By reflecting reality simulation games offer a risk-free environment for learning. For example, airplane pilots train with flight simulators. Modelling learning content as simulations seems to be easier than the use of other genres and game features to support the wanted learning strategy. This raises an issue when considering if a simulator is a game or not and what are the characteristics of simulators that make them games (Boyle et al., 2016). A famous serious simulation game example is commercialized first-person shooter game America's Army (Zyda, 2005). America's Army was first published in 2002 by U.S. Army and it attempts to simulate the combat of an American infantry soldier. The original purpose was to use

it to train soldiers and to communicate career opportunities within army to young Americans (McLeroy, 2008).

Following are a couple of successful examples of serious games in recent literature with the serious purpose bolded. Papastergiou (2009) performed an experimental study, **compared a non-game and a game application in an educational setting**, and concluded that the experimental group considered game-based application more attractive and educationally effective in comparison to the control group. Newbery et al. (2016) investigated **the effect of a serious game to entrepreneurial intent of undergraduate students**. The game was deemed authentic in experience and it helped the students to reflect on what entrepreneurship in practice is. Kuipers et al. (2016) developed a serious game with **the ultimate goal of reducing the amount sick leaves of nurses caused by back issues**. The back issues were cause by wrong lifting techniques and the serious game was used as an approach to change the behavior of nurses when it comes to training of lifting techniques. The game lead to the players behaviors to change towards accepting the training of correct lifting methods. Poplin (2012) presents a serious game with **the purpose of increasing public participation in urban planning**. The players found the game complex but enjoyable and fun. The game could even potentially provide results for public decision making but at the very least it seems to be able to reach its original purpose and engage people in urban planning.

2.4 Designing a serious game

As presented in **figure 7** in chapter 2.3, the purpose of a serious game is twofold. A serious game is supposed to be both entertaining and educational (Bellotti et al., 2010). This makes the design process of serious games more demanding in comparison to traditional video games. Serious games require the implementation of pedagogical strategy (Lameras et al., 2017). A serious game can be open about the pedagogical strategy of the game or choose to hide it (Mildner & Mueller, 2016, p. 69). Labelling a game to include learning or training content might make the game less desirable to

some but depending on the context of use, it might also be important to promote the game exactly as it is.

Serious games and games in general represent a wide range of purposes and target audiences they try to address. Therefore, it is difficult to create a general framework to support the design of serious games. Despite this, games for entertainment often have a huge potential for customers whereas serious games are used in a specific context for specific customers (Braad et al., 2016). Consumers of serious games might be an audience that is not familiar with digital games and not immediately attracted to the idea of playing games. Entertainment games are targeting a segment of people who already play games or are attracted to games otherwise. Braad et al. (2016) highlight the importance of involving the target audience in the design process of a serious game to answer the needs of potential customers as well as possible. In addition to this, during development the target audience can provide feedback to guide the iterative development process.

To successfully promote the learning content in a serious game the preparation for playing is important (Giessen, 2015). The preparation can be conducted in a form of tutorial to gameplay. Rucker (2002, pp. 35-36) advices the creation of a user's guide where explained are the basic idea of the software (or game), a guide to installation and start, and in depth explanation of all menus and controls and their functions. To promote the learning content in game and make the player aware of their progression the serious game has to offer continuous feedback. For the serious game to be viable for education or training, the feedback must be recognizable in the context the game attempts to promote (Bellotti et al., 2010). Michael and Chen (2005, p. 42) state that like other educational tools, serious game has to show if, when and how successfully the expected learning has occurred. The feedback can be delivered to the player in the form of summative or formative assessment. Summative assessment in the context of a serious game delivers the feedback at the end of the game and evaluates the overall learning occurred during play. Formative assessment is implemented in the game and

monitors the learning throughout the play (Boston, 2002). Formative assessment allows the serious game to guide the player towards the learning content if necessary and is therefore the recommended form of evaluating the player's progression. While assessing the learning process is in main role, the game also has to evaluate how much the player enjoys playing the game. (Bellotti et al., 2010)

To keep the player entertained and engaged to the game, the game has to offer challenges that match the players' skills. The idea of matching the skills to difficulty, making the player feel to be in control, and keeping the player motivated is called flow (see **figure 8**) (Csikszentmihályi 1990, p. 3).

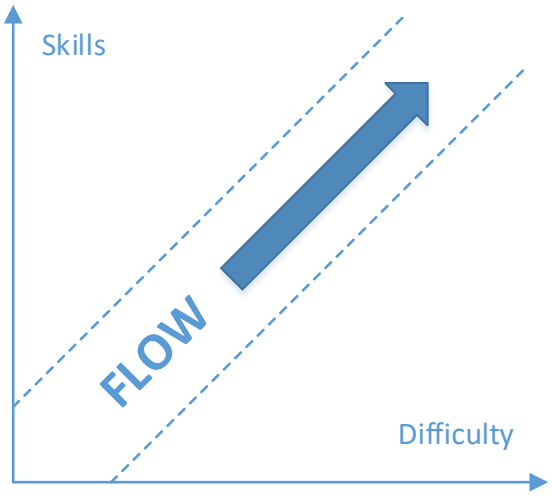

Figure 8. Matching the players skills and game's difficulty to reach a state of flow. (adapted from Csikszentmihályi, 1990)

Especially in a serious game where the player is expected to learn more or further train a skill, the game has to follow the learning curve, the flow, of the player (Dörner et al., 2016, p. 11). The problem with difficulty is to estimate the suitable starting difficulty for each player. Players have different backgrounds and require different starting points or at least a fast scalability to correct level of difficulty to enable the flow state. Too easy game can cause disengagement from the game through boredom whereas too

difficult game causes loss of interest through frustration and anxiety (van der Spek, 2012, p. 102-103). Theoretically, the difficulty and complexity of a game can be increased by either increasing interaction between players or generating complexity by design. In support of generating complexity, one can utilize external sources of information (Westera et al., 2008). Such information can for example be recorded data of physical movement, currency exchange rates and weather reports.

2.5 Collaboration in games

In cooperative games, players have different goals but use the help of each to achieve their own goals. In collaborative games, the players have common goals and work towards the common goals together (Nash, 1953; Björk & Holopainen, 2005, pp. 245-247). In learning context, cooperation refers to the distribution of work between learners and collaboration refers to learners studying together without distributing the work (Shih et al., 2010). Sedano et al. (2013) found out in their literature review that collaborative games are raising interest in the game industry as well as in the academia. The progress of technology creates new means for communication and platforms for games so that it is easier to engage people to play digital games with others.

Figure 9 links gaming industry to academic research. It shows the aspects present in collaborative serious games. By linking the learning environments recognized in academic research to the collaborative gameplay experiences emerging from gaming industry, a successful serious collaborative game can be created. Searching and building new technologies to support interaction can benefit both collaborative learning and gaming individually but also together. (Sedano et al., 2013)

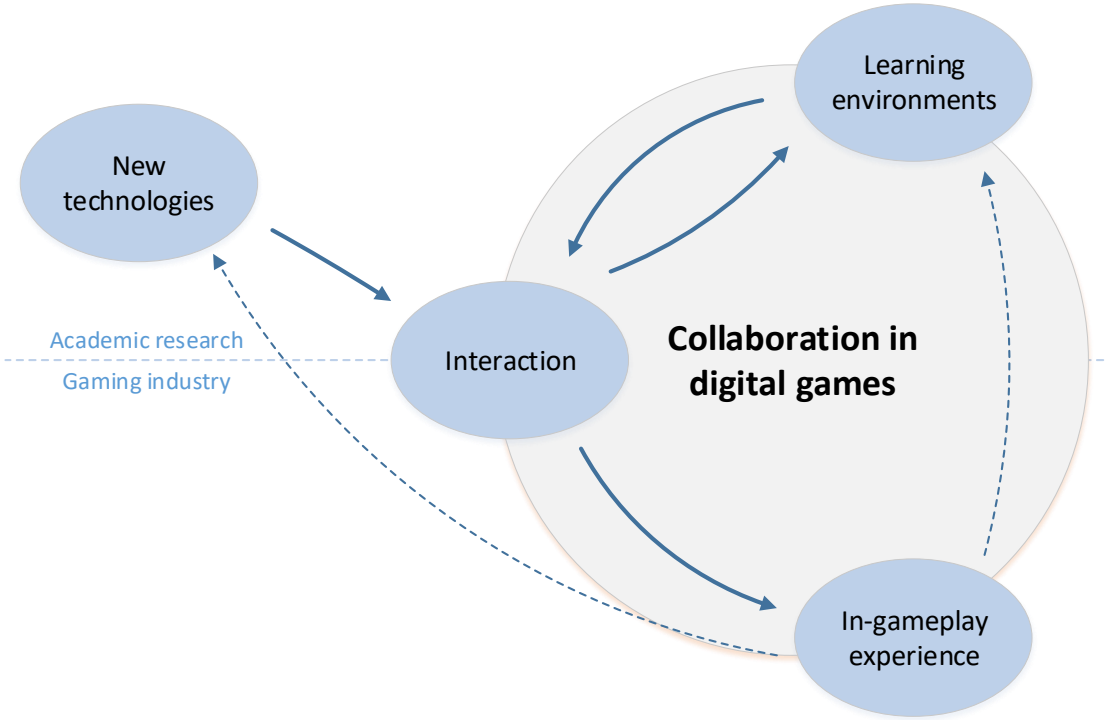

Figure 9. The link between academic research and gaming industry with collaboration in digital games. (Sedano et al., 2013)

According to Azadegan and Harteveld (2014), collaboration can be presented in a game in three different categories: as instinctual, supportive or integrative collaboration. Instinctual means that the players will not have time to think about the decisions on conscious cognitive level but rather have to react swiftly in collaboration. Supportive collaboration allows the players to plan their gameplay and strategies beforehand or at break points during the gameplay. Decisions made in action of the game are often made individually according to the collaborative strategy developed. Integrative collaboration provides the players time do collaborative decision making on cognitive level. Integrative collaboration is often used in collaborative serious games to highlight the mechanics that support the learning content. (Azadegan & Harteveld, 2014)

Zagal (2006) concludes that games are potentially a good way to support collaborative activities but they are incredibly difficult to design. Zagal (2006) studied collaborative

board games and their mechanics to establish design guidelines for collaborative digital games. The guidelines he proposes as lessons to learn and pitfalls to avoid are presented in **table 3**. After developing the guidelines, he assessed collaborative digital games against them and learned that most of the games do not apply all of the guidelines. Failing to apply all of the guidelines leads to the game being played against the collaborative design.

Table 3. Lessons to learn and pitfalls to avoid in the design of digital collaborative games. (Zagal, 2006)

Lessons to be learnt	Pitfalls to avoid
To promote collaboration instead of competition, a tension between individual and team utility should be introduced	Sufficient rationale to avoid one player dominating and making decisions for the whole team
Individual players should be allowed to make decisions and take actions alone	Unclear purpose and goals for the game to be engaging
Payoffs should be able to be traced back to single decisions	To a game to be played multiple times by the same people it needs new content
Players should have different roles and abilities to make collaborative decisions more natural	

Beznosyk et al. (2012) created an experiment to test different types of collaboration in games without communication. The collaborative game design patterns used in the research were identified by Rocha et al. (2008) and Seif El-Nasr et al. (2010). Seif El-Nasr et al. (2010) conclude that designing collaborative patterns for both educational and informal games is important. The patterns used in the research of Beznosyk et al. (2012) were: limited resources, complementary abilities, interaction with the same object, shared puzzles, abilities that can be used on other players, shared goals. Beznosyk et al. (2012) created six games, three of which required the players to work

together and the other three games shared the same space and objective but players did not need to interact with each other. Two of the games that required players to work together were found more difficult and at the same time more enjoyable than the rest. The most enjoyed collaboration patterns were “complementary abilities” and “interaction with the same object”. Beznosyk et al. note that these patterns were also the most affected by the lack of communication and that could have increased the enjoyment of the patterns. Zagal (2006) also considers that communication is in central role in collaborative games and by restricting or supporting different means of communication, the nature of the game can be changed.

