Lappeenranta University of Technology

School of Business and Management

Degree Program in Computer Science

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Design and implementation of collaborative platform with personalized gamification

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TIIVISTELMÄ

Artem Khvatov

Personalisoidusti pelillistetyn kollaboraatioalustan suunnittelu ja toteutus

Tässä opinnäytetyössä tutkittiin adaptiivista pelillistämistä. Päätutkimuskysymyksenä oli selvittää, miten adaptiivinen pelillistäminen voidaan toteuttaa käyttäen web-alustaa yhteistoiminnalliseen oppimiseen, jota voisi käyttää adaptiivisen pelillistämisen hyötyjen tutkimiseen. Tätä tutkimusta varten luotiin todellinen järjestelmä ja sen arkkitehtuuri ja suunnittelu on dokumentoitu osaksi tätä opinnäytetyötä. Adaptiivinen pelaaminen toteutettiin käyttämällä henkilökohtaisia haasteita, joita tarjoavat ulkoisen luokittelijan tuottamat säännöt. Keskeisiä tuloksia ovat, että on mahdollista toteuttaa adaptiivisia pelielementtejä käyttämällä heksadin käyttäjäprofiileja, mutta adaptiivisuuden vaikutusta motivaatioon on vaikea arvioida. Arviointi vaatii pitkäkestoisen case tutkimuksen, jossa toteutettua alustaa käytetään todellisessa ympäristössä. Tutkimuksessa tuotettua artefaktia voidaan käyttää jatkotutkimuksessa adaptiivisen pelillistämisen vaikutuksien tutkimiseen.

ABSTRACT

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Design and implementation of collaborative platform with personalized gamification

Master's Thesis

2018

63 pages, 6 figures, 9 tables, 4 appendices

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Keywords: gamification, personalized, adaptive, collaboration, learning, design science

This research was conducted to study personalized gamification. Main research question was to find out how to implement adaptive gamification using web platform for collaborative learning, which could be used to study the benefits of adaptive gamification. For this research an actual system was created and its' architecture and design choices are documented as part of this thesis. The personalized gamification was implemented by using personalised challenges that are provided by a ruleset generated by external classifier. The outcomes of the research are that while it is possible to implement adaptive game-elements by using hexad user profiles, it is difficult to measure the effect of personalization on motivation. The proper evaluation requires a long term case study in which the designed platform is utilized in a real environment. The artifact which was produced in this research can be used in future research to study the effects of personalized gamification.

ACKNOWLEDGEMENTS

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LIST OF SYMBOLS AND ABBREVIATIONS

DB   Database

EJS   Embedded JavaScript

HTML   Hypertext Markup Language

NoSQL   Not only SQL

UML   Universal Modelling Language

SQL   Structured Query Language

SUS   System Usability Scale

UI   User Interface

UX   User Experience

1 INTRODUCTION

Gamification has quickly gained popularity during last six years (Nacke and Deterding, 2017). This gain in popularity has been reflected in academia, with gamification being a popular topic in research (Hamari et al., 2014). According to data gained from the search engine for academic research called LUT FINNA, which combines search results of academic publications from various books, conferences and journals, there are total of 14178 publications on gamification. Of all the publications on gamification more than half are from last three years. Yet there are less than a thousand publications about adaptive gamification, which suggests that while gamification itself has been quickly rising and already being widely adopted, there have been few studies conducted on personalized or adaptive gamification (Deterding et al., 2011a; Hamari et al., 2014; Nacke and Deterding, 2017; Nah et al., 2014).

This master's thesis aims to advance the personalized aspect of gamification as well as design and implement a platform that uses personalized gamification to support computer-supported collaborative learning. This research builds on earlier research performed on the gamification of collaborative platforms and user profiles for personalized gamification (Knutas, 2016; Knutas et al., 2017a; Monterrat et al., 2015; Tondello et al., 2016).

1.1 Goals and objectives

The goal of this research is to study the process of changing from static gamification to personalized gamification which is a form of adaptive gamification. For this research a working prototype of a gamified system was designed and implemented to better understand this process. This document covers the various phases of creating a gamified system and personalizing gamification in it, from the theory and planning phase to the testing phase.

The purpose of this research is to implement a process of creating a collaborative learning platform systems, gamifying that system and applying adaptive gamification to it from the developers' point of view. This research will cover the various problems that one might face during this process and propose solutions to them. One of the outcomes of this research is a collaborative learning platform that can be used to test and study personalized

gamification in real or simulated environments. The platform designed in this research is the lowest level implementation of design science artifact; instantiation of a system with specific design.

While this document is primarily a documentation for a single implemented system the various designs proposed here can be utilized in other similar systems. Practical part of this study is to create a collaborative learning platform and document how it was designed, how game-elements were implemented in it, and how game-elements in the system were later changed to be adaptive. The purpose of the research project documented in this thesis is to provide a platform that can be used as a tool to learn about the effects of adaptive gamification in future research on adaptive gamification. Considering these the objectives of this research are following:

O1: Describe how to apply adaptive gamification to a computer-supported collaborative learning web platform.
O2: Document the architecture and gamification implementation of system.
O3: Evaluate the designed artifact instantiation.

1.2   Research question and limitations

This thesis follows design science approach by creating artifact that can be used to evaluate the effect of personalized gamification. Implementation of adaptive gamification is the main topic of this research and as such the research question is:

RQ: How to design and implement platform for collaboration, which can be used to study personalized gamification?

And as such the research sub-questions, which will be answered in discussion and conclusion chapters are following:
Q1: How to implement personalized gamification in platform for collaboration?
Q2: Do game-elements distract from actual purpose of the platform?
Q3: How can this platform be used to study personalized gamification?

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The validation of benefits of changing from static to adaptive game-elements is not covered in this study. There needs to be a follow up research to study the impact of change to adaptive gamification in the context of collaborative learning. The system produced in the case is big, only some modules and features are explained in detail. Core functionality of basic web service and supplementary modules are not explained in this research as those are not a focus area of this study. This thesis is limited to describing the parts of system that are involved with or related to gamification and collaborative learning.

1.3   Structure of the thesis

Thesis is divided into theoretical and practical parts. Theoretical part reviews literature about gamification and in practical part an actual instantiation of an artifact is designed and implemented according to design science methodology (Peffers et al., 2007). Design science research process is utilized in practical part of the research to create platform for collaboration with personalized gamification. This leads to creation of artefact which is constructed according to design science guidelines by Hevner et al. (2004).

Chapter 2 is the theoretical part and contains literature review of related and recent study about: gamification, personalized gamification, user hexad profiles and gamified systems. This is the knowledge base of this research according to the framework by Hevner et al. (2004) as illustrated in Figure 2. Chapter 3 is about practical part of the thesis and contains documentation and implementation details of the artifact that was created. In Chapter 3 we apply knowledge from Chapter 2 to create a platform that can be used to evaluate and justify our theory. Chapter 4 is about testing process and the results of research. It is the evaluation part of the research process and aims to create new knowledge by exploiting the created artifact. Chapter 5 is discussion part where the results are discussed in the context of guidelines provided by Hevner et al. (2004). Last chapter is the conclusions of research, which summarizes the whole research and discusses possible future work.

2 RELATED WORK ON GAMIFICATION

Articles for research in this thesis were collected from multiple sources. Several papers were included in literature review that were collected by using search system for scientific research called LUT FINNA. It is a meta search engine which combines search results from multiple databases for scientific articles, publications, books and theses. This includes some of the largest publishers like Springer, ProQuest, Elsevier, ACM, Scopus, IEEE and Emerald insight, but not limited to these. LUT FINNA is a powerful tool for finding literature for research and review. Furthermore several articles were discovered through lists of references of other articles.

The following three topics were studied and used as search queries in LUT FINNA:
- gamification
- gamified systems
- adaptive gamification

Used search terms were chosen based on the themes of this study. Search results were then filtered using following requirements to reduce the amount of articles to a reasonable number to go through manual review by abstract:
- Results must have full-text available
- Results must be in English
- Results must be of type scientific article
- Results must be published in 2011 or later

The total amount of articles that were gathered and reviewed was 40. Not all articles are present and referenced in this document, but has influence on the overall research nonetheless. Topics of the articles were distributed as such:
- 6 articles about personalized gamification
- 15 articles focusing on gamification of education
- 5 articles about gamification frameworks
- 3 articles described implemented gamified platforms

Each topic is covered in its own chapter followed by the summary chapter which explains how these topics influenced this study.

2.1 Gamification in theory

The definition of gamification was only established after gamification was acknowledged as accepted term in 2011 (Seaborn and Fels, 2015). Before that, the concept of gamification was not recognized as not all examples of gamefulness outside of games seemed to fit into the concept model of gamification (Seaborn and Fels, 2015). The most recognized definition which has then remained unchanged since it was defined is by Deterding et al. (2011a). Deterding suggests that gamification is about applying gamefulness, gameful interaction, and gameful design with a specific intention in mind. This has ultimately translated to the commonly used definition of gamification as "use of the game elements and mechanics in non-game environment" (Deterding et al., 2011b).

There are multiple definitions for gamification, that have some overlapping defining factors. Huotari and Hamari proposed a different definition for gamification with the intention of defining it in such a way that it would highlight the goal of gamification, instead of focusing on the methods of gamification (Huotari and Hamari, 2012). Huotari and Hamari argue that earlier definition rely on the fact that gamification is based around use of game elements. Their definition is based around the idea that gamification is an attempt to enhance a service with affordances with the intent of increasing the likelihood for the gameful experiences to emerge (Huotari and Hamari, 2012). Both definitions are in consensus that gamification is about enhancing systems which were not created for gaming purposes with experiences that make games fun and engaging.

The main purpose of gamification is to make products, services or tools more engaging and enjoyable to use (Deterding et al., 2011b; Hamari et al., 2014). The basic idea is to do this by adding game-elements or game features into system which motivate users, which would logically lead to users spending more time with a gamified system and use it more often (Deterding, 2012). Ultimately this leads to improvement of overall experience and increases the likelihood of users willingly returning to use a gamified system compared to

a system without game elements (da Rocha Seixas et al., 2016; Hamari et al., 2014).

Gamification may be used for different reasons depending on context and desired outcomes. Often gamification is used to motivate users, but other reasons like improving performance or quality of results are common (Huotari and Hamari, 2012).