3 DIGITAL GAME DEVELOPMENT AND TESTING

3.1 Digital game development process

Fundamentally, digital game development is similar to software engineering but in addition, game development requires creative design and artistic aspects (Blow, 2004). Game development being creative process in its core might not best be supported by the software engineering practices but they are currently used because game development lacks its own congruent guidelines (Aleem et al., 2016) and the engineering part is the most difficult one in digital game development (Blow, 2004). Murphy-Hill et al. (2014) state that software development in the context of digital games is not well researched yet but it is clear that the requirements of the product are more unclear in game development than in software development. The combined practices in serious game development are presented in **figure 10**.

Figure 10. Practices required in serious game development.

Digital game development process follows the practices from software engineering and involves four main phases: concept, pre-production, production, and post-production (Ramadan & Widyani, 2013). Concept and pre-production include creating the design for the game, testing the feasibility of the design and preparing materials for production. Production phase consists of producing the game software and implementing the design with necessary visual and audio effects. Initial testing is also conducted in production phase. Post-production contains the final tests in target market and marketing the game. (Lee et al., 2006)

Game development process tells the developer what to do, when and in which order during the development process (Rucker, 2002, pp. 27-35). Ramadan and Widyani (2013) examined the development processes of four game development studios and based on these proposed a general model presented in **figure 4** in chapter 1.4. Two of the game development studios followed a more traditional software development process where development follows a non-iterative waterfall model. People avoid using waterfall model in software development because it is difficult to specify and plan the program in advance of writing code (Rucker, 2002 p. 37). Even more so in game development, where creativity plays a key role. Usually, the lifecycle allows revisiting earlier stages like can be seen in the production cycle in **figure 4** in chapter 1.4. The two other game development lifecycles investigated in Ramadan and Widyanis (2013) research are highly iterative, one being completely cyclic. Choosing or building a development process for each project is important. Without a planned development process, software or game development project might simply be writing code and trying to fix problems as they develop instead of finishing a segment and then fixing crucial problems (Rucker, 2002, pp. 36-37). Since it is impossible to create flawless software, developers have to be able to recognize software or game breaking problems.

Creating the development process for a game development project is not necessarily enough to build a reliable schedule. The developers should identify major stages in the lifecycle and set milestones for them (Rucker 2002, p. 27-35). Examples of milestones

can be seen in the development process presented in **figure 4** in chapter 1.4. It is common to produce multiple alpha versions where you each time revisit the game design and modify it when necessary. Keeping all the different alpha versions archived is important in case the development faces crucial problems in later stages due to changes made to design. After reaching beta version the design should be set fixed and the concentration should be put into refining the game and making it ready for release. (Rucker 2002, p. 27-35)

The primary challenge in game development is to code a program that actually resembles the game design. The challenges of game development come in two categories – problems related to project size and problems related to highly specific requirements. To tackle the size issues, developers use development tools such as programming platforms, game engines and game asset management tools. (Blow, 2004) Aleem et al. (2016) found out in their survey that positive impact on game development process is formed in the following practices: team configuration, asset management, game design document, game engine development, test management, and programming practices. Game design document was found out to be the greatest contributor in the research.

Game design document is a documented plan on how to realize the game concept in the production phase. It structures the game design to help development but it can also limit creativity if developers bind the project completely into it. Game engine is a software framework that can be used as a foundation for multiple games without major modifications to it (Söbke & Streicher, 2016). Game engines help programmers to save time by reusing features and content already created in previous game development processes. Genre specific game engines are often developed by game development companies to support their own needs in current and future projects but there are also commercialized engines for anyone to use.

Digital games are categorized by genres. Genres have their own requirements regarding the development of the game. These requirements have to be considered in pre-production phase (Aleem et al., 2016). For example, modern first person shooters require advanced modelling of physics for movement of characters and flight of bullets. Some general requirements for playable games by Rucker (2002, pp. 15-18) are presented in **table 4**.

Table 4. General requirements for playable games divided by the needs of technical or creative development. (Rucker 2002, pp. 15-18)

Technical	Both technical and creative	Creative
Not restricted by user's hardware	Clear objectives and termination points	Attractive and good user interface
Instant and clear feedback during gameplay	Both advances and setbacks in game	Meaningful decision making
Visible game state	Promoting the (genre specific) game requirements	Suitable pace of progression
	Wide range of score factors	

Petrillo et al. (2009) reviewed literature, interviewed small game developers and researched game postmortems to find out what kind of problems digital game development projects usually run into. Game postmortem is a document that emphasizes the positive and negative experiences of a game development project (Hamann, 2003). The problems Petrillo et al. (2009) identified in postmortems were more detailed while the ones recognized in literature and interviews were broader. The problems found in literature and interviews were: scheduling, budget, quality, management, scope, technological issues. The occurrence of the more detailed problems found by Petrillo et al. (2009) in studied postmortems are presented in **figure 11**. Six problems occurred in over half of the projects. The main problems were unrealistic scope and too optimistic attitude towards the implementation of the game design into a software and adding new features during development. The optimism was

reflected on the high rate of delays and cutting of features (Petrillo et al. 2009). The other problems did not cause going over the budget that often. This probably means that budget was the only truly limiting factor in these projects.

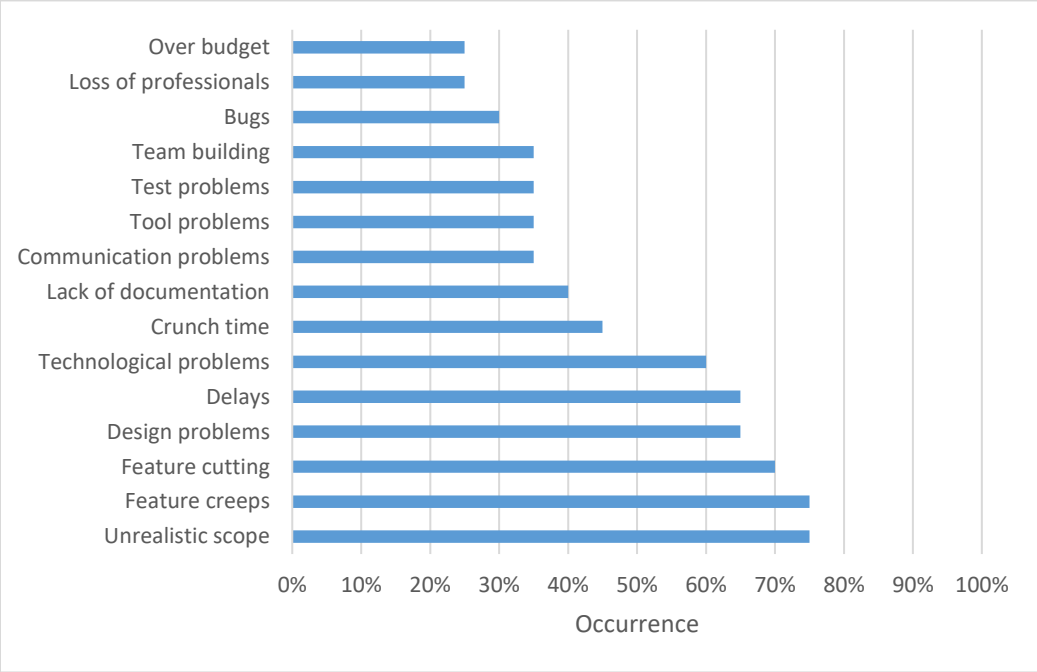

Figure 11. Occurrence of the problems found from game development postmortems. (Petrillo et al., 2009)

3.2 Producing and testing a serious game

Since a serious game is often targeted to a very small segment, it is important not to restrict the potential player base by making the game require high performing hardware (Michael & Chen, 2005, p. 31). Kelly et al. (2007) use serious game "Immune Attack" as an example of a digital serious game development process and note that if the serious game is to be used in research, the design and development should be carried out by a research team rather than professional game developers. This saves money and makes sure the details are presented correctly in the game. The key challenges they recognized in their project were ones commonly found in serious games projects – how to incorporate learning content and how to make a game entertaining at the same time.

Third key challenge was to scale the highly varying size and time effects in the game. Actual problems in their project were time issues and having to choose which design aspects presented by experts should be implemented and which should be left out. (Kelly, 2007)

Serious game development often faces a contradiction where the development project has a low budget compared to commercial video game development projects but the requirements for successful serious games are higher (Söbke & Streicher, 2016). Rucker (2002, p. 25-27) presents time, cost and quality as a triangle where changing one aspect affects the other two. As the budget in serious games is often low, the quality will suffer or the development schedule will be long. Rucker (2002, p. 25-27) argues that the overall quality can be kept high by compromising the amount of features in the game and making the game less complex. In this case, the developer needs to be cautious not to compensate the loss of features by dedicating too much time on the core features that were left. There are exceptions to the typical serious game presented by Söbke and Streicher (2016). U.S. Army's game America's Army which had a total budget of 33 million dollars in the first ten years of its development (Sinclair, 2009). On the other hand, America's Army has been criticized for using taxpayers money and for growing out of the original scope and budget set for the project (Funk, 2009). This emphasizes the difficulty of reasoning a serious game project when funding comes from public.

"Testing is the process of executing a program with the intent of finding errors" (Myers et al., 2004, p. 6). Myers et al. (2004) further define software testing as a process of making sure the software code does what it is intended to do. Another definition comes from IEEE standard 829-2008 (2008) which defines testing as an "activity in which a system or component is executed under specified conditions, the results are observed or recorded, and an evaluation is made of some aspect of the system or component". Ideally the developer would want to perfect the software by testing all possible states and input-output combinations but in practice it is impractical or even impossible to

find every error in any software (Myers et al., 2004, p. 9). Kasurinen (2012) states that software testing process is a core process in making a software product successful.

Digital games and their development processes are similar to conventional software development but they add requirements for aspects of creative design (Blow, 2004). Kasurinen and Smolander (2014) interviewed 28 professional game developers as a part of their research and only three of them considered the software work to be in primary position of game development, and twelve of those interviewed viewed game development as primarily creative work. Their research also found out that game developing organizations do their testing in a similar way than conventional software organizations but the practices are not fully comparable.

ISO/IEC 25010 standard (2011) defines a quality model for computer systems and software products that can be used to determine the factors to test in software. The quality model is presented in **table 5**. Another set of standards related to software testing is ISO/IEC/IEEE 29119-2 (2013). Applying the concepts of the test process model from this standard can result in better quality of end products as found out in the study from Kasurinen (2012). Test design and implementation process from ISO/IEC/IEEE 29119-2 (2013) is presented in **figure 12**.