2.2   What is a gamified system?

A gamified system in the context of software engineering is a platform or service that has been enhanced by adding game elements or game features (Ferro et al., 2013). Most commonly this is achieved by using a point system with leaderboards, badges, achievements or ratings (Seaborn and Fels, 2015). The difference between a meaningful game and gamified system that has game elements lies in the fundamental difference of their nature and usage. The primary purpose of games is recreational activity and to provide user with feeling of enjoyment that keeps us engaged and want to keep playing (Rigby and Ryan, 2011). Even if game has an underlying useful activity or meaningful aspect, like education, awareness raising or problem solving, it is still primarily a game and not everyone will benefit from the useful activity it has. Monterrat et al. (2014) summarises difference between learning games and gamified applications well in a Table 1 shown below. In his comparison he uses the term learning game as the most popular way to enhance games with meaningful aspect. Learning games are games with the added purpose of educating players (Prensky, 2001).

Table 1: Differences between a learning game and a gamified application (Monterrat et al., 2014)

	Learning game	Gamified application
Design process	Designed as a game from the beginning	Adding game mechanics to an existing application
Resulting application	A game with educational elements	A learning application enriched by game mechanics

The purpose of gamified system is not changed by adding gamification to it (Seaborn and Fels, 2015). The game-elements in gamified system serve as a tool for motivating users and are never the main focus and should not be. If game elements become the main focus

of gamified system, it essentially turns into a meaningful game (Huotari and Hamari, 2012). User is not playing the gamified system as opposed to meaningful games, but is using a tool for it is specific purpose. Game elements are there to motivate users (Deterding, 2012) by making the use of tool more interesting and engaging (Topîrceanu, 2017). Therefore even though gamified system has game elements, it usually does not mean user will have fun with the system (Rigby and Ryan, 2011). Whereas the games should be fun and engaging first and provide meaningful activity as supplementary aspect.

Almost every system with human interaction can be gamified in some way (Deterding, 2015). However, instead of asking which systems can be gamified, we should be asking which systems should be gamified (Hamari et al., 2014) and how to gamify them (Deterding, 2015). There are many examples of gamification in various systems and services, but not enough study into whether it is actually beneficial for the system. Even if there is observed benefit of gamifying something, the effort that was put into applying gamification to the system might not be worth it. It might be better to use the available workforce and resources on other aspects of the system or service rather than on gamification. So even if something can be gamified it does not mean it should be (Hamari et al., 2014). Once it has been determined that a system may benefit from gamification, the next step is to determine the methods and goals for gamification.

In its simplest form an application, web service or website can be gamified by adding a points and rating system, which allows users to rate messages, posts or other created content withing service with predefined reaction (Huotari and Hamari, 2012). Usually these are limited to a binary actions like upvote and downvote, which give or take a point from post. Certain forums and chat platforms however expand on the idea and add more descriptive reactions. On a game focused forum called Facepunch there is a system called Post ratings[1] which adds a number of ratings with different purposes. Ratings like funny, artistic, useful, informative and dumb are for conveying reactions to posts, while ratings like agree and disagree are there to remove the need to write replies that are simply agreeing or disagreeing. This rating system effectively reduces the amount of zero-content posts which can be just as well be posted as a rating or reaction. In anticipation of getting positive feedback people will try to create better content that will be rated with positive

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1 https://www.wikipunch.com/Post_ratings

ratings, while avoiding negative ones. This system has a positive effect on the overall quality of the content created on the forum due to people willingly putting more effort into their posts. This rating system is unique to Facepunch forum, but is a great example of how simple gamification like this can be really effective.

On this same game forum Facepunch there also used to be another gamified system called Smartness[2] for messages, which automatically calculated content quality of posts and punished users for poor post quality. The idea behind this system was to discourage users from posting low effort replies and pay attention to proper spelling and punctuation in their messages. Any spelling mistakes, racial slur and improper use of punctuation and capital letters would decrease the post score, while coherent messages would gain a positive score depending on how long they are. Especially racial slur and swearing would dramatically decrease the score rating of messages. In a worst case scenario the user could get automatically banned for a set amount of hours or days, depending on how negative the score was and how often same user has already been banned before. The users of the forum were penalized for poor post quality and rewarded with small upgrades to their user profile (like a larger avatar size, colored nickname or title) for reaching certain milestones with total score. Each post with no spelling mistakes would give you one point of smartness, while a single mistake could take away several points unless you edited your post and fixed it.

This system was removed from the forum before it migrated to a new version of forum in 2009. A majority of users still wished for it to be returned in a poll, but there was no word of it returning by the owner of the forum. Arguably this system greatly improved overall post quality across the forum and many users remember this system as their first grammar teacher. Despite being harsh this system was appreciated and its effects can be seen to this day on said forum as users that were using forum during smartness system have less spelling mistakes and correct punctuation compared to newer users. These examples suggest that systems that not only reward users for their activity in a system, but also publicly penalizes for mistakes and harming behavior might be better form of gamification than designing a gamified system with purely positive feedback.

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2 https://www.wikipunch.com/Smartness

2.3 Personalized gamification

Personalized gamification is an advanced form of gamification which is also called adaptive gamification in some literature (Al-Othman et al., 2017). The idea behind personalized gamification is to make the system adapt to the users and personalize the content, game elements or other aspects of the system individually for each user. This kind of approach is believed to be more effective in motivating users compared to a generic gamification approaches (Ferro et al., 2013). The difference to static gamification is that it attempts to suit the needs and preferences of different types of players. Different people correspond to different player hexad types and as such engage with the system in their own way and should have different gamification elements to support the way each user uses the system.

A research on theory-driven empirical studies has shown that while self-determination theory is dominant psychological theory behind motivation for gamification it does not always explain why certain game-elements were effective (Nacke and Deterding, 2017). One particular study by Mekler et al. (2015) about effects of game-elements on intrinsic motivation has shown that while game-elements (badges, points and leaderboards) certainly improved performance of users compared to non-gamified system, there was no significant impact on competence need satisfaction or intrinsic motivation (Mekler et al., 2017). Nacke and Deterding (2017) suggest that this could be explained by goal-setting theory, which is another theory of motivation and suggest that leaderboards may function as a form of goal-setting which invites user to set performance goals when near the top of the leaderboards (Landers and Armstrong, 2017; Nacke and Deterding, 2017).

Nacke and Deterding (2017) compare high scores on leaderboards that are "difficult or impossible to reach" to "difficult or impossible goals" given to people. These findings suggest that it is important to provide users with appropriate level of challenge to either build intrinsic motivation or cause users to set goals (Landers and Armstrong, 2017). However this is difficult due to how different people prefer different levels of challenge. Some people like to quickly achieve points, badges and other rewards for trivial tasks, while some people are looking for that feeling of accomplishment that they only get from completing a difficult task or reaching a far fetched goal (Deterding, 2012; Mekler et al.,

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2013). This is why personalised gamification has recently been on the rise in both games that adjust difficulty depending on player performance and gamified systems that offer challenges to users based on various inputs within system, users activity and performance.

An extensive literature review by Seaborn and Fels (2015) shows that gamification does not always yield positive results. In their research they found that majority of gamification cases had mixed results or that results were statistically insignificant (Seaborn and Fels, 2015). This could be explained by lack of personalization of gamification for users. Different users react in a different way to gamified elements of a system, and possible solution for this is to personalize these game elements to reduce the negative impact of gamification while keeping or increasing positive effects.

2.4   Hexad profiles

Different players prefer different aspects of gamification and use systems differently (Ferro et al., 2013; Monterrat et al., 2014). Some people prefer to actively interact with others, while others might like to observe and explore the system (Monterrat et al., 2014). One way to apply personal gamification is to change game-elements based on player type. For this purpose there is a need for a method to categorize users in order to personalize gamification elements for different user types. Monterrat et al. (2014) proposed a hexad model which attempts to categorize users into six types of players. Tondello et al. (2016) also provide a survey that can be used to determine the player type. How this survey and hexad model was used in designed platform is explained in following chapter.
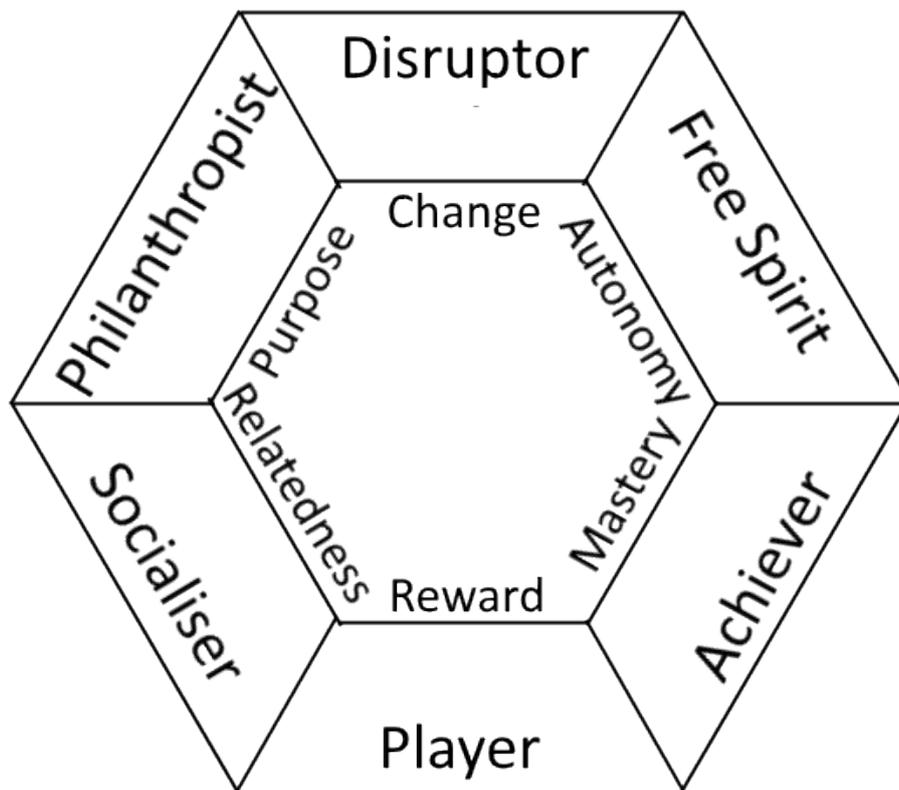
Figure 1: Gamification User Types Hexad (Marczewski, A., 2015)

Tondello et al. (2016) lists following user types:

- **Philanthropists**, which are motivated by purpose. Instead of expecting a reward they are willing to help others and contribute for altruistic purposes. Philanthropists like to gift and trade items in games, share their knowledge or administrate and manage systems or organizations.