Table 5. Quality model for determining factors for testing. (ISO/IEC 25010, 2011)

Functional stability	Functional appropriateness, accuracy, compliance	Security	Confidentiality, integrity, non-repudiation, accountability, authenticity, compliance
Reliability	Maturity, availability, fault tolerance, recoverability, compliance	Compatibility	Co-existence, interoperability, compliance
Performance efficiency	Time-behavior, resource utilization, compliance	Maintainability	Modularity, reusability, analyzability, changeability, modification stability, testability, compliance
Operability	Appropriateness, recognisability, learnability, ease of use, attractiveness, technical accessibility, compliance	Portability	Adaptability, installability, replaceability, compliance

The standards define well the technical side to software testing. The practical execution of software testing can be divided into two processes. Black-box and white-box testing. In black-box testing the goal is to find circumstances when the software does not work according to the specifications. The tester does not concern themselves about the internal structure of the software. In white-box testing the tester particularly examines the code of the software and tries to find inconsistencies and errors from there. (Myers et al., 2004, pp. 9-11)

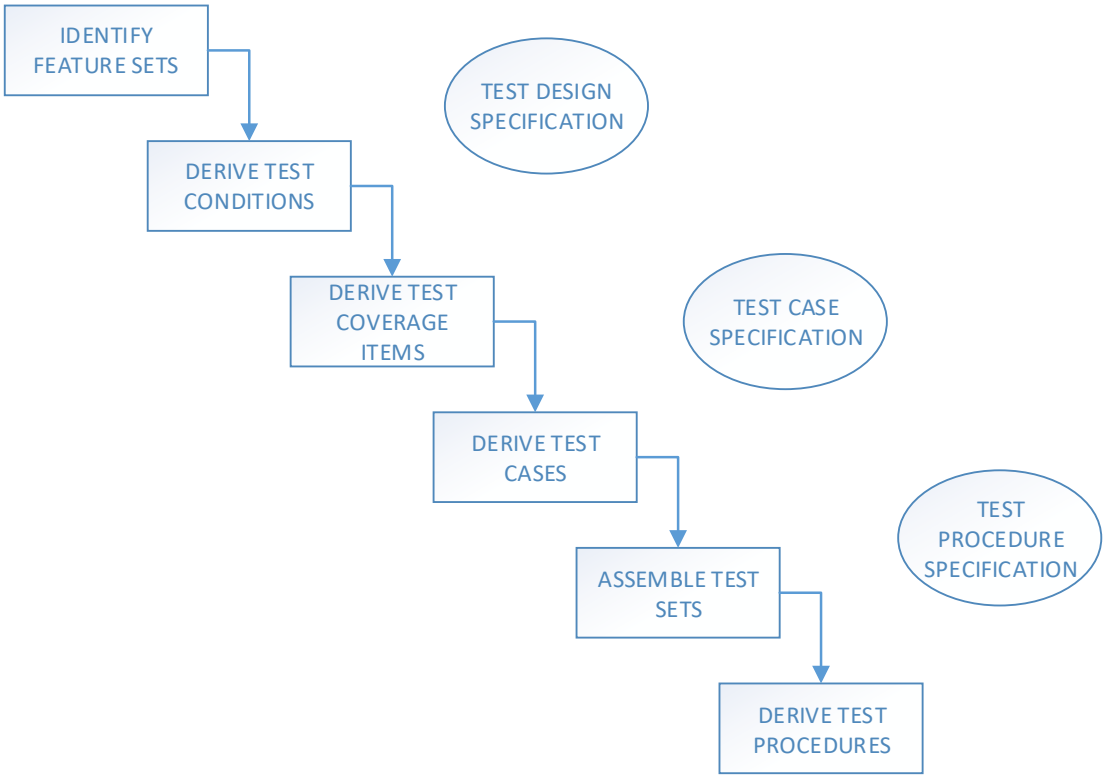

Figure 12. Test design and implementation process. (ISO/IEC/IEEE 29119-2, 2013)

Playtesting a digital game can be considered a part of black-box testing process. During the design and development of the game the designers and developers can do the playtesting but after the game concept is playable it should be tested by other people. First with people such as friends and colleagues outside the project and then with people completely outside of the production (Fullerton, 2008 pp. 248-251). Fullerton (2008 pp. 278-279) also raises five qualities to test in the playable concept stage that are required to be fulfilled for a game development to be considered successful: functional, internally complete, balanced, fun, accessible. Playtests are not the only game related tests necessary to validate a serious game. It is necessary to also test for the realization of serious purpose, the learning content (Söbke & Streicher, 2016).

Ramadan and Hendradjaya (2014) combined the software testing and playtesting practices and proposed a digital game testing method and prioritized the quality factors

presented in standards and Fullerton's (2008) model. This method is presented in **table 6**. The research by Kasurinen and Smolander (2014) supports the prioritization of Ramadan and Hendradjaya (2014) as they observed that testing the user experience factors impact the game design in a way that the end product is more catered to the target customers. Ramadan and Hendradjaya (2014) tested their method by assessing two mobile games. The method was deemed successful in the way that it can provide information regarding the quality of the assessed game. The authors criticize their method for being too general and would improve it by either making the method game genre specific or by including more game specific quality factors.

Table 6. Digital game testing method with test factors in priority order. (Ramadan & Hendradjaya, 2014)

Priority	Factor	Sub-factors
1.	User experience	Fun, balanced, usability
2.	Functional	Functional (feature availability) performance, internally complete, service compatibility
3.	Maintainability	-
4.	Portability	-

Combining all the game testing frameworks and practices into software testing principles presented by Myers et al. (2004, p. 15), following principles for digital game testing can be created:

- Define expected test results
- Avoid being the only tester of your own game
- Go through test results thoroughly
- Test with valid and invalid inputs
- Examine if the game works as intended and also find out if it can be played in unintended ways
- Expect to find errors
- Finding errors make the existence of more errors probable
- Testing is creative and intellectually challenging work

4 ECOGAME CONCEPT AND GAMEPLAY

4.1 ECOGAME concept

The prototype of ECOGAME is developed in the Google Apps platform and the game is accessed through Google Drive cloud service. Playing the game requires a working internet connection and Google account. Since the game operates in a cloud service, the player does not need do install any additional software in addition to a web browser. Operating in cloud also allows continuous saving of the progress, which in turn allows in the case of connection problems the players to continue exactly from the situation the game was left in. The actions performed in ECOGAME are mostly resolved in Google's servers and therefore the burden on the players' hardware is very light. Both of these issues, easy to access software and hardware independency, are essential for a successful serious game (Michael & Chen, 2005, p. 31).

The concept of ECOGAME was created by Pirinen (2017) in his Master's Thesis, and this thesis describes the adaptation process of it into the chosen platform. ECOGAME does not perfectly reflect the concept due to the limitations of the platform and the developer's creative choices.

ECOGAME portrays a par of a business ecosystem formed of three companies. Each company is represented by one or two players. More than two players playing as a company would unnecessarily slow down the decision making within a company and negatively affect the length of a game session. A game session is meant to be played at once and depending on the choice of length it can last from one and half hours up to four hours. The choice of length is based on the fact that the target group of players are company representatives and it is necessary that the players are playing at the same time. Getting these company representatives to participate in multiple sessions or to spend a whole workday playing ECOGAME is simply not possible when the game is still in research and no benefits are proven to be gained by playing it.

The centerpieces of the game are the maturities of the companies and the benefit to cost ratios of projects performed by the companies. The maturity of an individual company is presented as six attributes based on collaboration variables presented by Abreu and Camarinha-Matos (2008): risks, agility, innovation, market, specialization, network. These attributes determine the level of projects available for the player. Larger projects that yield higher potential benefits generally require the company to be more mature. The benefits gained from projects in the game are distributed between all the players investing in it. The company, which starts the project, gains a small percentage of the total benefits gained from the project and the rest are distributed between all the participants according to their contributions. In practice, created benefit is shared depending on many different factors – for example, the power balance in the ecosystem (Chicksand et al., 2011). Since ECOGAME is concentrated on improving collaboration through communication, it is not relevant to attempt to model complex benefit sharing behavior.

4.2 Playing ECOGAME

A game of ECOGAME can be divided into three separate stages: individual preparation, player interaction and gameplay, scoring and discussion. Each of these stages has their own objective. Individual preparation immerses the player in the game, player interaction and gameplay transfers the serious purpose of ECOGAME to the immersed player, and scoring and discussion delivers feedback and makes the player aware of the occurred acquisition of the serious content. The general flow of a session of ECOGAME is presented in **figure 13**. The optional preparation in individual preparation stage provides the players an introduction to the game through a video tutorial for the basics of the gameplay and a user's guide for more in depth explanation of the mechanics in the game. User's guide can be found in appendix 1 and it includes figures from the different views of ECOGAME. The game begins after the players set up their companies through the start view and move on to their own companies' views. The companies' game views include a front page, which introduces the players to their company's role in the business ecosystem of the game, and a play page where most of

the games actions are performed. During a game session, each player should have their own player spreadsheet and the main game spreadsheet open at all times. After tutorial and player profile creation the main spreadsheet serves the purpose of a platform for information sharing and tracking of past projects. The project log shows the contributions and gained benefits for each completed project. The shared page also provides information regarding the current state of networks goals.

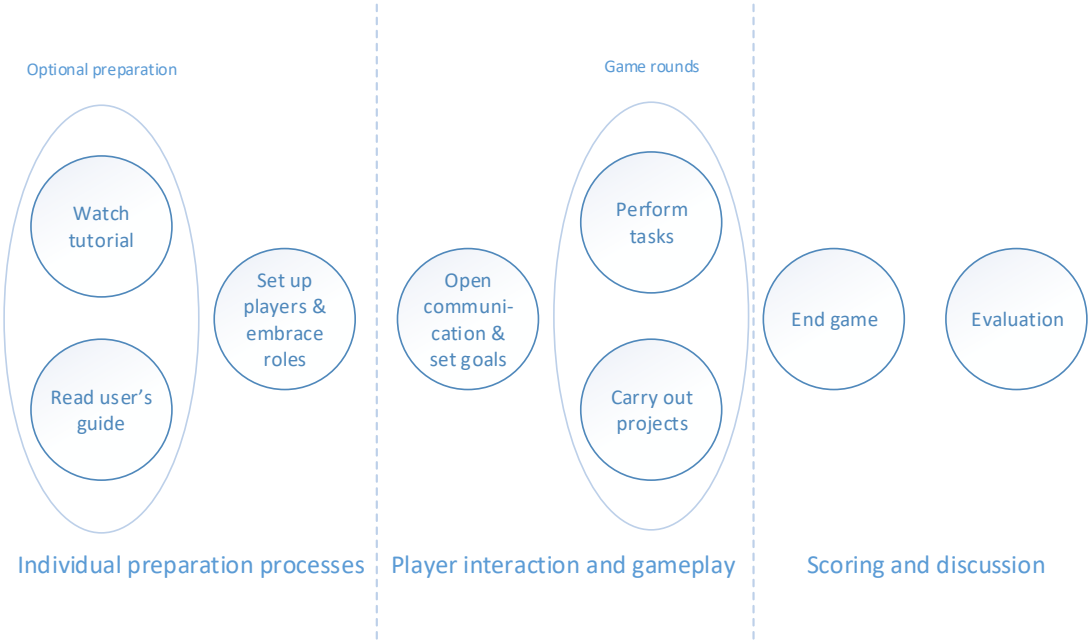

Figure 13. The general flow of one game session of ECOGAME.

As presented in **figure 13** a round consists of carrying out projects and performing tasks. When a player chooses to start a project, they are offered up to three choices in order of small, medium or large project in scale. As the more demanding projects are also larger in scale, a company having low maturity level might not get to choose other than the small, or between small and medium projects. The offered projects are always the most demanding in each size category that the company is capable of carrying out. If a project is chosen it will be removed from the pool of projects to be offered for the rest of the game. Exception to this is one small barely beneficial project which ensures that a company can always start a project no matter how badly they are performing.

During one round, each company starts one project and chooses the partners they can and want to share the project with, if any. Exception to this is if the company in turn to start a project has run out of budget for the current round. They will then have to skip the project instead and the round will consist of less than three projects. While carrying out projects communication between players is in major role. Especially in the beginning when companies might be in very different situations and cannot share many projects with each other. If companies wish to successfully complete large projects later in the game, they need to communicate their attributes and resources to each other.

The larger the project the better the possible benefits to be gained are. To achieve the optimal benefits from larger projects, the companies have to collaborate because the round budget of one company is unlikely to be enough to yield the best possible benefits. For another company to take part in a project, one must meet the same maturity requirements for the project as the project-starting company. This creates an incentive for players to communicate and develop their companies towards a similar direction to ensure they can make complete use of any project opportunity presented to them. To gain the optimal benefits from a project the participating companies need to figure out a suitable total contribution and a duration for the project. In addition, the number of participants is a factor for benefits to be gained. Whether it is wrong sized contribution or a wrong amount of resources focused to a project, the result can be disappointing.