- **Socialisers**, who are motivated by relatedness. Socialisers want to interact with other users and are motivated by social aspect of the system. They like to be part of groups, networks and teams, and learn about other people.

- **Free Spirits**, which are motivated by autonomy. They like to explore and create content within system with freedom to express themselves in mind. They enjoy easter eggs, customization, exploration and various non-linear aspects of system.

- **Achievers** are motivated by competence. They wish to progress and prove themselves by completing difficult challenges. They want to show their success to others in a form of badges and achievements.

- **Players**, that are motivated by extrinsic rewards. They are driven by the promise of reward and do whatever is needed to get it. Unlike achievers they seek challenges

only for their rewards, not for the challenge itself.

- **Disruptors**, are motivated by change. They are not necessarily the desired type of player, but this is the player type that tends to disrupt the system to force changes. They will test the system boundaries and can either be harmful or beneficial to the system.

Suiting the needs and supporting the different ways different users use gamified system is not an easy task. It involves a lot of thinking and testing and you may have to understand the perspective of each user type and design the game elements to support each user type accordingly.

3 GAMIFIED PLATFORM FOR COLLABORATION

The design and implementation process of platform for this research follows the design science research model framework for information systems by Hevner et al. (2004). A simplified version of this framework is illustrated in Figure 2 below. The first step was to design the artifact based on the theory and organization strategy. Based on the research on the idea of personalized gamification and player hexad profiles it was decided to apply and test these ideas with a real system by designing and implementing a collaborative learning environment for students and gamifying it with adaptive gamification (Tondello et al., 2016). This platform is designed to be used for studying personalized gamification.
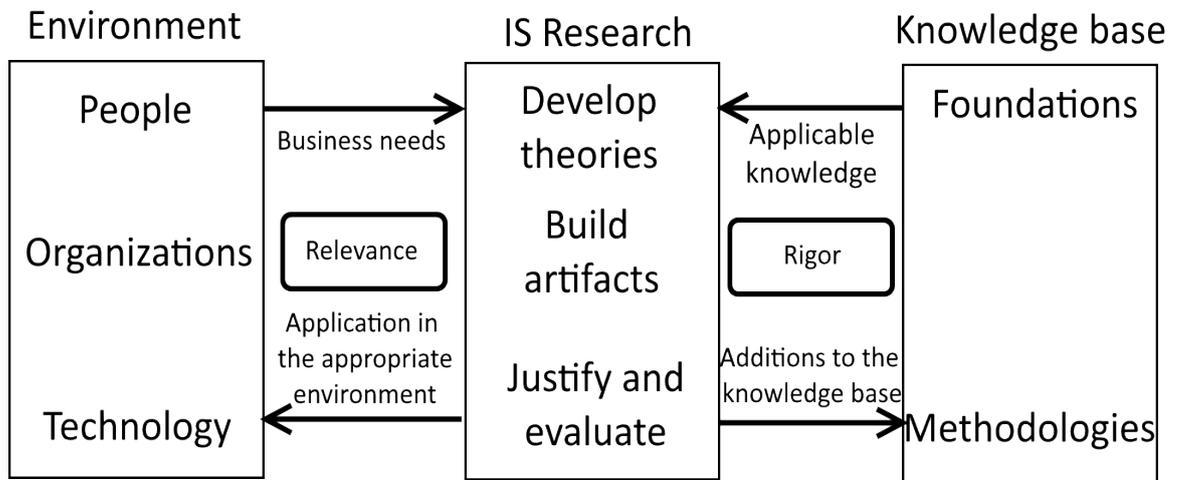
Figure 2: Information System Research Framework (Hevner et al., 2004)

Foundations part of the framework is covered by literature review of this research in Chapter 2, which supports the information system research part of the framework. The environment part of the framework is the LUT (Lappeenranta University of Technology) organization which has set strategies and processes for research projects and Cyberlab project which is funding this research and providing guidance and shaping this research into something valuable to the organization. Artifact evaluation part of the framework is covered in Chapter 4 in the form of controlled user testing using user scenarios in simulated space. The platform which is designed and implemented is the outcome artifact of design science framework. A summary of this process in relation to research framework by Hevner et al. (2004) is displayed in Table 2 below.

Table 2: Research process relevancy to DSRM

Framework segment	Segment part	Relevancy
Knowledge base	Foundations	Literature (Chapter 2)
Knowledge base	Methodologies	New knowledge (Chapter 5)
Information Science Research	Develop/Build	Artifact (Chapter 3)
Information Science Research	Justify/Evaluate	Testing (Chapter 4)
Environment	People	Me, supervisors and examiners
Environment	Organizations	LUT, Cyberlab project

Adaptive gamification was achieved by implementing personalized challenges for users. These challenges together with classifier engine, completion rules, triggers and challenge acquisition pre-requirements were designed by Knutas et al. (2017) in their research on the adaptive gamification. Knutas proposes a method for classifying different challenges based on input parameters including player hexad type of user and several situational variables. (Knutas et al., 2017b) This system will be later referred to as LudusEngine.

The designed platform would use LudusEngine to give students different challenges based on their hexad user type, state of the system and users prior activity within system. The goal is to create a system that can be used to study the benefits of adaptive gamification, steps required for implementing this kind of system and difficulties or problems that arise during development. The following chapter will describe the system throughout its' lifecycle from a regular web platform to gamified platform and finally a platform with adaptive gamification using LudusEngine classifier. The initial plan was to use LudusEngine as external service with access layer to allow dynamic tweaking of classifier. However, during platform implementation it was decided to include the classifier rules directly into the system.

3.1   Veijo-project

For the design research a working prototype of gamified system was designed and implemented in a form of a web platform for collaborative learning made for students use during programming courses. Platform has various game-elements implemented in an attempt to give users incentives to perform various tasks and interact with each other. The

aim of this interaction is to help students learn from each other and most importantly allows students to solve difficult problems together. This platform offers both a traditional discussion forum functionality for issues and tasks and more modern group chat functionaliy. Both parts are directly linked to each other and are designed to support problem solving and task completion without the need of another external third-party software.

The system that was created went through three major iterations, which drastically altered the nature of our platform and its' features. During first iteration work was focused on creating the base functionality of collaborative learning platform. During second iteration this system was enhanced with game-elements and its' architecture was slightly altered to allow this. During third and last iteration the system was further changed to support adaptive gamification. These iterations are described each in detail in the following sections to better understand the processes of transitioning from simple system to gamified system and from gamified system to a system with adaptive gamification. The requirements that were specified for the collaborative learning platform can be seen in Table 3.

Table 3: Platform requirements

ID	NAME	DESCRIPTION
RQ1	Responsive UI	User interface has to be responsive and work well with any screen size or device.
RQ2	Simple UI	User interface should be simple and not cause visual burden on users, but still keep available functions if they are needed.
RQ3	Profiles	Users should be able to register and fill out information and set avatar on their own profile page.
RQ4	Administrators	There has to be administrator role, which has sufficient tools to manage the system to keep it running and stop abusive behaviour.
RQ5	Groups	Users should be able to create groups and add other users to their group.
RQ6	Verification	Users need to be verified to have access to all functions of platform.
RQ7	Issues	Users can create issues to seek help from other users.
RQ8	Replies	Users can reply in issue threads to help solving issues together. Reply marked as solution by issue creator is appended to top of thread as solution to the issue.
RQ9	Chat	Platform should have chat room where verified users can talk to eachother.
RQ10	Chatrooms	Groups should have their own chatrooms where they can talk in

		private.
RQ11	Private messages	Users should be able to send private messages to other users.
RQ12	Password reset	Users should be able to reset password through email.

3.2 System architecture

The platform is built to run on Node.js with Express[3]. Express is a Node.js middleware which provides some useful base features like router functionality that make it easier to organize system into separate files. Middlewares are the available plugins for express, which can be easily used with a couple of lines. Middlewares in Node.js work in such a way that they interrupt HTTP requests on specific URL paths before passing the request to next middleware. Middlewares do not necessarily need to react to every request and can just pass the request without manipulating it. Middlewares can also break this chain and send a response to client. For example a simple middleware could be set up to handle get requests on "/index.html" and responding with a home page for website. Routers is an express exclusive functionality which works like middlewares in Node.js, but have a different purpose. Routers allow to categorize the code that is executed based on the URL path requested by the client into separate files and folders.

Platform uses middleware called EJS[4] to render web pages to user by using templates. EJS stands for EmbeddedJavaScript and it allows creating template files with ejs extension to help organizing the web view into blocks and pages. Essentially EJS files are HTML files with ability to insert JavaScript code into it, which gets executed before the template is sent to client as a completed HTML file response. EJS is used so that there are three different EJS files with different purpose that help organizing HTML code in a meaningful way: layout, views and reusable blocks which can be included in views.

Layout is the main HTML template, which is used in every response and acts like a frame for other template files. This file is usually called layout and it is used in combination with views. Layout file handles all other parts of HTML page except for the contents of HTML body. Basically layout file handles the head, styles, scripts, footers and general layout of all

3 https://expressjs.com/
4 http://ejs.co/

HTML responses, while views are the templates for actual content of individual pages.

Templates make it easier to manage HTML code bits of various elements and provides easy way to create reusable template blocks. In our case study implementation the EJS templates were divided into folders based on their type and usage: layouts (in the root folder), main templates (in the "main" folder), form templates for various get and post forms (in the "forms" folder), reusable template blocks (in the "details" folder) and template blocks that are primarily used in layout templates and only used once on each page (in the "partials" folder).

For the data storage our platform uses the widely used and well supported database called MongoDB[5]. MongoDB is a NoSQL database (DB), which allows to use dynamic schemas without having to explicitly define model schemas and values. MongoDB is accessed through a middleware called mongostore with the additional support of mongoose middleware. Mongostore is a MongoDB driver middleware for Node.js, while Mongoose is a middleware that allows using MongoDB schemas in a convenient object oriented way by using separate model files for each model schema.