Each company has their own budget for each round to use in tasks and projects. The budget depends on the maturity of the company and as the companies evolve so does the budget – allowing the companies to invest more in larger projects. Projects also return a variable percentage of the possible benefits back to the budget or in the case of failed project, some additional costs can be created. Tasks do not yield immediate benefits but rather develop the maturity of the company through the attributes.

The companies' attributes can be developed through projects or small tasks that are individual operations for each company performed during game rounds. The attribute gain from a project depends on the success of the project. A failed project can even lower the attributes and cause a substantial dent in the player's budget. In addition, if an attribute is completely overlooked, there are risks for each company that can realize and cause unexpected costs and even further weaken the state of the company. Concentrating only on a couple of attributes can be a valid strategy to be able to carry out demanding specialized projects that possess a potential for huge benefits, but some kind of balance in attributes is required to avoid risks. The overall maturity of a company also affects the budget they have for investing in projects and tasks. The game does not naturally guide how to distribute the budget between tasks and projects but the players are expected to realize that tasks can be rather useless if the company is already very mature. On the other hand, if a company is not mature enough to meet requirements for projects from others, they should spend on tasks and try to invite other companies to invest in their projects as the company starting a project gains slightly more benefits than the other investors do.

The amount of tasks per round are limited and each time a player wishes to perform a task they get to choose which attribute they want to improve. After choosing the attribute they are given a task and the player simply needs to input the contribution to the task. The attribute gains from successful projects are better than those from tasks but tasks are important when a company needs to catch up with their partners or there is a sum left in the budget after performing all the projects of a round.

Serious purpose of ECOGAME is to improve the collaboration between companies working in a business ecosystem. Beznosyk et al. (2012) found out that a collaborative game can be found enjoyable and have good results even when communication is very restricted. This kind of approach does not work for ECOGAME because the decision making in the projects does not force collaboration but rather encourage discussion on whether collaboration is beneficial or not. Restricting communication in ECOGAME

would most likely lead to each company carrying out their projects alone because it is difficult if not impossible to make a collective decision on a project investment without proper communication. The means of communication in ECOGAME are Google Hangouts application in the Google Apps platform, which allows the players to have conversations between all of the players or just two of them, and the shared page in the main file where companies can easily exchange information. The information can be shared to the shared page in two parts. The first part, the players attributes, represents more of the technical knowledge a company holds and which real companies are comfortable sharing to their network or ecosystem partners. The second part is the information on the finances of the player and it is like the cost information, which real companies are not comfortable sharing and where the field problem behind the research lies.

End and evaluation of a game session

The game is scored both individually and ecosystem-wise. One factor applied to both, individual companies and the whole ecosystem is the ratio between benefits and costs. The other factor, the change of the maturity level of the company, is applied only on individual level. The changes in maturity level cannot be compared between the players in one session as the starting situations of the companies differ. However, individual scoring can be used to compare individuals playing with the same starting setups in different game sessions. There are many statistics given at the end of the game that can be used to compare the players of one session but the differing starting situations make ranking the players of one session impossible. Some of the statistics given at the end of the game are shown in **figure 14**.

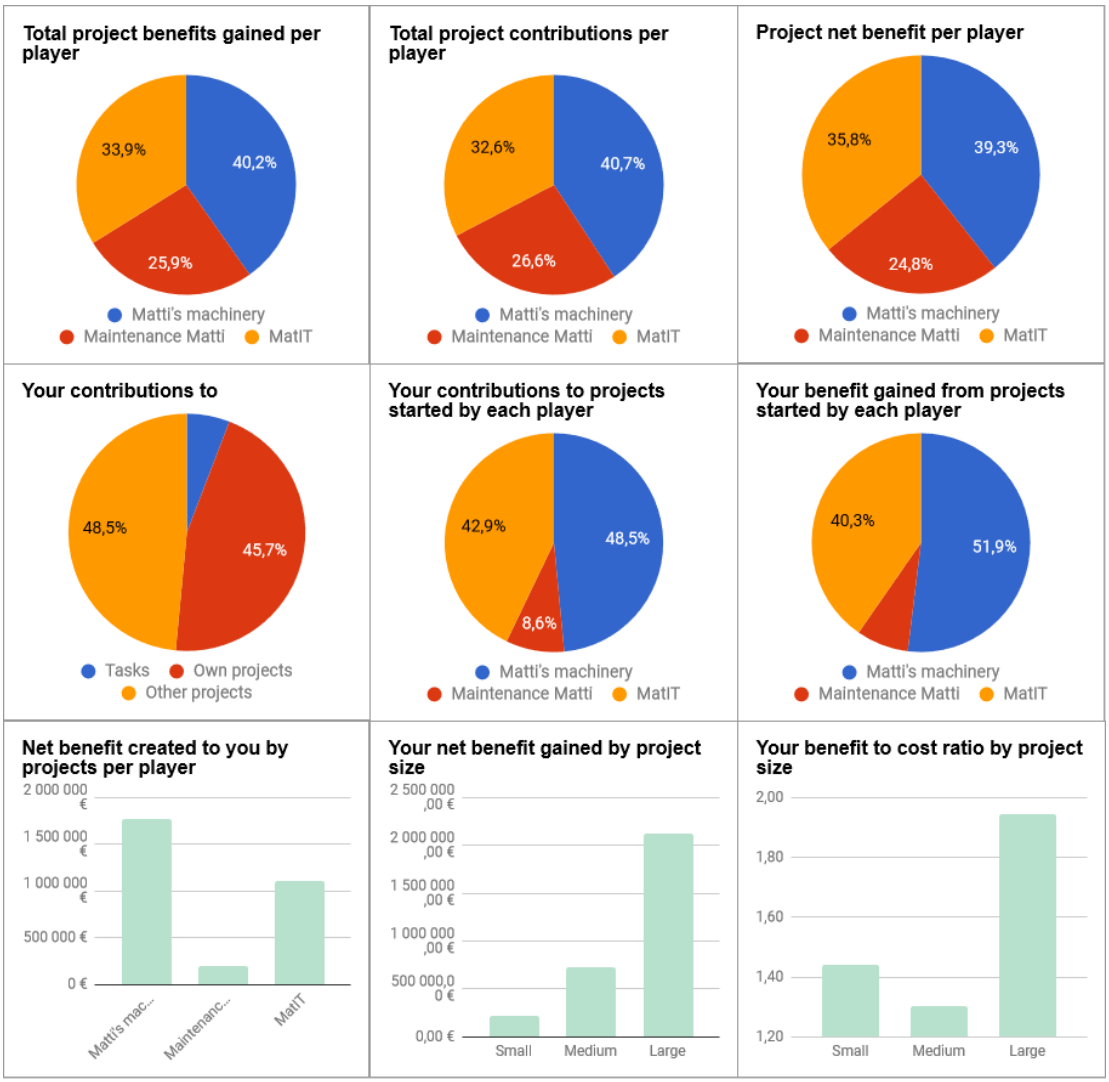

Figure 14. End game statistics of a game session.

The companies set goals both individually and together as an ecosystem after setting up the game but before beginning to play. The goals, ecosystems benefit costs ratio and individual maturity growths, control the gameplay and define in the end if the game session has been successful. The success of the game session is a subjective opinion but the developer sees success as the serious purpose being filled, and the serious purpose is being filled when the players have collaborated well enough to reach the goals they set in collaboration. The goals might be difficult to set for the first game session and therefore it is advised that players go through the optional preparation

presented in **figure 13** and in addition, if time allows, play a round beforehand to familiarize themselves with the game.

The scoring, as in the achieved benefit to cost ratios, can be used to compare game sessions and players with players from other game sessions but in evaluating the achievement of the serious purpose of ECOGAME, the progress towards the self-set goals plays a more important role. The benefit-cost ratio goal set by the ecosystem describes well the expectations of the players. If the players set a low ratio as their goal, they are not expecting to collaborate much and rather seek low but stable benefits. If the goal is set to the higher end of the possible spectrum, the players are ready to collaborate from the beginning.

Facilitator's role in the game

Communication between players is performed in external communication tool, which allows the players to form multiple conversations between two players and a conversation between all players. Facilitator can also be contacted through the conversation tool if necessary. If all the players are physically present in the same place, the group can also communicate without the tool.

Facilitators main role is to set the length and difficulty of the game in the main spreadsheet. Difficulty can be adjusted by modifying the starting attributes of the companies and giving them access to only a few tasks each round. The length of the game is determined by the amount of rounds to be played. From the results of alpha test phase, which is further discussed in chapter 5.3, we can assume that the setup and the end of the game take 30 to 60 minutes of time in total, depending on if the players have familiarized themselves with the game beforehand and how much discussion is raised at the end. Each round of gameplay takes on average 20 minutes – slightly more in the first few rounds and less later on in the game.

In addition to being a common place for the players, the main file is also a tool for the facilitator to fix the most common errors that can happen during a game session. If the internet connection is not stable, a started functionality might not run into the end and cause the game to be stuck from the players' perspective. Another common reason for an error to occur is a function taking longer than average to resolve on the servers side and an impatient player trying to run the same function multiple times.

While the game is in its current state, being tested and researched, the platform requires the facilitator to be present in the game sessions. If the game is found successful in fulfilling the serious purpose set for the game and solving the field problem in the environment of the DSR, the game should be produced into a version where facilitator no more plays any kind of role but rather the game can be played without one. On the other hand, ECOGAME is a tool for research and it is necessary to observe and gather data from play sessions that cannot be gathered through the tools included in the game. This data mainly relates to the oral communication between players, and engagement, immersion and fun experienced by players. After the role of a facilitator as a game manager is made redundant, the facilitator can observe the game as a researcher. With the prototype of ECOGAME it is however necessary to have additional resources besides the facilitator for observing if the additional data is to be gathered.

5 DEVELOPMENT PROCESS AND CHOICES OF ECOGAME

5.1 Graphical user interface of ECOGAME

The development process did not completely follow the one presented in **figure 4** in chapter 1.4 because the concept creation was carried out by a different person at the same time than the production cycle was in progress. To stay on schedule it was necessary to start producing the graphical user interface (GUI) and mechanics of the game before there was an understanding of what the finished game would look like. This goes against the ideas of creating a game design document and planning the programming work before producing game code. The platform and programming language, Google Apps and JavaScript, were chosen to reflect the skills of the producer and the suitability of the platform to the serious game theory rather than to specifically answer the needs of the to be created game concept.

As the game development was carried out by two different people at the same time, the development of the game software had to be carried out in an order that supported the design work. The alpha stages of development are presented in **figure 5** in chapter 1.4. Stage 1 is highly iterative since the concept is still forming and the development concentrates on GUI and mechanics to support the implementation of game concept. Constant white-box tests are executed by the developer. The aim of the tests at this stage is to make sure that the game works under the assumption that players play it as intended. Finding and correcting bugs and glitches occurring in special situations is performed in later stages.

In the development of GUI for a serious game it is important to consider the different kinds of players and make the GUI easy to access and use for anyone. ECOGAME is meant to be played by company representatives who have the authority to decide about the sharing of information within an ecosystem. These players are likely to use computers in their daily work but the skills and understanding can still be highly

varying. The GUI should not include too many objects to interact with and all necessary objects to interact with should be clearly available to the players.