A total of seven collections were identified and modelled using mongoose schema modelling:
- Users
- Challenges
- Groups
- Issues
- Messages
- Chatmessages
- Events

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5 https://www.mongodb.com/
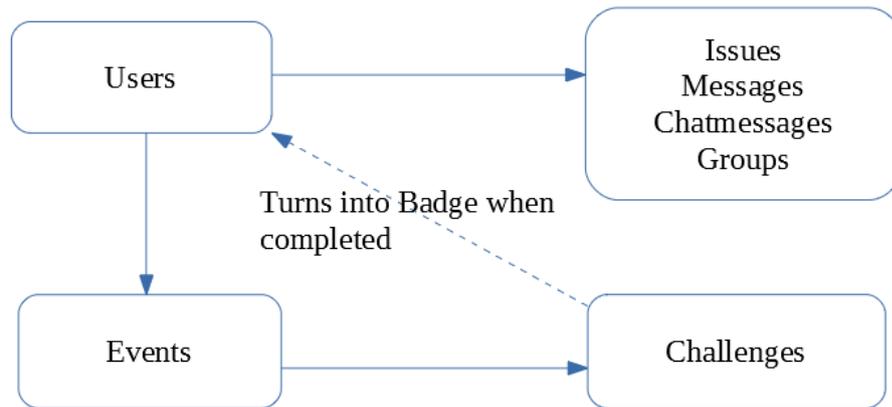
Figure 3: Simplified database schema

A simplified database schematic is illustrated in Figure 3. In general the database consists of collections for various user created content, users collection and events collection. Users are the main actors in platform and are responsible for creating new content. They are the central part of the database. Items in other collections are always related to user that has created them. Events collection is for logging actions that user taken and contain information about targets of actions (other collections), action type (what user did), timestamp and actor (user).
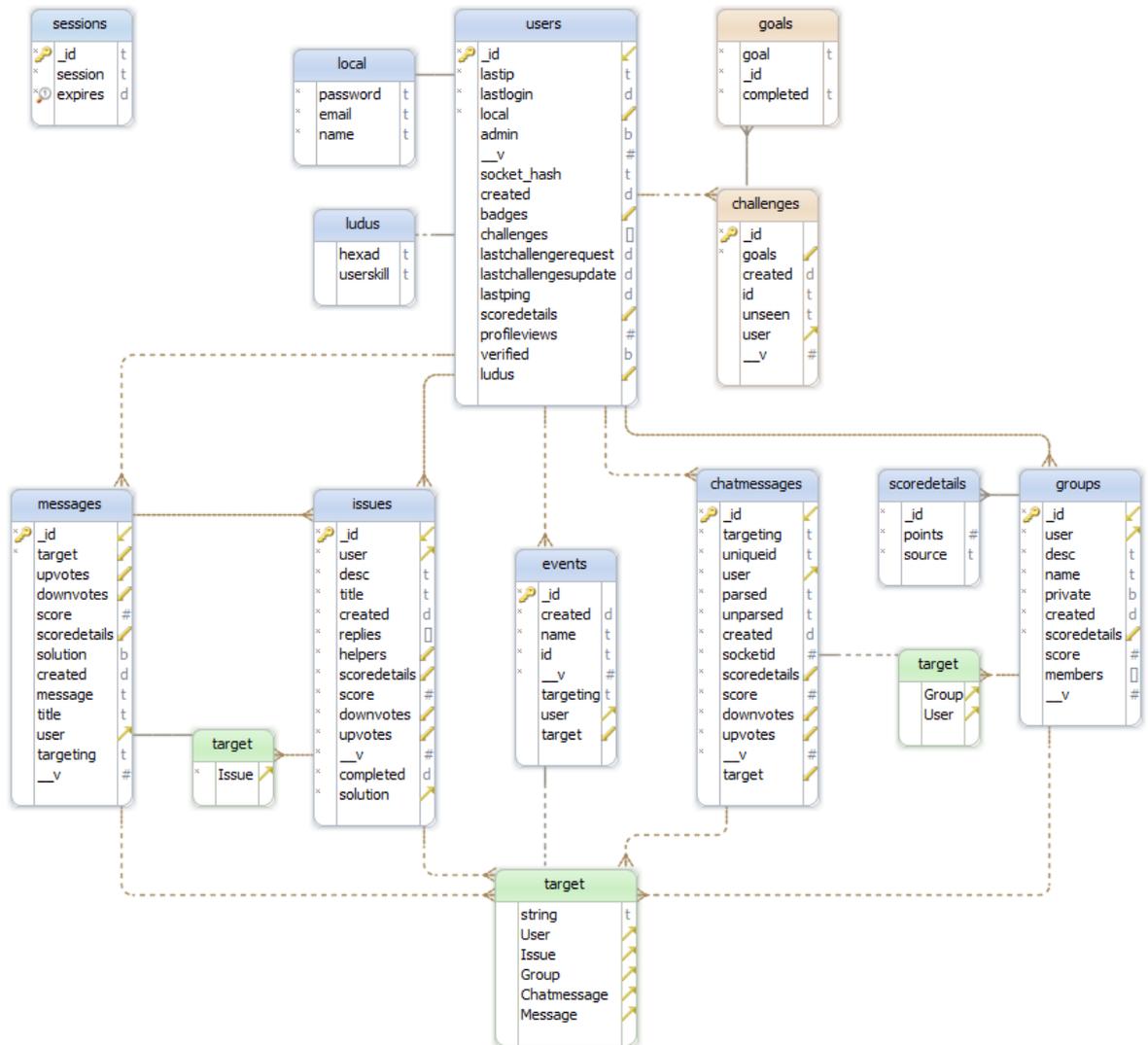
Figure 4: Class diagram of the platform

Each DB model schema is illustrated in Figure 4 using Universal Modelling Language (UML). Users model is at the centre of class diagram, because of how user is related to every other collection through ownership relation. Every other model has foreign key user which is linked to users collection through _id primary key. This relation defines which user has ownership of instances of all other objects that are created in platform like challenges, chatmessages, messages, groups, issues and events. This also provides user with permissions over content that user has created. If it is an issue, the user may edit, delete or mark it as solved. If it is a group, user can add other users to his group or edit group information.

Events schema is a special one, because it is used to create event instances whenever user performs any action within platform. This is used to log user actions which can then be used for checking if user has completed any challenges or letting administrator check for malicious activity by users. Events has two important fields: user field, which points to the _id of the user that performed an action and name of the action. There are also supplementary fields called targeting, which describes what kind of object or database model was the target of action and target, which is the actual foreign key link to the database model or object.

3.3 Development phases of collaborative platform

Our web collaboration platform went through several iteration cycles of agile development. There are three major identified iterations of system which will be referred from here on as first, second and third version accordingly. An iteration zero of the system in this case would be the basic web server with database and user profiles. Coverage of these basic functionalities is outside of the scope of this research. The focus is in implementing learning platform functionality, gamifying it and changing gamification to adaptive and thus only the changes related to gamification and gamified parts of the system are documented.

In the first iteration the system that was created for this study contained no game-elements. The focus was on creating the platform itself with all the required base functionalities which would later be gamified with certain game-elements.

These objectives lead to the following requirements for the first version of the system:
- Users (in this case students who use the platform) need persistent profiles for storing user information, setting avatars and accessing various features of the platform
- Group feature (in this case it will be teams formed by students) which allows users to create their own groups and manage members
- Task system for groups which allows users to organize their work by creating threads for tasks, where they can discuss tasks within their group and finally mark task as completed

- Issue tracker with issue specific threads in the similar manner as grouptasks which allows users to ask for help to problems they face. These issues are visible to everyone so that users can help each other.
- Responsive chat system, which is linked to the rest of the platform.

Chat is linked to the rest of the platform by creating separate chat rooms for each group and also allows users to privately talk to each other. The purpose of chat is to allow users to discuss the issues on the issuetracker, help each other with smaller problems or generally discuss anything related to groups and projects.

In earlier study cases like this, users usually moved their discussion into other private channels by using other third party software. Users only used the provided platform if required by course, and even then only used the core functions. Chat has a text parser which automatically detects links and other content from messages and turns them into clickable links or embedded objects like videos, audio clips or images. There are also other tags that can be used in messages like code blocks to show snippets of code in an easy to read way. The purpose of making chat simple to use and as feature rich as possible is to make users want to stay and keep discussion within system, which will naturally keep the system more active as well, because it is directly linked to the chat portion.

The next phase during development was to add game elements to the platform and adjust some features accordingly. For the preparation to add gamified elements and features to the system, following additional requirements were necessary:
- A need for system which will record all actions within the platform with following information: timestamp, type of action, target of the action and acting user information
- User profiles need to be extended with additional information that is used for providing gamification (list of badges and challenges)
- Score system which allows users to upvote and downvote various content by other users that is added to platform
- Issuetracker will need a score value, based on upvotes and downvotes, which will be used to order highly voted issues before others
- Changes to the user interface to display new gamification elements: scores, badges

and challenges (challenges are only visible to user)

- Leaderboard with users and user groups listed and ordered by score value
- A flexible challenge system, which allows challenges to be modified easily and independently from each other, through a set access layer while also providing a platform where common issues are solved and solutions to these issues visible to everyone.

The system was designed with the goal of gamifying the collaborative learning. This platform was enhanced with static generic gamification features like leaderboards, points, challenges that are given to users and badges as a proof of completing certain challenges. These gamification elements were chosen as the most fitting for this kind of system. Points are given to users for messages or posts that have been upvoted by other users. Each user can upvote another users content once which gives one point for the owner of that content. Points are also given to users for completing challenges. Points are supposed to reward users for their actions and provide with a sense of progression. Users may have a set amount of challenges at most, which is by default set to three challenges max at the same time. As soon as user completes one of the challenges, the system attempts to replace it with a new one by requesting new challenges from the LudusEngine classifier middleware. Completing certain challenges also give users a badge that is displayed in their profile visible for everyone. Leaderboards on the other hand allow users to compare their progress with other users or compare their groups' points to others.

Challenge files are in a separate folder and use a specific configuration template to setup challenges. There are nine fields to configure in each challenge file.
- Name of the challenge (and badge if badge is given for this challenge)
- Description of challenge, which explains what it is about
- Points value that player receives for completing the challenge
- Field for setting challenge as unique so it can only be received once
- Field for setting if player gets badge for completing challenge
- Field for making this challenge a secret until completed
- Completion check function (can be used in combination with goals)
- Array of goals with separate completion check functions

This information is used to generate the functional and visual parts related to challenges in user interface and also contain functions for updating the progress and completion of challenges. Challenges might have sub-tasks that you need to complete and once all sub-tasks are complete, the challenge is marked as completed and user is rewarded with points and badge. The purpose of this system is to simplify the process of altering challenges later.