In the google apps platform we have developed four spreadsheets that compose the game. One of the spreadsheets is for shared use and includes the start view and shared view shown in **figure 15**. Players access the game by opening the main spreadsheet for shared use where they have instructions for playing the game. Players are advised to first watch the tutorial and read the user's guide. The game session begins by creating a company profile, which can be done through the setup buttons on the start view. After creating profiles, the players are asked to open their companies' respective spreadsheets. Access to a company spreadsheet is only granted to the player assigned to the corresponding role, and the facilitator to observe the game. The company spreadsheets introduce the players to their roles in the ecosystem and offers the play view. The scripts run in google apps platform are performed server side and therefore all the spreadsheet openings and view changes needs to be done manually which causes a small inconvenience. It would be more clear and fluent for the flow of the game if the game would automatically move the player to a correct view. Besides the player setup, all actions performed by players are done through buttons in their respective play views. Even though information is scattered around in multiple different views, it is important that all the actions are present in one to avoid confusion during gameplay.

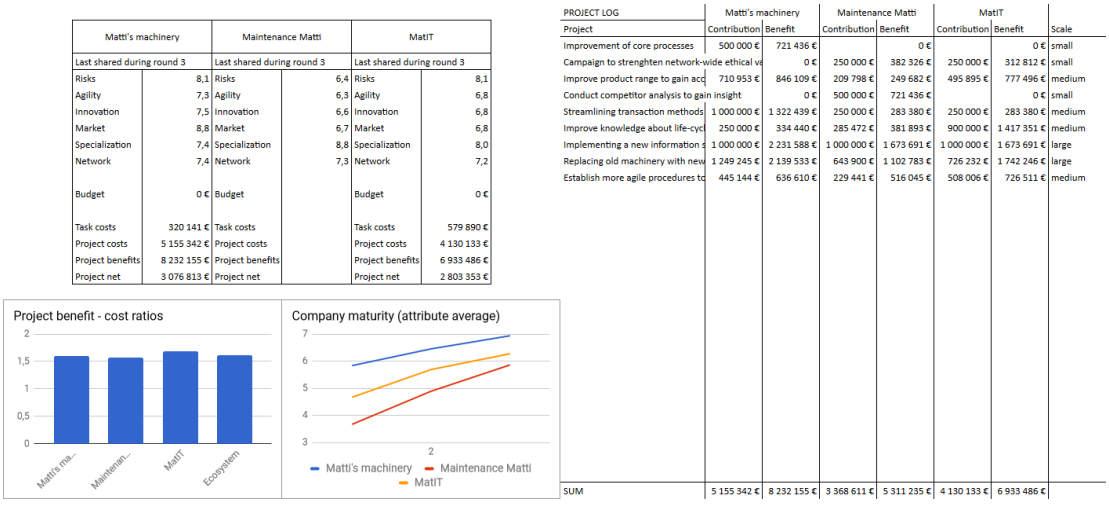

Figure 15. Game view shared by all players.

Play view offers the player a view to the current state of their profile – name of the profile, current characteristics and scoring factors. In addition to the profile state, the player accepts new tasks and events and submits their decisions regarding these in the view. As the game progresses the characteristics and scoring factors change according to the decisions made by players.

5.2 ECOGAMEs data and structure of the game code

All the game data is stored in the spreadsheets of the game and the purpose of the game code is to manipulate it according to the rules of the game. All data related to projects and tasks in the game are in sheets in the main spreadsheet and not accessible to the players because in theory a player could optimize their gameplay by studying the data. The data that records the game session is mainly held in each of the player spreadsheets. Every submitted task and project is recorded and used to create statistics for end of the game analysis. In addition, whenever a change is made to company's attributes or finances, the maturity state and finances are recorded. This full gameplay data is not automatically shown to players but they can access if they wish, and in their play view, they have a visual presentation of their attribute development and the cumulative costs and benefits.

The game code itself is mainly a collection of functions to transfer data in the spreadsheet and execute calculations that are presented as changes in the attribute values or scores of players. The game code consists of global variables, main functions and sub functions. Global variables are variables that are widely used in the functions and defining them locally inside functions would be impractical. Global variables in ECOGAME are defined for different spreadsheets and sheets.

Main functions are called to perform actions during gameplay. Such functions are for example: player setup, ending a round or submitting a project. For example, the main function to start a new project underwent through numerous changes. As the function needs to check for many different conditions before giving the player a choice of new

project, the function was needed to change to fix numerous normally occurring bugs. In the first iteration the function only checked if it was already last round and if the company had already carried out a project in the current round. In the latest version the function additionally checks if the company has any budget left, if there are previous decisions to be submitted or if another company has an active project. The same function is also used to start a new round if all projects are submitted for the round. In its core, the new project function launches sub functions to check for fulfillment of requirements of projects by the project starting company and by the partners. Sub functions are called from main functions upon fulfilling certain set criteria. The criteria for calling a sub function in most cases is simply checking if the required input is given or if the player is allowed to perform an action they are attempting to. Sub functions perform the data reading and transferring and necessary calculations required for main functions.

Regarding the programming process and handling the code, the Google Apps platform proved to be very inflexible. A script file containing the game code cannot be tied to multiple spreadsheets and for that reason each of the four game files has to have their own script files. This causes the problem of having to have multiple instances of functions, which have exactly the same procedure, in different scripts. This makes correcting errors in the game code a very slow procedure and polishing the game code rather an annoying task. Even though one of the goals for the production of the game was to produce a well structured and easily modifiable game code it seems like that could not be achieved with the limitations from the platform and the fact that the concept could not be applied in full from the beginning of planning the structure of the game code.

As the projects are the core mechanic of the game, the functions in relation to starting and submitting projects need to be well thought and constructed. The sub function to check for requirements for a new project originally randomly chose three from the pool of eligible projects and presented them for the player to make a choice from. After the

tests, developer saw fit to remove the randomness from this process and ended up measuring the projects by size and providing the player the best choice from each size category. At this point the function was also changed to remove the chosen project from the pool of available projects for the rest of the game session to improve the immersion capabilities of the game. The engagement of a player to the role of theirs could break if they were to be offered the same projects repeatedly. These couple of changes to the core mechanic were made to ensure the game can provide the state of flow to the players

5.3 Alpha test phase with research team

The game was tested three times with a research team during the game's alpha stage of production. The alpha version in the first test included most of the desired functionalities but lacked proper task and project scoring models. The feedback from the test session concentrated on the lack of visual expression such as using colors to indicate the increase or decrease of an attribute. Also, the testers wanted to see more information on past choices and their impacts. Overall, the players wanted more feedback during the game session which was a very valid concern as Bellotti et al. (2010) mention that feedback recognizable in the serious context of the game is crucial in achieving the serious goals of the game.

The second alpha test version introduced a costs and benefits system for scoring and evaluation of the game. The end game view was at the time unclear and along the scoring of the game required more effort. Rather than simply giving a restriction for maximum contributions for each project and task the testers felt that a budget system to restrict spending in longer time span would be more suitable. In addition to these changes, only a couple minor bugs and visual changes required work to do before third and final alpha test.

Final alpha test version of ECOGAME included a round-specific budget system based on the maturity of a player's company. This time the setting for the test was also

different compared to the previous tests since the companies started the game with highly varying maturities. Companies had difficult time to optimize their spending each round, which can be corrected by allowing the players to play a round to test the mechanics before starting the actual game. The most significant problem faced in the third alpha test was that the companies were not able to share projects with each other when it would have been necessary. This is partly a design choice for the game as the players with more mature companies are expected to help the less developed ones through their projects, not the projects of the mature companies. The project requirements are set individually for each of the network attributes and therefore it is very difficult to be able to share large projects during the course of the game if the players take off from very different starting points. This is not purposeful for achieving the serious goal of ECOGAME as it restricts collaboration possibilities too much. Therefore, the project requirements were changed to be based on the overall maturity for sharing rather than each attribute separately. The main results from all three alpha tests are gathered in **table 7**.

Table 7. Main change requirements from alpha test phase by each test.

Alpha test version	First	Second	Third
Visual effects	Colors and notifications	More appropriate colors	-
Mechanics	Tool for communication	-	Tutorial for players; more options for information sharing
Rules	-	Changes to scoring and resource models	Clarification to resource system; changes to project requirements
Feedback	More information on progression while playing	Log of past projects	-
Evaluation	-	Clarification to evaluation	-

5.4 Game setting and beta test phase with students

The setting of the game very much guides how deep collaboration is required from the start. If the companies in the ecosystem of the game are set to be in fairly similar maturity levels, the projects they start are accessible for all players. This kind of setting steers the communication between companies to be concentrated in budget management and not so much in developing the company maturities. A more difficult setting, in the sense of requiring deeper collaboration, would be the companies of the ecosystem being in very different maturity levels and therefore would have to put work into developing their maturity levels before being able to execute highly beneficial projects. In the beginning, the most mature company of the ecosystem might need to take losses to get the smaller ones properly running and to yield better benefits in long term. The latter setting naturally requires more collaboration and better communication than the former one. Considering the players set the goals for the ecosystem after familiarizing themselves with the game setting and roles it will be interesting to see how ambitious goals they set for themselves both when the starting situation is fairly stable and when the starting situation between roles is imbalanced.

As the students are not the main target group of the game and the field problem in the environment of this DSR is not related to education, expected results from the student test have to be comparable to expected behavior of the real target group of players. Motivation for students to play ECOGAME comes from gaining points towards a course completion. As the motivation for players in the target group is the possibility to increase collaboration and gain cost advantages in their ecosystem, the student test setting needs to be set up in the way that students adopt the role of a company in such situation. The correct setting can be achieved by giving the students detailed and interesting backgrounds for the companies they are going to be representing in the game. If the setting is successful and the students are properly engaged, the results from the student test can be applied for the preparation of field testing portion of the research. It is not expected from the student test to get any answers on the realization of the serious purpose of the game in the context of the field problem. If the serious purpose

of increasing collaboration is realized for the students maybe the game has potential in the educational field as well but that is not in the scope of this research.

The purpose of the student test is not only to be preparation for the field testing but also to further polish the prototype of ECOGAME. Following the game quality factors presented in **table 6** in chapter 3.2 the student test seeks to determine the user experience and functionality of ECOGAME. In other words, student test is used to study the success of the creative part of the game development as opposed to alpha test phase mainly testing the success of the technical and production part of the development process.

As mentioned earlier, the game records the progression of a game session very well so the game session itself gives good feedback on the functionality of the game. The fun portion is more difficult to measure. To measure the degree of fun a questionnaire is to be presented to the student testers. In addition to trying to measure the degree of fun, the questionnaire can also be used to gather feedback on the technical side of the game even though it is not the main focus in the test.

6 DISCUSSION AND CONCLUSIONS

6.1 Analysis of ECOGAMEs design

Caillois (1961) presented the idea that if a player plays a game multiple times voluntarily, they are bound to learn something – at least to play the game better. ECOGAME is meant to be played voluntarily by company representatives but as playing of ECOGAME is likely to be a part of other projects; the motive of players is unclear. Drawing any conclusions about learning from ECOGAME because the game is voluntary cannot be applied to cases where only one session is played. **Table 8** presents the design choices made for ECOGAME based on this and other presented theories and arguments.

The serious purpose of a serious game according to Dörner et al. (2016) is what the developer of the game means it to be. For ECOGAME the serious purpose is to increase collaboration between business ecosystem partners by engaging them in decision making situations where they have to communicate properly and make decisions in collaboration if they wish to maximize their success in the game. The integrative collaboration represents the learning content in ECOGAME and the entertainment is expected to come from roles of players and the mechanics of the game. The entertainment of the game is to be proven in further research.

The amount of feedback in ECOGAME is vast but the way it is represented might not be refined enough. During alpha tests the players wished to receive more feedback. Every decision and input made in ECOGAME is recorded so the tools to improve the feedback exist. It is difficult to attempt to determine the correct amount of feedback given to players and it is another aspect, which can only be determined after further testing of the game.

Table 8. Analysis of the game design choices and applications in ECOGAME.