Table 4: Configuration file of sample challenge

```javascript
var Event = require('../../models/event');
var Chatmessage = require('../../models/chatmessage');

module.exports = {
  "name": "Writer",
  "desc": "Write two chatmessages",
  "points": 3,  //points received for completing this challenge
  "unique": false, //only give this challenge once per user
  "badge": true, //display badge for this type of challenge
  "hidden": false, //make it a secret (hidden from user) challenge until completed by user
  "hooks": null, // ["SYNC", "GET", "POST", "CHATMESSAGE"] etc array of events.

  "check": function(challenge, cb, req, res) {
     if (challenge.goals && challenge.goals[0].completed && challenge.goals[1].completed) {
        cb(null, true);
     }
     else
     {
        cb(null, false);
     }
  }, //this part is not necessary if all goals/subchallenges are to be completed. leave as null for autochecking

  "goals": [
     {
        "goal": "Write once",
        "check": function(challenge, cb, req, res) {
           var user = challenge.user;

           Chatmessage.find({
              user: user._id,
              created: { $gt: challenge.created }
           }).limit(1).exec(function(err, results) {
              if (err) {
                 cb(err, false);
              }
              else {
                 cb(null, results.length>=1);
              }
           });
        }
     },
     {
        "goal": "Write twice",
        "check": function(challenge, cb, req, res) {
           var user = challenge.user;

           Event.find({
              id: "CHATMESSAGE",
              user: user._id,
              created: { $gt: challenge.created }
           }).limit(2).exec(function(err, events) {
              if (err) {
                 cb(err, false);
              }
              else {
                 cb(null, challenge.goals[0].completed && events.length>=2);
              }
           });
        }
     }
  ]
};
```
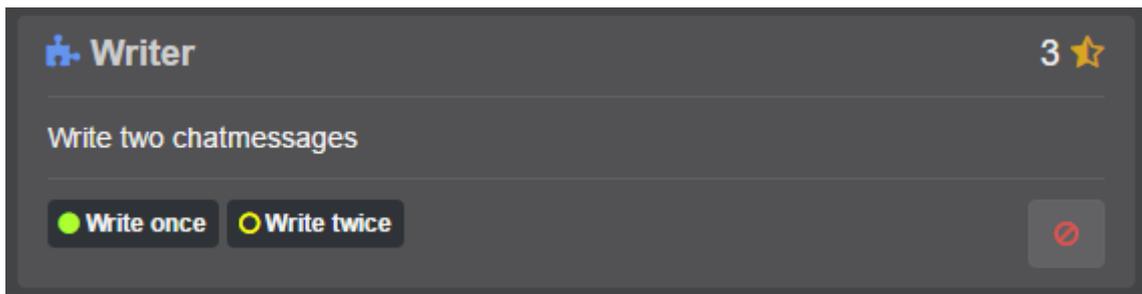
Figure 5: Example challenge as seen in user interface

Figure 5 shows how an example challenge as configured in Table 4 looks like to users in user interface. This is a snapshot of one challenge as seen by user in his profile page. Image of full profile page can be seen in appendix 2 at the end of this document. Interface of the system is designed to be as intuitive as possible, while maintaining simple and compact design.

Each challenge configuration and completion logic is contained in its own JavaScript file in the final version of our gamified platform. Before this system was reworked, all challenges were listed in a single file with every challenge stored as object in array list. Old solution made it simple to include challenges into gamification engine and load information, but whenever there was a need to edit or add new challenge, there was a chance that the whole file became unreadable due to a single small syntax error or problem with challenge completion checking logic. To address this issue and make our platform more resistant to user errors in challenge configuration files, a separate system which loads challenges from a folder designated for storing configuration files of challenges was implemented. This system takes care of problems with loading challenges and normalizes the configuration parameters of files. Even if there is some information missing or one challenge contains errors and cannot be loaded, other challenges are still functional and gamification platform can still run. In addition, this system makes sure that challenge information is always updated by reading challenges from configuration files instead of storing the instanced challenges into database for users schema like before.

After static gamification was implemented the platform was ready for third iteration to add adaptive game-elements. In third iteration of platform the system that handles challenges was further improved to include a challenge classifier called LudusEngine. This part of the

system takes several variables as inputs to generate a list of suitable challenges for the user. The challenges that are given to each user depend on the state of the system (activity, open issues, incomplete tasks/assignments etc.) and the user state (activity, information, earlier events, user skill and hexad type). The aim of this classifier is to provide personalised challenges to users with the intent of increasing the chances of gameful experience emerging.

Thus the following changes to requirements were needed to support adaptive gamification.

- Changes to user model to include information that is needed by LudusEngine (user hexad type and user skill).
- Changes to base logic for challenge distribution, so that new challenges are requested through LudusEngine
- Changes to how new challenges are requested to support addition of multiple challenges at once if LudusEngine returns an array of challenge Ids
- New hooking system for challenges to reduce the strain on the system
- Hexad user survey upon creating user, which determines and saves the player type

Because the decision to include personalized gamification was in mind from the start, most of the work and features required for this final iteration were mostly done in second iteration. Initially the idea was to use external challenge classifier through REST and JSON. This was planned to allow for some fine tuning of the challenge distribution, but was not included due to some difficulties in setting up appropriate service and API support. Due to difficulties of using external service for generating challenges to users a snapshot of generated set of rules by a classifier was parsed from HTML report of python version of LudusEngine. This HTML report was parsed into JavaScript code that was implemented directly into our platform as another middleware. The functionality to use external classifier still remains and can be switched by changing the URL path of used service. Currently this service is simulated by the platform itself and requests are made locally. A snippet of challenge classifier function that was generated from LudusEngine report can be seen in Table 5. This snippet is truncated to save space, but a full version with all 60 classification rules is included in appendix 1.

Table 5: LudusEngine classifier snippet

```
function ludusengine(data, cb, req, res) {
        var Hexad = data.hexad || '';
        var Userskill = data.userskill || '';
        var Ownteam_opentasks = data.ownteam_opentasks || '';
        var Ownteam_task_age = data.ownteam_taskage || '';
        var Otherteam_opentasks = data.otherteam_opentasks || '';
        var Chatactivity = data.chatactivity || '';
        var Ownpoints = data.ownpoints || '';
        var Ownteamactivity = data.ownteam_opentasks || '';
        var Otherteamactivity = data.otherteam_opentasks || '';

        var classids = [];

        if (Chatactivity=='high') {
                classids.push(1);
        }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                classids.push(2);
        }

        //[…several lines removed from here...]

        if (true) {
                classids.push(27);
        }

        cb(null, classids);
}
```

The LudusEngine classifier function takes several parameters as input and returns an array of challenges that user is eligible to by calling a callback function with the resulting array. This callback function is standardized thorough the platform and always takes two inputs: error string, which is null if there are no errors and result parameter which can be string, boolean, array or an object. In case of error or missing response this value is null.

For LudusEngine to work as intended, a hexad user survey by Tondello et al. (2012) was implemented in the process of account creation. This survey sets the hexad player type to one of the six types in hexad model by Marczewski (2015). The survey is a seven point Likert scale questionnaire with four items for each of six user types. These items are presented to user in randomized order, with no identification of corresponding user type behind item. The image snapshot of this survey can be seen in appendix 2.

In the final stage of the development another model was added to database, the Tasks model which is based on Issues model. Tasks are replicated for each group when creating a task for multiple groups into Grouptasks. This way each group can complete same given

task independently from other groups it was assigned to. Tasks for multiple groups can be created by site administrators or by group members if they are part of multiple groups. This tasks model schema is missing from the final class diagram of the platform as seen in Figure 4, but for the most part works similarly to issues from the database perspective. The difference is with how each tasks is replicated as separate copy to each group as a Grouptask model, while the Task model works as the anchor for the replicated group tasks and contains all the information about tasks itself. These replicated group tasks on the other hand have separate threads for messages and can be completed and viewed separately from each other.

4 TESTING AND EVALUATION OF THE GAMIFIED PLATFORM

Platform was tested by using automated benchmarking tool and evaluated by using user scenarios. These evaluation methods are two of the twelve methods identified and listed by Hevner et al. (2004). These and other evaluation methods for design science artifacts are listed in Table 6. Automated benchmarking tool Benchmarking tool will provide performance information and quickly find any problems with platform. User scenarios will find the more abstract problems with user interface and user experience (UI and UX).

Table 6: Design evaluation methods for design science artifacts (Hevner et al., 2004)

1. Observational	Case Study: Study artifact in depth in business environment
	Field Study: Monitor use of artifact in multiple projects
2. Analytical	Static Analysis: Examine structure of artifact for static qualities (e.g., complexity)
	Architecture Analysis: Study fit of artifact into technical IS architecture
	Optimization: Demonstrate inherent optimal properties of artifact or provide optimality bounds on artifact behavior
	Dynamic Analysis: Study artifact in use for dynamic qualities (e.g., performance)
3. Experimental	Controlled Experiment: Study artifact in controlled environment for qualities (e.g., usability)
	Simulation – Execute artifact with artificial data
4. Testing	Functional (Black Box) Testing: Execute artifact interfaces to discover failures and identify defects
	Structural (White Box) Testing: Perform coverage testing of some metric (e.g., execution paths) in the artifact implementation
5. Descriptive	Informed Argument: Use information from the knowledge base (e.g., relevant research) to build a convincing argument for the artifact's utility
	Scenarios: Construct detailed scenarios around the artifact to demonstrate its utility

Both user scenario usability testing and automated performance have properties from multiple evaluation methods as listed by Hevner et al. (2004). The automated performance test using small tool designed for benchmarking the gamified platform to measure page loading speed is a dynamic analysis according to evaluation methods by Hevner et al. (2004). It is one of the analytical evaluation methods used to measure performance. This

tool also reports about problematic or missing pages found on platform and can as such be considered as tool for functional testing, because it discovers failures and identifies defects by traversing through links on platform. User scenario testing on the other hand can be considered both a controlled experiment where usability of the platform is studied and descriptive testing using scenarios. In user scenario testing users perform a set of tasks and are observed for any mistakes they make or problems they face in controlled environment. This lets users provide feedback on how they perceive the utility of artifact while also evaluating its' utility.

The Table 7 below summarizes how evaluation methods in this research are related to evaluation methods described by Hevner et al. (2004) in Table 6.

Table 7: Evaluation methods in this research

Evaluation/Test	Evaluation type	Evaluation method
Automated benchmarking	Analytical	Dynamic analysis
	Testing	Functional (Black Box) testing
User scenario testing	Experimental	Controlled experiment
	Descriptive	Scenarios

For automated benchmark and all user scenario tests this platform was run in virtualised development host by Cloud9 for free users. Cloud9 provides a single core CPU, 2gb of ram and 4gb of storage space to workspaces for free accounts. Running a platform on a dedicated machine with more storage space, ram and more processing power could significantly improve performance and lower load times.

4.1   Performance test

For system performance testing another small web software was created. This tool is designed to do automated testing and benchmarking of the platform created in this research, but can be used to benchmark any other website. It imitates user clicking links on the web page and systematically going through every link on the website. It also quickly finds the most severe problems or errors found on website and calculates the average load time for each page. Example run of the tool through our platform is shown in Figure 6.
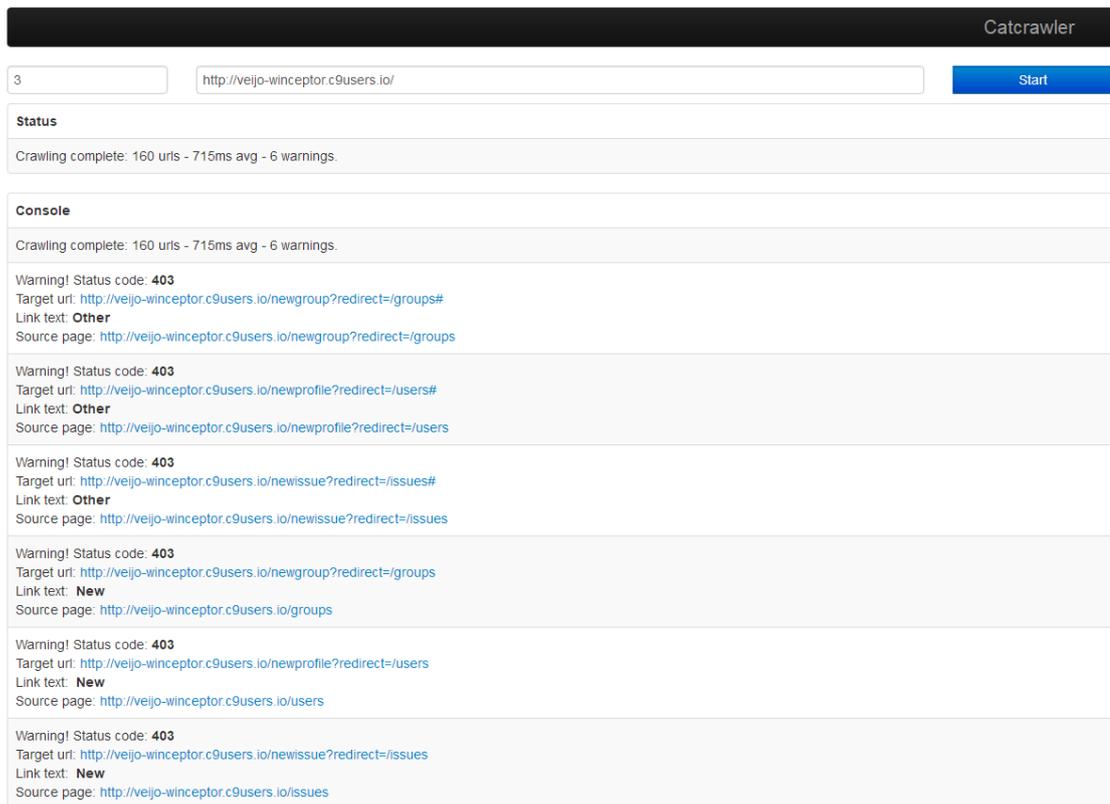
Figure 6: Automated testing and benchmarking tool

4.2   Usability test

For artifact evaluation it was decided to build some use case scenarios and do a small scale user testing for gamified platform. The objective of this user test is not to find out the benefits of gamification or if gamification works. The objective is to find out if there is a negative impact caused by presence of game-elements. In many cases, gamification had either mixed results in research. In worst case game-elements even caused negative impact by distracting or demotivating users (Seaborn and Fels, 2015). This is why it is more useful and easier to evaluate the possible negative effects of gamification with the assumption that, if there is no negative impact, then it must be at least as good as non gamified version of a system. Evaluating the positive impact of gamification is much more difficult and would require a long term case study with actual users. Evaluating the positive results of gamification means we have to measure the increase in motivation. This cannot be done realistically in an artificial testing environment, because during testing users are following given instructions and scenarios.

The testing was done by giving test subjects some scenarios and instructions to follow. All test participants are chosen from among students at our university by asking for volunteers. Test is constructed so that platform is populated with some sample data and a scenario that test participant has to follow. At the end of each user test, the state of the platform is rolled back to previous state, so that next user can start test by following scenario instructions. After test participant completes all test scenarios, he may log out and is given a survey to fill. System Usability Scale (SUS) survey was implemented and used to score the usability of platform. Originally designed by John Brooke in 1986 SUS (System Usability Scale) is a survey using five-point lickert scale, which measures general usability of the system. In addition the test subjects are asked for any open verbal feedback. This feedback is gathered and used to determine the general usability score of platform.

To easily test system under same conditions with each test user, it was decided to prepare testing environment in advance by backing up a certain state of a system, which could then be loaded before each user begins using platform. A backup of the system prepared for test scenarios was created by running command:

mongodump --db localdatabase --out backup/testbackup

For each test user, this backup was restored by running the following command:

mongorestore --drop --db localdatabase backup/testbackup/localdatabase

User scenarios that were used in user testing are included in Appendix 3. These scenarios were given to users to follow, while supervising the testing situation and following actions of user. User are not be helped with tasks that are given in user scenarios unless user is unable to proceed, deviates from planned scenario too far or asks for help. During user testing users actions are observed and any irregular or noteworthy observations are noted down. Whenever user asks for help this also noted down and is categorized as a problem. After each scenario is completed, user is asked for open feedback about scenario or problems that they faced. These notes can be seen in Appendix 4. Notes are anonymized to protect test subjects privacy.

4.3   Test results

According to automated performance and page validation test, the average duration from when user clicks a link and new page is loaded and ready to be browsed was 715ms. A

load time for pages is considered good if its around half a second and acceptable if its less than one second. If users have to wait for longer than one second they might start to feel discomfort by how long they have to wait and lose focus. (Nah, 2004)

User tests suggest that there are no problems with gamified parts of the system, however there seems to be significant amount of problems with user interface (UI) itself. This was apparent from observations and feedback gathered during usability testing. Some problems were more common than others, but almost all problems were related to UI. The only problem related to game-elements was about the frequency of pop-ups and notifications. Multiple test users complained about how many notifications the platform displays whenever you do something and that they are not dismissed automatically. This can be addressed in next iteration of platform by changing which notifications are displayed, removing unnecessary notifications and making a system for animated automatically disappearing notifications.

Table 8: SUS survey scores

User	SUS
1	85
2	77.5
3	42.5
4	65
Average	67.5
Standard deviation	18.6

"SUS yields a single number representing a composite measure of the overall usability of the system being studied. Note that scores for individual items are not meaningful on their own." (Brooke, 1996) "Based on research, a SUS score above a 68 would be considered above average and anything below 68 is below average, however the best way to interpret your results involves "normalizing" the scores to produce a percentile ranking." (usability.gov, 2018)

Average score however should not be interpreted as percentages, even though it is on the scale from 0 to 100. It is better to consider this number relative to SUS scores of older iterations of same or similar systems. That way it can be easily compared if general

usability has improved or not. An average score from SUS (Software Usability Survey) by the test participants was 67.5 points. It is considered to be below average, which suggests that there are either some severe problems with usability or a lot of small usability issues. This correlates with the feedback received from testing as there were multiple problems identified during testing.

5 DISCUSSION

The platform which was implemented in this research was designed for the purpose of studying personalized gamification. This platform fulfils the requirements set for this platform by the organization (LUT) and its' purpose is relevant to the problem that we are trying to address, which is to implement a platform for collaboration with personalized gamification. This research was done with the attempt to understand how to implement personalized gamification in online platform for collaboration, which can then be used to study how personalized gamification affects motivation and whether it has significant benefits or not. In this study personalization was achieved by dividing users according to hexad user types and giving personalized challenges based on user type and system state according to LudusEngine. The approach using personalized game-elements based on users player type is pretty new and unique for this kind of environment. This field is relatively unexplored and artifact which was produced in this research can be used in future research to study the actual effects of personalized gamification approach.

This research follows the design science research process guidelines as described by Hevner et al. (2004). How each guideline is applied in this research is described in Table 9. The designed platform fulfils the outcome requirements set by first guideline. It is artifact in the form of instantiation of a solution to a research question. The problem relevance of this research is explained in Chapter 1, with research objectives being directly tied to the solution of the problem. The design evaluation is covered in the Chapter 4, where produced artifact is evaluated by utilizing analytical and experimental methods. Design evaluation of artifact had some complications, but user feedback and observations during user scenario testing provided insightful information and helped finding flaws and usability problems in the platform.

Table 9: Application of design-science research guidelines

Guideline (Hevner et al., 2004)	Description (Hevner et al., 2004)	Applied in this research
Guideline 1: Design as an Artifact	Design-science research must produce a viable artifact in the form of a construct, a model, a method, or an instantiation.	An artifact that was produced in this research is a viable instantiation, which is described in Chapter 3.

Guideline 2: Problem Relevance	The objective of design-science research is to develop technology-based solutions to important and relevant business problems.	The relevancy and importance of the problem is explained in Chapter 1 and Chapter 2 of this research.
Guideline 3: Design Evaluation	The utility, quality, and efficacy of a design artifact must be rigorously demonstrated via well-executed evaluation methods.	Two different evaluation methods were used to evaluate the artifact. Testing and evaluation is covered in Chapter 4.
Guideline 4: Research Contributions	Effective design-science research must provide clear and verifiable contributions in the areas of the design artifact, deisgn foundations, and/or design methodologies.	Architecture and design of implemented artifact are documented in Chapter 3. The artifact is also openly available for use in other research.
Guideline 5: Research Rigor	Design-science research relies upon the application of rigorous methods in both the construction and evaluation of the design artifact.	Both design and evaluation of artifact is based on well established methods from reliable literature as described in Chapter 2.
Guideline 6: Design as a Search Process	The search for an effective artifact requires utilizing available means to reach desired ends while satisfying laws in the problem environment.	All available literature, tools, devices and environments were efficiently used to design, implement and evaluate artifact.
Guideline 7: Communication of Research	Design-science research must be presented effectively both to technology-oriented as well as management-oriented audiences.	This document should be effective presentation of conducted research. A separate presentation can be held for involved organization (LUT) if needed.