Reference	Theory / argument	Applied in ECOGAME
Caillois (1961)	Playing is a voluntary action and forced play is rather not play at all	Yes.
Garris et al. (2002)	Game dimensions	Yes. Roles for players, goals set by players, game mechanics as rules, graphs and colors for sensory stimuli, challenge through different setups, mystery by incomplete information on partners, control through communication.
Westera et al. (2008)	Randomness to cause unpredictability	Yes and no. Some randomness with the implementation of risks but avoiding randomness to promote benefits of successful collaboration
Zyda (2005); Dörner et al. (2016)	Serious game purpose both entertainment and education; showing the fulfilling of the serious purpose	Yes.
Giessen (2015); Rucker (2002)	Importance of preparation	Yes. User's guide, tutorial video and possibility for a training round in the beginning of a session
Bellotti et al. (2010); Michael and Chen (2005)	Importance of continuous feedback.	Yes and no.
Csikszentmihalyi (1990)	Game flow	Yes. The difficulty at the beginning is set by the facilitator but the players set the goals of the game according to their skills in relation to the difficulty.
Azadegan and Harteveld (2014)	Integrative collaboration	Yes. No time restrictions allows the players to communicate properly and make decisions alone or in collaboration, as they wish.
Zagal (2006)	Lessons and pitfalls.	Yes and no.

The lessons to learn and pitfalls to avoid from Zagal (2006) can be found in **table 3** in chapter 2.5. Promoting the collaboration instead of competition should be clear to the players of ECOGAME as soon as they are to set the goals for their game session. Individual players are allowed to make decisions alone and it is not penalized in any way. Payoffs can be traced through the project log but as previously mentioned, the continuous feedback could be more clear. Players have different roles and starting points but the abilities are the same. Collaboration should be promoted enough without giving players special abilities even though it is something to think of in future development. As can be seen, the lessons presented were learnt in ECOGAME design but the avoiding the pitfalls is not as clear. In ECOGAME one player cannot make inputs for other players but a player in better starting position than others might try to dominate the game through communication tools. The purpose of ECOGAME is simple and clear but if it is enough to make the game engaging, is yet to be proven. The content of ECOGAME is still lacking. For multiple game session different themes could be provided, especially more than the three roles for companies that the game currently has.

6.2 Analysis of development of ECOGAME

Aleem et al. (2016) highlights the importance of creating a game design document before starting the production of the game code. Game design document includes a description on how the developer plans to transform the game concept into a digital game product. For ECOGAME creating a game design document was not possible due to the production of game code starting before the concept creation was concluded. Other game development tools discussed by Blow (2004) and Aleem et al. (2016) are programming platforms, game engines and game asset management tools. Google Apps platform can be considered as both, a programming platform and a game engine of sorts. The game engine association can be used if we consider the separate applications in Google Apps platform as reusable tools. For example, the spreadsheet application used to build ECOGAME includes functionalities like data storing in cells and built-in functions to perform actions with information within cells. The platform

also allows using different applications together and internet sources for information to further describe the flexibility of the platform. However, these two details were not found necessary and not used in the development of ECOGAME. **Table 9** shows the choices and applications of presented theories related to software engineering and game development in ECOGAME.

From the problems Petrillo et al. (2009) found in their research some are recognizable also in the development process of ECOGAME. If the occurrence of problems presented in **figure 11** in chapter 3.1 are compared to the ones faced in ECOGAME development, a few can be recognized. Feature cutting and feature creeps were both issues as the development project lacked the game design document as earlier mentioned. Some features are unnecessarily precise when their role is very small in the game. Some features are very difficult or impossible to implement at this stage of development even though they would be beneficial for the game. Especially some features that would decrease the time it takes to run functions would be quite important to have but now too time consuming to include. The other problem of ECOGAME development is the lack of documentation within the game code. The game code is difficult to further develop by anyone other than the original developer since the game code lacks clear structure and documentation. This problem also arises from the lack of clear game design document to support planning of the game code production but also from the fact that each application file in the Google Apps platform requires their own script file. Most modifications to game code had to be done on three different script files, and to document all the changes properly it would have used up too much time.

Table 9. Analysis of the game development choices and applications in ECOGAME.

Reference	Theory / argument	Applied in ECOGAME
Ramadan and Widyani (2013); Rucker (2002)	Iterative development process	Yes. Figure 5 in chapter 1.4 best describes the iterative nature of ECOGAME development.
Aleem et al. (2016); Blow (2004)	Game design document, programming platforms, game engines and game asset management tools	Yes and no.
Petrillo et al. (2009)	Problems in game development projects	Yes.
Michael and Chen (2005)	No hardware restrictions	Yes. The game only requires a computer or mobile device with internet access and a web browser.
Rucker (2002)	Requirements for playable games	Yes and no.
Kelly et al. (2007)	Serious game development by researchers	Yes. The development of ECOGAME was carried out by a research team.
Fullerton (2008); Ramadan and Hendradjaya (2014); IEEE 829 (2008); ISO/IEC 25010 (2011); ISO/IEC/IEEE 29119-2 (2013)	Digital game testing method with prioritized test factors drawn from playtesting and software testing practices	Yes and no.
Myers et al. (2004)	Digital game testing principles	Yes. The principles presented at the end of chapter 3.2 were used in alpha testing and are applied to the plan of beta test.

The general requirements for playable games by Rucker (2002) are presented in **table 4** in chapter 3.1. Most of these factors, such as hardware restriction and continuous feedback, are already discussed in this chapter. Some of the presented factors are visible in game. For example ECOGAME has clear advances and setbacks represented by successful and failed projects and ECOGAME promotes its requirements, communication and collaboration, clearly. Two factors that are not well adopted to ECOGAME are the amount of score factors and clear termination points. ECOGAME

has a very restricted amount of score factors visible to the player – benefit to cost ratio and company maturity. However, scoring models for projects are complicated although there are only four factors that affect the score of a project: total contribution, project size, number of participants and duration of the project. Termination points in regards of game ending after a final round or a company not being able to continue due to bad shape are not discussed to players. A company can theoretically go to overall maturity of zero and thus not have any budget to take part in projects. Game ending is not currently visible to players before the last round starts but that is another aspect to ask in further tests, if the players feel it is better to know the length of the game or not.

The testing methods were gathered by Ramadan and Hendradjaya (2014) and are shown in **table 6** in chapter 3.2. The alpha phase tests were concentrated on the functional and maintainability factors and reached good results especially in considering the functionality. The most important factor, user experience, was tested mainly through the usability sub-factor – and was found sufficient by the testers. It is important the game's usability is good from the players perspective but for the facilitator it is not as good. Facilitator has to have good knowledge on the game's structure and most common problems caused by unstable internet connection or the game can get stuck at times. The fun and balanced sub-factors of user experience are to be further tested and measured in beta test and later in field testing. The least important factor in the model, portability, is not considered at all. The development team is not familiar enough with other platforms to estimate how easy the game would be to port. This aspect will get to be tested in future if ECOGAME is after validation being reproduced in another platform.

6.3 Further development of ECOGAME

Referring back to **figure 9** in chapter 2.5, the possible further development of ECOGAME lies in the applicability of a serious game to emerging technologies. During the development process of ECOGAME was already discussed the possibility to use augmented reality glasses for GUI of the game to further promote the

communication by removing the computer screens from between the players. This technology was not available to the development of ECOGAME and it hardly is available for enough of the potential players in the target group to justify using it at this stage. Currently, the technology that is available for all the potential players are any kind of computers or mobile devices with internet connection and web browser. The platform and tools used to create ECOGAME could have been better but the end result of this thesis, beta version of ECOGAME in Google Apps platform, is good enough to continue with the research. After ECOGAME is validated with field testing, another development project for a functionally better business ecosystem game should be conducted. Kelly et al. (2007) noted that the input from researchers is crucial in the successful development of a serious game and that is what ECOGAME currently holds. It is created through two Master's Theses and initially tested by researchers. Once the presented DSR is rigorously completed, the game can be developed in another form in collaboration with professional game developers.

6.4 Further research with ECOGAME

This thesis presented the development process of ECOGAME. The development process, which is still lacking the execution and results from beta tests, is however only the first part of the DSR presented in the introduction of this thesis. If we consider the three cycles of DSR we have now concluded the design cycle. The DSR as whole is an iterative process and design cycle will be revisited again after gathering results from field testing in relevance cycle, but most of the work belonging to design cycle is now concluded.

Next part of the research is to take the game into field testing. Field testing will arguably be the most demanding step and the most important one for drawing conclusions on the whole DSR process. The game currently presents a part of an ecosystem that includes three companies. For field testing it will be necessary to build multiple test cases and for each of them it will be necessary to bind a representative from at least three different companies for half a day at the same time. ECOGAME does not hold

any promises, that is what the field testing is for – to find out if the game is a solution to the field problem. On the other hand, three players is quite the low end while discussing ecosystems. Should the game be scaled up to include more players? Possibly yes, but building the test cases just become more and more difficult to build when they become larger and longer in duration. Why would these companies take part in such test? That is the question which needs a proper answer for the research to go forward.

The field problem arises from business ecosystems and that is why other types of ecosystems are not considered currently in this research. However, building cases for field testing could be significantly easier if other kinds of ecosystems could provide comparable test results. Let us consider knowledge ecosystems where universities can be considered partners. Now for the field testing there would be at least one player who knows there is something to gain from the field tests, progress of research. For the game of three participants, a university participating would make building the cases remarkably easier.

Another aspect of ecosystems that was not discussed in this thesis at all is the maturity of the ecosystem. The field problem is recognized in existing and working ecosystems so it can be assumed that the lack of collaboration has existed from the birth of the ecosystem. Should the field testing cases be built around newly formed or forming ecosystems? These kind of ecosystems could find playing ECOGAME provide them something even if the game does not answer the presented field problem – they might find it worthwhile to get to know their ecosystem partners, their current collaboration and decision making skills.

After going through the second step, field testing, and concluding the work in relevance cycle, the DSR seeks to provide theoretical contribution to the theories used in design cycle. Whether ECOGAME manages to solve the field problem or not, some theoretical contributions regarding collaboration in business ecosystems will be brought into back to knowledge through rigor cycle. The results can be anything from the game not

providing any aid to challenges in collaboration in business ecosystems to the game solving all the issues and making collaboration and communication in business ecosystems significantly better.

If we step outside the DSR, there might be more value to ECOGAME than considered in this thesis. As a digital tool, ECOGAME can easily gather data about the game sessions and their progressions. In addition, since communication between decision makers is a key factor in ECOGAME much data can be gathered by analyzing for example the tone, content and extent of discussions. If we take even further approach to the possible uses of ECOGAME for research, it could even provide information on how well the players in the target group learn to play a digital game or what their attitude is towards games in general.

7 SUMMARY

This thesis presented the development process of ECOGAME and mainly discussed the processes of design cycle in design science research framework. The thesis drew background from environment through relevance cycle and theories from knowledge through rigor cycle. The final part of design cycle, in the form of student beta test is to be conducted later – as well as the field testing in relevance cycle, which will provide results to draw conclusions on how ECOGAME answers the field problem recognized in practice. In addition to the presented DSR, ECOGAME might hold further value in gathering data for other areas of research or solving problems in other fields of practice.

Below is concisely presented how the thesis answered the set research questions:

RQ1: Why does collaboration fail in business ecosystems?

The main challenge of collaboration in business ecosystems is the line drawn between the sharing of technical knowledge and cost information. Companies are not ready to share sensitive information even if they are working in a close relationship, in a business ecosystem.

RQ2: How can a game improve collaboration in business ecosystems?

A game can offer the companies a fun and risk-free environment to try different means of collaboration and communication. A game built with rigorous methods and based on relevant theories should be able to train the players towards the serious purpose the game promotes. The main motivation of making a game fun is to have players spend more time playing and stay engaged to the game during the play.

RQ3: How does ECOGAME improve collaboration in business ecosystems?

ECOGAME is built based on various methods recognized in literature. In ECOGAME, communication is key. Players have incomplete information on each other and only through clear communication and by setting their individual goals in line with the common goal – they can reach maximum benefits.