It is difficult to evaluate the benefits of gamification in test environment, because the purpose of gamification is to motivate and improve performance. In this research only the general usability of the platform could be evaluated. From the user testing it was clear that there are problems with user interface and user experience, but none of the issues were directly related to the addition of game elements or gameful experiences. There is a need for a follow up study to compare the benefits of applying gamification and personalized gamification.

There are other gamification approaches that were unexplored in this study, but should be considered for future research. One possible approach to personalized gamification is to

disable or hide some game-elements from certain user types entirely instead of personalizing the game elements. Some people might prefer to not have badges, points or challenges at all, or prefer to just have the simple upvote and downvote mechanism, but no complicated challenges. Hiding and showing game-elements based on user type could possibly improve the overall experience of using platform, while improving the gameful experience by only showing what each user wants to see and use.

Another more aggressive, but possibly much more engaging approach would be to make users' score into something more meaningful. It could be turned into usable points which can be used to do various actions on platform. For example the upvoting and downvoting mechanic could be gamified so that your score (the sum of upvotes, downvotes and other points) could be used as a form of currency. Upvotes would consume one point to give one point to another user, while downvotes would consume your point to reduce other users points by one. This approach would turn the points you receive into more meaningful and functional part of a system, instead of points being simply a number. This feature could also be personalized based on hexad player user types by giving different users different abilities. For example the disruptor would use double the points when downvoting other users to decrease other users score by two, while philanthropist would give double points when upvoting other users. Both would still consume same amount of points when voting and be limited to one vote per message, but have slightly more power in different areas according to their user type.

With this kind of gamified voting approach users would have to focus on creating quality content to receive points, which would require other users to spend their points on upvoting said quality content. This way challenges would also become more appealing, because you can get the promised reward (points for completing challenge) in a sure way from them. The score itself could also be changed into player health points or stamina, which users can spend to upvote or downvote content. I believe this kind of approach would be more fun and more engaging for the users, while also preventing the otherwise easily abused upvote spamming by multiple dummy accounts. It would also turn a simple voting mechanic into a game on its' own. This approach of course brings its' own problems like the ability to downvote other people for no reason if you have plenty of spare points yourself, but trying this approach and addressing these problems requires its'

own study.

Personalizing game elements require extra work compared to using generic or static game elements. Personalized gamification requires both rethinking the roles and purposes of each gamified element, making so that they are personalized to each user and redesigning how these game elements work on technical level. To provide personalized gamification you first need to determine how to personalize the game elements and also change the system itself to support personalized gamification. To personalize game elements, you need input variables (user actions, user type, system state, etc.) related to the user, event logger (for recording user actions) and a method for personalizing game elements.

The contribution of this research to body of knowledge is the instantiation of implemented artifact, evaluation data from testing the artifact and pointers for future research in same field. Designed platform can be used in another research to study the benefits of personalized gamification in depth. In future this research can be advanced further by creating different versions of the platform which was designed and implemented in this study. By creating one version with no gamification at all, one with static gamification and one with adaptive gamification you could compare having no gamification at all to simple generic gamification to personalized gamification approach. These three versions of platform can be used in real or simulated environment over a long period of time to gather both qualitative data through surveys and user feedback, and also gather quantitative data through the systems event logging capability. This data could be used to figure out the differences in systems about how people use them and what kind of effect do these different approaches have on motivation of users.

The shortcoming of this research is the inability to conduct a long term study with various versions of platforms and testing is instead limited to general usability testing and problem identification. The evaluation methods were not sufficient to justify the benefits of used approach for personalized gamification. To measure the positive effects of personalized gamification it is necessary to conduct a long term study, with actual system, in real environment and real users. Personalized gamification is relatively new and unexplored field and needs more data and testing to find the actual benefit and effect of adaptive gamification in comparison to a static one and whether it is worth the extra effort and

workload. The design science artifact produced in this research can be modified and reused with different approaches and re-evaluated to attempt to find out which approaches are more effective.

The source code of platform is available under GNU General Public License on BitBucket git repository at following URL: https://bitbucket.org/winceptor/veijo

6 CONCLUSIONS

The research in this follows the design science research model principles and provides an artifact which can be used in future research to study the effects of personalized gamification. Personalized gamification is relatively new kind of approach which aims to provide better gameful experiences to all users, by tailoring the game-elements to individual users. In this research a collaborative platform was designed and implemented using user hexad player types for personalization of challenges. These challenges were provided through LudusEngine classifier which distributed challenges based on user hexad type and various inputs from platform.

This research showed that while it is possible to gamify platform with such an approach, it is difficult to test the benefits of personalized gamification in test environment. Instead, a long term case study is needed to understand how personalized approach affects the user experience and user motivation. In this research the evaluation of produced artifact was done using user test scenarios with usability survey at the end, but these can only identify the immediate problems with general usability. This kind of evaluation does not answer the question about how personalized gamification affects intrinsic motivation of users.

In the future this research could be expanded by trying different approaches to gamification by utilizing the platform implemented in this study. The different approaches could be used to make multiple versions of same platform to test their differences on user motivation and gameful experiences. One such approach would be to gamify the voting mechanic itself to make platform more engaging and game-like. This voting system could also be personalized for each user based on hexad user type to make it into a game of sorts with hexad user types acting as player classes in a game. Philanthropists would for example be able to spend more points on upvoting other users, while disruptors could spend more points on downvotes. Different player types would have distinct upvote and downvote mechanics that represent that player type.

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Appendix 1. Challenge classifier

```
function ludusengine(data, cb, req, res) {
            var Hexad = data.hexad || ";
    var Userskill = data.userskill || ";
    var Ownteam_opentasks = data.ownteam_opentasks || ";
    var Ownteam_task_age = data.ownteam_taskage || ";
    var Otherteam_opentasks = data.otherteam_opentasks || ";
    var Chatactivity = data.chatactivity || ";
    var Ownpoints = data.ownpoints || ";
    var Ownteamactivity = data.ownteam_opentasks || ";
    var Otherteamactivity = data.otherteam_opentasks || ";

    var classids = [];

            if (Chatactivity=='high') {
                        classids.push(1);
            }
            if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                        classids.push(2);
            }
            if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                        classids.push(2);
            }
            if (Hexad=='philanthropist' && Ownteam_opentasks=='high' && Ownteam_task_age=='high' &&
Otherteam_opentasks=='high' && Chatactivity!='high' && Otherteamactivity=='high') {
                        classids.push(3);
            }
            if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                        classids.push(3);
            }
            if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                        classids.push(4);
            }
            if (Chatactivity=='low' && Hexad!='freespirit') {
                        classids.push(5);
            }
            if (Chatactivity=='low' && Hexad=='freespirit') {
                        classids.push(6);
            }
            if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                        classids.push(7);
            }
            if (Chatactivity=='low' && Hexad=='freespirit') {
                        classids.push(8);
            }
            if (Hexad=='player' && Ownpoints=='low' && Ownteam_opentasks=='high' && Otherteamactivity=='high')
{
                        classids.push(9);
            }
            if (Hexad=='philanthropist' && Ownteam_opentasks=='high' && Ownteam_task_age=='high' &&
Otherteam_opentasks=='high' && Chatactivity!='high' && Otherteamactivity=='high') {
                        classids.push(9);
            }
            if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                        classids.push(9);
            }
```

```
        if (Hexad=='player' && Ownpoints=='low' && Ownteam_opentasks=='high' && Otherteamactivity=='high')
{
                classids.push(10);
        }
        if (Hexad=='philanthropist' && Ownteam_opentasks=='high' && Ownteam_task_age=='high' &&
Otherteam_opentasks=='high' && Chatactivity!='high' && Otherteamactivity=='high') {
                classids.push(10);
        }
        if (Hexad=='player' && Ownpoints=='low' && Ownteam_opentasks=='high' && Otherteamactivity=='high')
{
                classids.push(11);
        }
        if (Hexad=='philanthropist' && Ownteam_opentasks=='high' && Ownteam_task_age=='high' &&
Otherteam_opentasks=='high' && Chatactivity!='high' && Otherteamactivity=='high') {
                classids.push(11);
        }
        if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                classids.push(11);
        }
        if (Userskill!='high') {
                classids.push(12);
        }
        if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                classids.push(13);
        }
        if (Chatactivity=='low' && Hexad!='freespirit') {
                classids.push(14);
        }
        if (Otherteam_opentasks!='high') {
                classids.push(15);
        }
        if (Chatactivity=='low' && Hexad!='freespirit') {
                classids.push(16);
        }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                classids.push(17);
        }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                classids.push(18);
        }
        if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                classids.push(18);
        }
        if (Hexad=='player' && Ownpoints=='low' && Ownteam_opentasks=='high' && Otherteamactivity=='high')
{
                classids.push(19);
        }
        if (Hexad=='philanthropist' && Ownteam_opentasks=='high' && Ownteam_task_age=='high' &&
Otherteam_opentasks=='high' && Chatactivity!='high' && Otherteamactivity=='high') {
                classids.push(19);
        }
        if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                classids.push(19);
        }
        if (Otherteamactivity!='high') {
```

```
                    classids.push(20);
            }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                    classids.push(21);
            }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                    classids.push(22);
            }
        if (Ownteam_opentasks!='high' && Hexad=='achiever') {
                    classids.push(23);
            }
        if (Ownteam_opentasks!='high' && Hexad!='achiever' && Hexad!='philanthropist') {
                    classids.push(24);
            }
        if (Ownteam_opentasks!='high' && Hexad!='achiever') {
                    classids.push(24);
            }
        if (Ownpoints=='lowdifference') {
                    classids.push(25);
            }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                    classids.push(26);
            }
        if (Hexad=='player' && Ownpoints=='low' && Ownteam_opentasks=='high' && Otherteamactivity=='high')
{
                    classids.push(27);
            }
        if (Hexad=='philanthropist' && Ownteam_opentasks=='high' && Ownteam_task_age=='high' &&
Otherteam_opentasks=='high' && Chatactivity!='high' && Otherteamactivity=='high') {
                    classids.push(27);
            }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                    classids.push(27);
            }
        if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                    classids.push(27);
            }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                    classids.push(28);
            }
        if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                    classids.push(29);
            }
        if (Hexad=='achiever' && Ownpoints=='low' && Ownteam_opentasks=='high') {
                    classids.push(30);
            }
        if (Hexad=='player' && Ownpoints=='low' && Ownteam_opentasks=='high' && Otherteamactivity=='high')
{
                    classids.push(30);
            }
        if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                    classids.push(30);
            }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
```

```
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                classids.push(31);
        }
        if (Hexad=='socializer' && Chatactivity=='questions' && Userskill=='high' && Ownteam_opentasks=='high'
&& Otherteam_opentasks=='high' && Ownteamactivity!='high' && Otherteamactivity=='high' && Ownpoints=='low')
{
                classids.push(31);
        }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                classids.push(32);
        }
        if (Ownteam_opentasks!='high' && Hexad=='philanthropist') {
                classids.push(33);
        }
        if (Hexad=='freespirit' && Chatactivity!='low' && Ownteam_opentasks=='high' &&
Ownteam_task_age=='high' && Ownteamactivity!='high') {
                classids.push(34);
        }
        if (Ownteamactivity=='high') {
                classids.push(35);
        }
        if (Ownpoints=='otherlow') {
                classids.push(36);
        }
        if (Hexad=='achiever' && Ownpoints=='low' && Ownteam_opentasks=='high') {
                classids.push(37);
        }
        if (Ownpoints=='ownlow') {
                classids.push(38);
        }
        if (Ownpoints=='ownlow') {
                classids.push(39);
        }
        if (Ownteam_task_age!='high') {
                classids.push(40);
        }
        if (Hexad=='achiever' && Ownpoints=='low' && Ownteam_opentasks=='high') {
                classids.push(41);
        }
        if (Hexad=='achiever' && Ownpoints=='low' && Ownteam_opentasks=='high') {
                classids.push(42);
        }
        if (true) {
                classids.push(27);
        }

        cb(null, classids);
}
```