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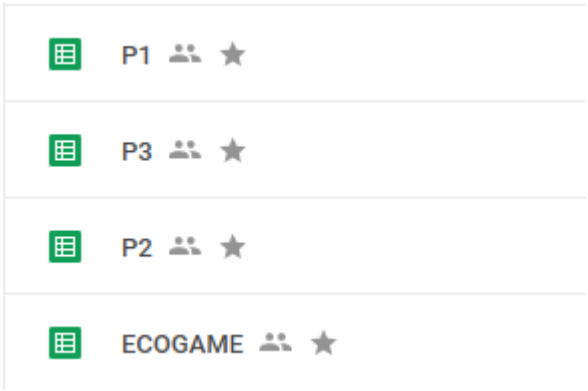
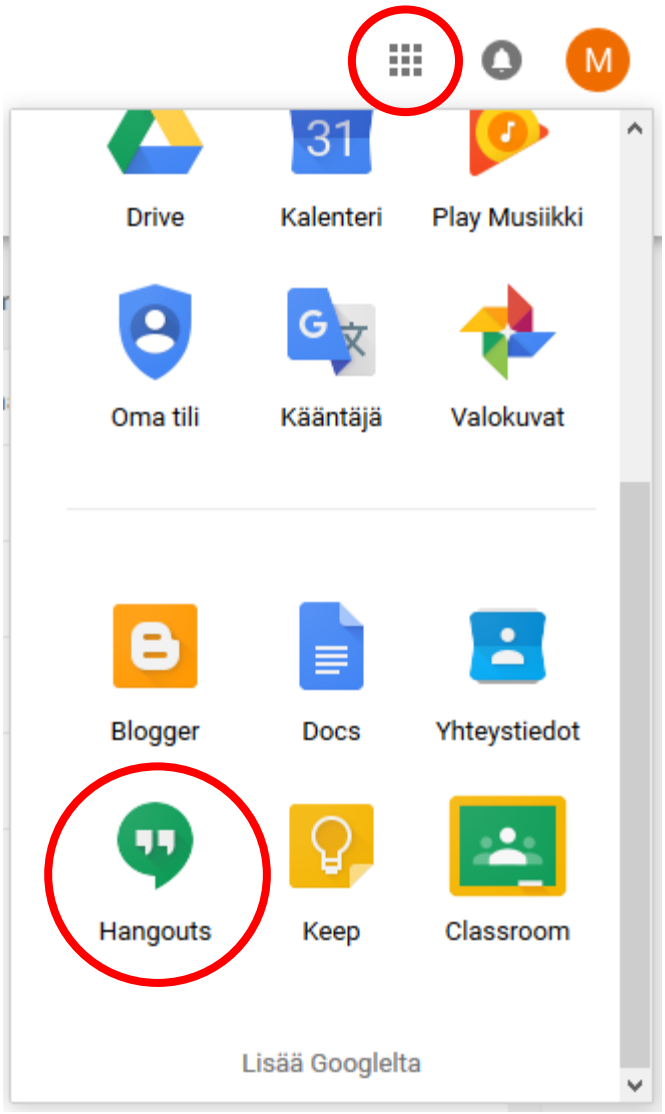
APPENDIX

Appendix 1. User's guide for ECOGAME players, 7 p.

USER'S GUIDE FOR ECOGAME (version 0.31003)





BEFORE GETTING TO PLAY

First step to do before getting to play ECOGAME is to open Google Drive (drive.google.com) and log in to your personal Google account or use an account given by the facilitator.

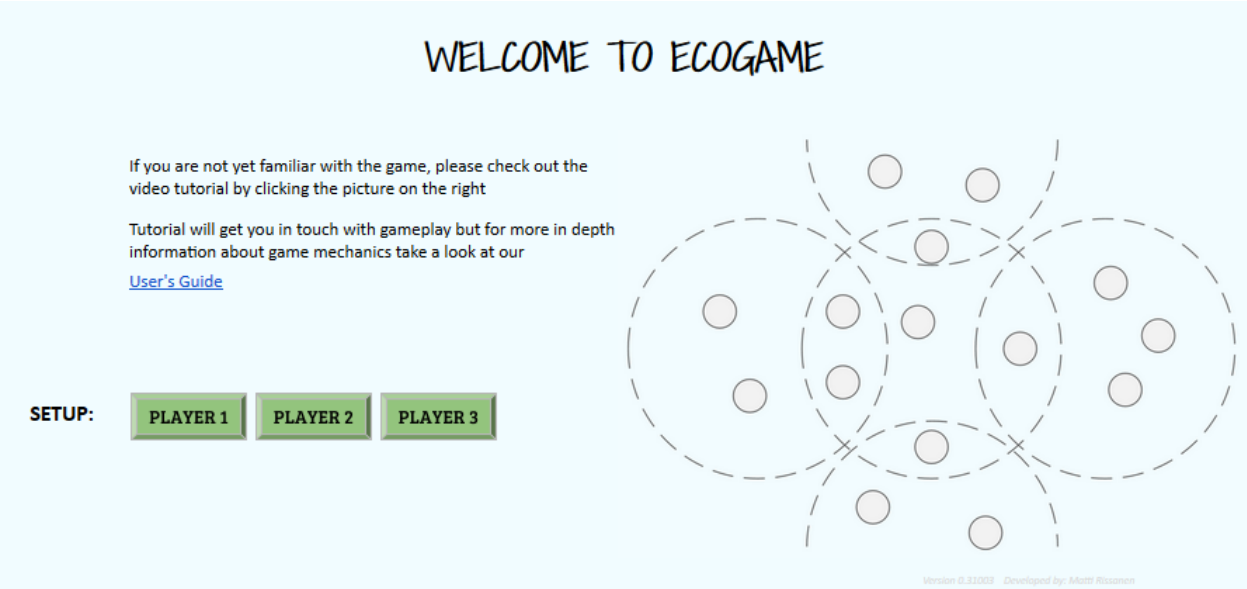
After logging in, the game files (shown in picture above) can be found from the section "Shared with me" inside a folder with name following the format of "ECOGAME_yyyy_mm_dd" (shared automatically to given accounts, personal accounts need to be invited separately. Please inform the facilitator of your gmail address in case of using your personal account to play).

For communication, especially for discussions between just two players, can be used Google Hangouts tool found from the Google Applications –menu. Icons for menu and Hangouts are highlighted in the picture to the right.

After opening communication, we are ready to play. Please start by opening ECOGAME-file from the game files.

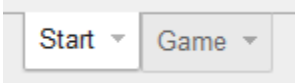
SETTING UP

When you open ECOGAME-file, you will be greeted with the view below.



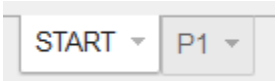
This is the Start-page and here you can perform player setups to assign players and name their companies. Start-page also helps you to get to know ECOGAME by giving links to both, video tutorial and this user's guide.

ECOGAME-file also includes Game-page which holds information on the ongoing game session's state. Game page is introduced a bit later but to access it you simply change the page from below the main view.

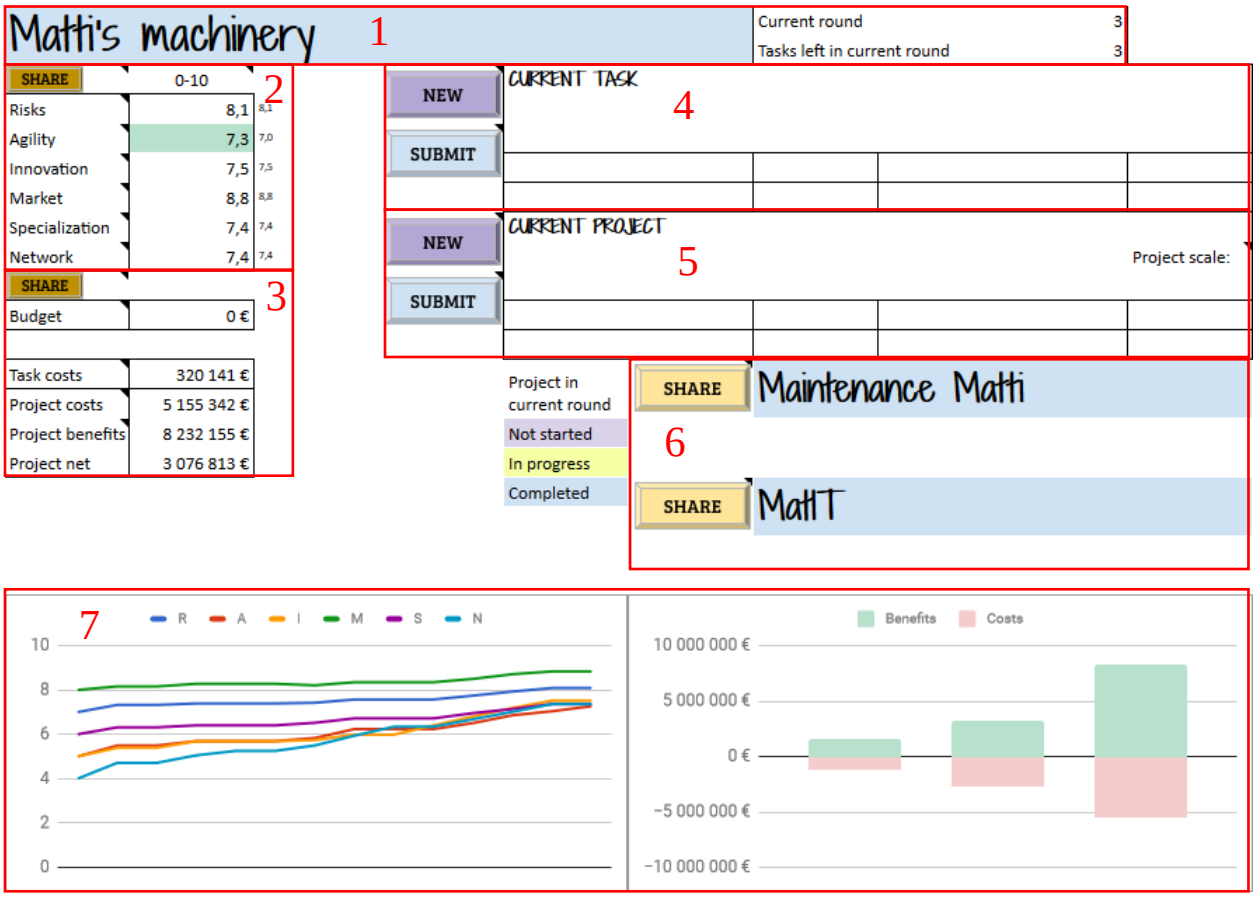


After all three players are set up and ready to play, each player should open their respective player files. P1 for Player 1, P2 for Player 2 and P3 for Player 3. P-file should only be accessed by the player assigned to it, and facilitator.

PLAYING THE GAME



When you access your personal P-file, you will be given information about your company and the role it plays in your business ecosystem. After familiarizing yourself with this information, the players should together set goals for the game session. Facilitator can help with the ballpark figure of what the settings of the game are going to indicate about reachable goals. Goals are set individually for company's maturity and together for the overall benefit to cost ratio by the ecosystem. After setting the goals, you should move on to P-page. In this example we are showing the P-page of Player 1, Matti's machinery, at the end of a game round.



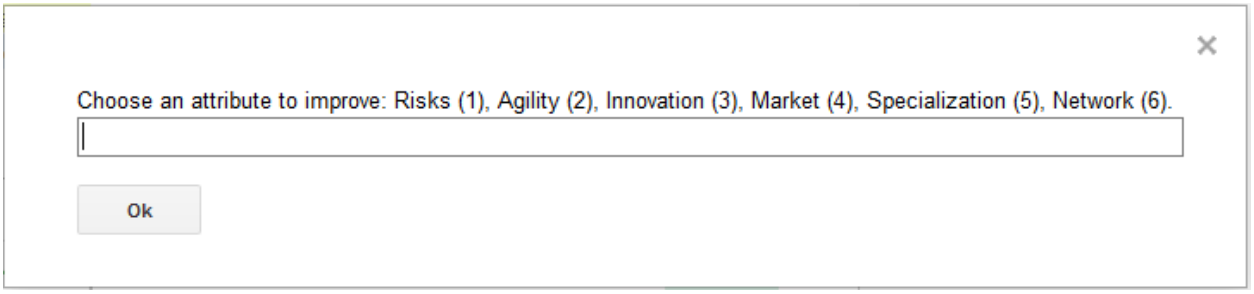
P-page holds a whole lot of functionalities and information and most of it is explained below:

1. Your company's name and information on the current round and tasks you have left to perform in the current round. The background color of your company's name indicates whether your company has already started a project in the current round or not, or if you have a project in progress. Color codes can be found in the middle of P-page.

2. Your company's attributes. Your company's maturity is determined by the average of six attributes: Risks, Agility, Innovation, Market, Specialization and Network. Individually these attributes determine the projects that are available to you. The first number after the name of an attribute indicates the current level and the smaller number on the right indicates the previous level for each attribute. If an action (task or project) affects an attribute positively, it will be indicated with green color. Negative change is indicated with red color.

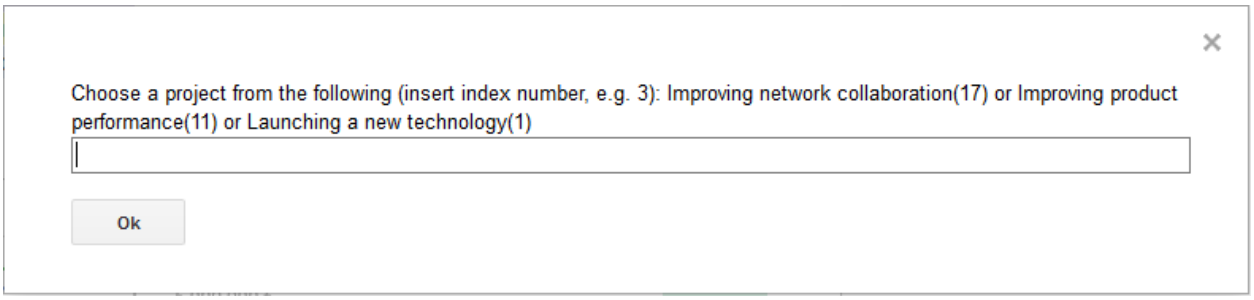
3. Your company's finances. Budget is given for each round depending on the maturity of your company. Budget should always be fully consumed during a round, because any surplus does not affect the budget of the next round. Costs and benefits shown in finances are cumulative for the whole game session.

4. Performing tasks. You can generally perform 3-5 tasks each round, depending on the game's settings. When you choose to start a new task, you will be given the following message:



Here you simply input a number representing each attribute (1-6) to get a task related to it. A task slightly improves an attribute. After getting a task, you will need to input a contribution for the task and then proceed to submit it with the submit-button. The contribution cannot be more than your current budget allows. You should not contribute too much on tasks since they do not directly provide any financial benefits but rather improve your attributes so better projects become available.

5. Performing projects. Each round consists of three projects, one started by each player. If you have not started a project yet and none are in progress, you can start a project with the new-button. New-button besides the project-area is also used to start a new round at the end of a round. A project choice is presented in the picture below:



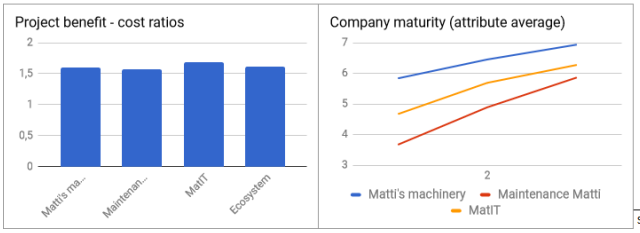
In the example picture we have a choice between three different projects. This is not always the case. Projects are classified by the scale of the project (small, medium or large) and the player gets to choose from each of the size categories. If the player's maturity level is low, they are likely to get to choose only between small or medium projects, or they only get offered the small one. Whatever the situations is, the projects are presented in the order small, medium and large and the choice is done by giving the index number presented after the name of each project as an input. There are two inputs for the project once chosen, size of contribution and the duration of the project. Project benefits are realized instantly regardless of the chosen duration of the project. Project duration in combination with participating companies represents the total spent human resources for a project and should be chosen the project scale in mind.

6. Sharing a project started by you. Once you start a project, you will see if your ecosystem partners are able to participate in it. If they are not, a text will appear below their name to indicate this. The requirements for a company to participate in a project from another company depend on the overall maturity of the receiving company rather than each attribute separately, as is the case when starting a project. If you choose to share the project, you cannot submit your own input for the project before you have gained input from the partner(s) you shared the project with. The benefits of a shared project are distributed in accordance to contributions after the project starter is given a small segment of total benefits.

7. P-page graphs. Personal graphs that show the improvement of each attribute in the left graph and roundly benefits and costs in the right graph.

GAME LOBBY

Matti's machinery		Maintenance Matti		MatiT	
Last shared during round 3		Last shared during round 3		Last shared during round 3	
Risks	8,1	Risks	6,4	Risks	8,1
Agility	7,3	Agility	6,3	Agility	6,8
Innovation	7,5	Innovation	6,6	Innovation	6,8
Market	8,8	Market	6,7	Market	6,8
Specialization	7,4	Specialization	8,8	Specialization	8,0
Network	7,4	Network	7,3	Network	7,2
Budget	0 €	Budget		Budget	0 €
Task costs	320 141 €	Task costs		Task costs	579 890 €
Project costs	5 155 342 €	Project costs		Project costs	4 130 133 €
Project benefits	8 232 155 €	Project benefits		Project benefits	6 933 486 €
Project net	3 076 813 €	Project net		Project net	2 803 353 €



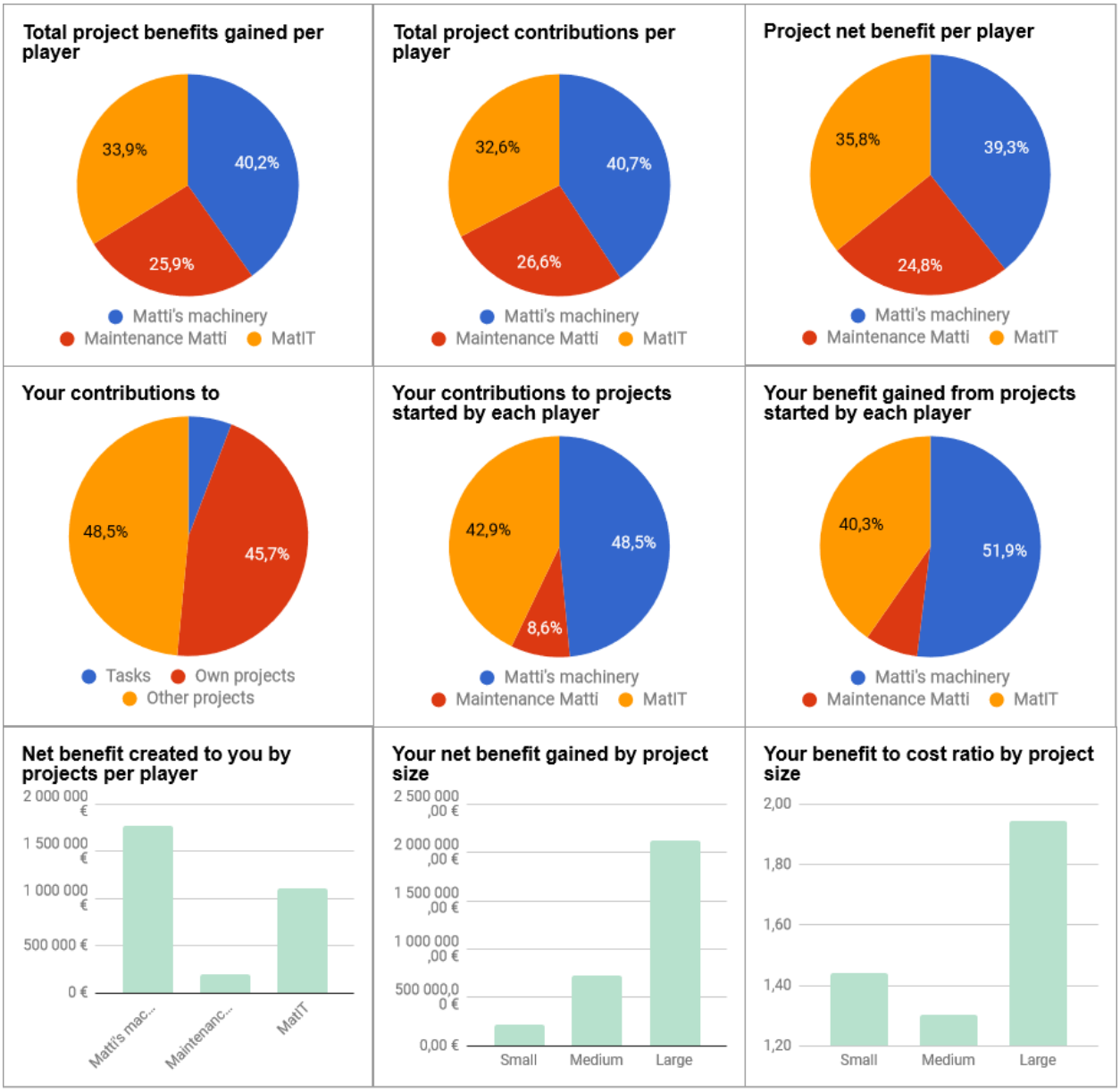
PROJECT LOG	Matti's machinery		Maintenance Matti		MatiT		
Project	Contribution	Benefit	Contribution	Benefit	Contribution	Benefit	Scale
Improvement of core processes	500 000 €	721 436 €		0 €		0 €	small
Campaign to strenghten network-wide ethical va		0 €	250 000 €	382 326 €	250 000 €	312 812 €	small
Improve product range to gain acc	710 953 €	846 109 €	209 798 €	249 682 €	495 895 €	777 496 €	medium
Conduct competitor analysis to gain insight		0 €	500 000 €	721 436 €		0 €	small
Streamlining transaction methods	1 000 000 €	1 322 439 €	250 000 €	283 380 €	250 000 €	283 380 €	medium
Improve knowledge about life-cyc	250 000 €	334 440 €	285 472 €	381 893 €	900 000 €	1 417 351 €	medium
Implementing a new information s	1 000 000 €	2 231 588 €	1 000 000 €	1 673 691 €	1 000 000 €	1 673 691 €	large
Replacing old machinery with new	1 249 245 €	2 139 533 €	643 900 €	1 102 783 €	726 232 €	1 742 246 €	large
Establish more agile procedures to	445 144 €	636 610 €	229 441 €	516 045 €	508 006 €	726 511 €	medium
SUM	5 155 342 €	8 232 155 €	3 368 611 €	5 311 235 €	4 130 133 €	6 933 486 €	

In addition to personal P-pages, there is a Game-page in ECOGAME-file for all players to use. This lobby has information on how the players are progressing towards their goals in the form of two graphs and information on the past projects in the form of a log. Lobby also includes a section

where to players can easily share information regarding the state of their company. Sharing of information is done manually through buttons in P-page. These share buttons are shown in P-page picture in sections 2 and 3.

END OF THE GAME

The game is ended by facilitator after all rounds are played through. The final company maturities and benefit to cost ratios can be read from the graphs in lobby and in addition players gain access to statistics regarding the game session (presented below).



FINAL WORD

For further questions please ask your facilitator or contact the game's developer via email: ecosystemgame@gmail.com

Enjoy the game!