Appendix 2. Hexad type survey

Appendix 2.

The items are colored to make 24 item questionnaire feel less tedious and to allow user to more easily track which question he is currently on.

Appendix 3. User test scenarios

ID	a1
Title	signup
Description	Signing up with a new user
Actor	Unregistered user
Preconditions	User is not registered and is not logged in
Postconditions	User is registered and logged out
Scenario	1. Go to main page of platform (link provided during test)
	2. Open signup page
	3. Create account
	3. Fill out hexad user survey
	4. View your profile
	5. Try to complete one challenge (optional)
	6. Log out (skip SUS survey)

ID	b1
Title	issuetracker
Description	Creating a new issue
Actor	Verified test user (provided)
Preconditions	User has premade testing account
Postconditions	User has created new issue and viewed it through dashboard and solved himself
Scenario	1. Go to main page of platform (link provided during test)
	2. Login with provided test user account
	3. Go to issues page
	4. Create new issue
	5. Mark issue as solved
	6. Return to dashboard / home

ID	b2
Title	groupwork
Description	Joining group and completing one of the tasks
Actor	Verified user (can use same from scenario b1)
Preconditions	User has done scenario b1
Postconditions	User has joined group and completed task
Scenario	1. Go to main page of platform (link provided during test)
	2. Go to dashboard and join available group / team
	3. Go to group page
	4. View incomplete grouptask
	5. Write a new message in grouptask
	6. Mark your message as solution to task

ID	b3
Title	newgroup
Description	Creating a new group
Actor	Verified user (can use same from scenario b2)
Preconditions	User has completed scenario b2
Postconditions	User has created group and invited some users to join
Scenario	1. Go to main page of platform (link provided during test)
	2. Go to groups page
	3. Create new group
	4. Go to groups chat channel and say something
	5. Log out
	6. Fill out SUS survey

Appendix 4. User test results

User scenario: a1

Observations:
- One user did not see limitations to email domains (lut.fi or student.lut.fi) and tried to use another email. This should be made clearer so users will not be required to re-enter information or correct mistakes they do not understand.
- Another user entered unaccepted email (wrong domain), but no problems with the rest of the form inputs.
- Password fields during registration were not showing up as required field after entering information once, but receiving form input error.
- Dark theme for user interface made parts of hexad user survey difficult to read due to dark colors blending into background or too bright colors glowing too much.
- One hexad survey question was unclear to user.
- One user tried to click on titles of challenges, because they looked like links. They do not need to look like links or have some kind of functionality to react to clicking.
- One user accidently followed directly to scenario b1 with his own created user in scenario a1 instead of provided test user. (no problem, testing resumed from the beginning of b1).
- An unverified users may be invited to a group, but cannot join before they are verified. This can stay like this since it allows system to be more flexible.

Problems:
- Untranslated string for error message about disallowed email ###illegal###, now fixed to "Email domain not allowed".
- Password requirements for new user are not clearly indicated during registration.
- Message about unverified account has slightly wrong margins around it.
- Challenge goals are not updated immediately on the same page refresh as they are completed, which results in challenges getting completed before all goals are visually completed.
- Form inputs for new task are missing placeholder information for inputs.

- Registration instructions unclear and not visible after entering information, especially email should be more clear about allowed domains etc.
- Challenges look like links, but cannot be clicked on. This confused one user because they expected something to happen.

Feedback:
- Profile page should state that it is "profile page" or "user page" instead of just showing username in title.
- One user really liked that hexad survey questions were distinquishly colored.
- System should redirect user to their profile page after registering, because there is nothing on dashboard/homepage yet for them.
- According to one user, challenges look weird, but could not explain what exactly should be changed.
- One user wondered why is he asked for user skill self-evaluation during registration. Maybe this and hexad users purpose should be explained to user better.
- Multiple users complained that popups/notifications should disappear automatically instead of making user click on them.

User scenario: b1

Observations:
- One user navigated pages really quickly and easily found correct links and buttons.
- Few users tried to click unclickable status "Unsolved" and were confused because it did not work.
- It was unclear that each issue and task has a separate thread of messages behind the title link. Maybe it should also have a button which opens it to make clearer.
- User tried to mark issue as solved directly from overview list of issues which did nothing and confused user.
- One user did not understand how to open issue thread and went to edit issue instead. In the edit page user could not set issues as completed and asked for help.

Problems:
- Clicking "mark as solved" and pressing cancel, still completes issue. Severe bug.

- When user attempted to edit issue, it became a groupissue of a random group. Severe bug, fixed on the spot.
- Issues should be "solved" not "completed". Need to change the language slightly to make it more consistent across platform.
- Another user pressed cancel to solving prompt, but platform confirmed action regardless.
-

Feedback:

- Multiple users complained that it should be possible to solve issues directly.
- Yet another user complained that "solved"/"unsolved" status should be a button which solves or unsolves issue.
- Layout was confusing according to several testers and it was difficult to understand where to go.
- One user wondered why is issue title not a required input.
- When receiving multiple challenges no need to repeat "new challenges" part.
- According to several users the process of solving issue is confusing, should make it more clear what user is doing.
- One user suggested that issue solved status should be possible to change on issue editing page.
- Multiple users complained about notifications not disappearing automatically and requiring extra click to close.
- Issue thread layout was also confusing according to multiple users.
- One user did not like how big the submit button for new comment is and how it was completely out of place.
- Same user complained that the edit button, list of issue helpers and issue solving button are poorly organized.
- According to several users lists do not look like lists of items, but separate blocks, because header and items are too separated from each other.
- One user commented that back button in edit page is too small, is out of place and should be named "cancel" instead.

User scenario: b2

Observations:

- One user again distracted by layout.
- Less users navigating to wrong pages after completing scenario b1.

Problems:

- When hovering mouse past usernames, an information popup blocks "Join group" button. Changing popup to instant transition instead of smooth fadein and fadeout could help.
- Users encountered same problem later when joining chat: Hovering past names shows user information popup which hides "Join chat" button.
- Clicking "mark as solved" and pressing cancel, still completes task. Same problem as with issues in scenario b1. Multiple users faced this problem.
- Prompt for marking message as solution is wrong and does not tell which message is about to be marked as solution.
- For some reason user gets "Access denied" error when marking message as solution. Severe problem.
- Thread says there are 0 replies after marking the only message there as solution.
- There is no way to uncomplete task or unmark solution if you make a mistake.
- Button text is inside icon <span> and causes wrong font to be used.

Feedback:

- One user suggested it would be better to show link to tasks on header, just like issues.
- Once again users complained that you cannot click "Incomplete" status of tasks to mark as completed.
- Similarly to a problem in scenario b1 multiple users complained that a list of items does not look like a list of items, because header and list elements are too separated and look like individual things.
- Joining a group does not need to be confirmed, instead user suggested it would be better to hide invites behind a droplist to not accidently join groups.
- One user really disliked amount of popups, reduce the amount and frequency of popups, by removing unneeded or obvious ones.
- Group name in task title is unnecessarily big and distracts from the task name,

because it is right next to a link to task thread. Make it smaller or remove entirely.

- One user commented that solution to task should be titled "Solution" otherwise its unclear why there is same message multiple times.

User scenario: b3

Observations:
- Users seem to be getting used to navigating platform as users navigate faster now than in previous scenarios.
- One user removed himself from the list of invited users when creating new group.
- One user was confused by groups/invites on dashboard. It should clearly tell which ones are "My groups" and which ones are "Group invites".
- User tried to click on "Groups" header for a list of users groups.

Problems:
- Group creator is not a member of a group they create.
- Leavign empty group name causes untranslated string ###noname### to appear instead of group name. Fixed afterwards.
- Having 0 members in a group causes double line breaks to appear around empty space in group information.
- Invited members are not shown for groups listed in dashboard. Bug.
- Editing chat message in the middle causes empty lines around it due to wrong classes.
- Youtube embedded links overflow chat area out of bounds with small screen.
- A link to public chat channel redirects to last chat channel, instead of public channel.

Feedback:
- Chat button on group page should be put somewhere better, or renamed to something like "Enter chat room".
- Groups that have already sent invite to user should appear in a list of chat rooms for that user.
- Groups list on dashboard should be renamed to "My groups" instead of just

"Groups", otherwise it is confusing.

- One user suggested that dashboard could encourage interaction, by for example offering things to do or showing challenges when there are no tasks or issues for own group.

- There could also be some kind of highlights or popular/hot/upvoted issues and tasks.

- One user suggested that it would be better to show issue/task/group blocks even with empty list and suggest things to do like creating new task if there are none.

- Multiple users complained that logging out should redirect to frontpage.