MORE FUN, FEWER RISKS: DEVELOPMENT OF A GAMIFIED WEB APP FOR RISK MANAGEMENT

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Abstract

Erklärung

(gemäß §5(3) der "Studien- und Prüfungsordnung DHBW Technik" vom 29.09.2017)

Ich versichere hiermit, dass ich meine Studienarbeit mit dem Thema: "More Fun, Fewer Risks: Development of a Gamified Web App for Risk Management" selbstständig verfasst und keine anderen als die angegebenen Quellen und Hilfsmittel benutzt habe. Ich versichere zudem, dass die eingereichte elektronische Fassung mit der gedruckten Fassung übereinstimmt.

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List of abbreviations

Die nach Ansicht des Autors wichtigsten Abkürzungen:

API	Application Programming Interfaces
HTTP	Hypertext Transfer Protocol
MVC	Model View Controller
REST	Representational State Transfer
SQL	Structured Query Lanuage
UC	Use Case
JSX	JavaScript XML
JPA	Java Persistence API

Glossary

Bartle's player type The Bartle test of Psychology, developed by Richard Bartle, is used for the classification of users regarding their gaming behavior. There are four different user types: Achiever, Explorer, Socializer and Killer. Achievers want to achieve points and status through playing, Explorers are interested in discovering new aspects of the game, Socializers like the interaction with other players and Killers are an extreme form of Achievers, which get their energy from the defeat of others. Players can have character traits from all four player types. The tests aim is to find the major type for a player. [1, p. 44, 45]

Game design principles Game design principles are central properties on which games are built. [1, p. 8]

Game mechanics Game mechanics are typical methods which are used in games. [1, p. 8]

REST todo

SQL todo

1. Introduction

context, motivation, aims, purpose, ..

2. Theoretical background

This chapter introduces the theory of the domain risk management (chapter 2.1), gamification (chapter 2.2) and Progressive Web Apps (chapter 2.3).

2.1. Risk Management

Software projects in the past have struggled to succeed. The Standish Group [2] has compiled a database of over 25,000 software projects over the years 2011 to 2015. They found that only about 30 percent of these projects were successful without any curtailments. The larger the projects were the less often they turned out successful. This issue has been discussed in the literature since even before the early 1990ies [3]. Almost two decades later the problem of IT project failure still persists motivating this work.

2.1.1. Project Failure

There are plenty of reasons for projects to fail and frequently even large companies and organizations experience costly failures of big projects [4]. Projects are often defined as failed, when they cannot meet time or budget constraints or do not fulfill the pre-defined requirements. However, this definition is not useful in every context [5]. IT projects often follow agile management techniques allowing for changes in the pre-defined scopes [6]. To allow for a wider understanding of what IT-project failure means Lyytien and Hirchheim group such failures into four different categories [7]:

- Correspondence: Not meeting the pre-defined objectives
- Process: Exceeding time or budget restrains
- Interaction: Lack of end-user engagement
- Expectation: Inability to meet stakeholder's expectations

Each of these shortcomings can be interpreted as project failure.

2.1.2. Reasons for Project Failure

Analogous to the variety of ways in which a project can be defined as being unsuccessful there are many reasons which can lead to any such failure. Plenty research has been done to investigate the causes of project failure [8]. Events that lead to project failure can be understood as risks. Islam [9] provides the following definition for risks in an IT context:
"Software risk, is defined as, the possibilities of suffering a loss such as budget or schedule over-runs, customer dissatisfaction, poor quality and passive customer involvement due to an undesirable event and its consequences during the life cycle of the project."

Many such risk factors have been identified in the literature by now. Whitney and Daniels [10] as well as Tesch et al [11] present compilations of risk factors. Based on the risks provided the following types for risk factors were derived:

- Lack of support
- Resources and personnel
- Scope and requirements
- Technology and design
- Communication and cooperation
- Discipline and motivation

We group the risk factors collected by the abovementioned papers into these categories according to the following table.

TBL. 2.1.: *Categorization of risk factors*

Category	Whitney and Daniels	Tesch et al
Lack of support	Lack of executive support/commitment	Lack of top management commitment to the project Lack of corporate leadership
Resources and personnel	Personnel shortfall and straining computer science abilities Shortfalls in procured components or labor Resource usage and performance Poor project team composition Inadequate technical expertise	Insufficient/inappropriate staffing Inadequate skills and means
Scope and requirements	Unrealistic schedules and budgets Constantly changing requirements Unrealistic project goals and objectives	Lack of frozen requirements Changing scope/objectives Excessive schedule pressure Changing needs Excessive and secondary innovation Requirements creep
Technology and design	Developing wrong functions, properties, and/or user interfaces System functionality Problematic technology base/infrastructure	Introduction of new technology Lack of technical specification
Communication and cooperation	Scheduling and timing Subcontracting Personnel management Project management and control problems	Lack of adequate user involvement Failure to manage end user expectations Misunderstanding the requirements Conflict between user departments Poorly communicated goals/deliverables Poor project management Lack of a documented project plan
Discipline and motivation	None	Failure to gain user commitment Lack of scientific methods Ignoring the obvious Unethical behavior

To counter such risk factors risk management practices can be integrated into the overall project management. Risk management serves to identify risks, analyze them and to address them to minimize the damage these risks could do to project [11].

2.1.3. Project Risk Management

Risk management is a process that should be initiated early in the project lifecycle to enable proactive handling of threats [9]. In general the cycle of risk management involves the following

steps: Identification, Analysis, Response/Treatment and monitoring and control [9], [11], [12]. The steps should be undertaken at the beginning of the project and updated whenever changes occur. There are different and more detailed variations [11], however for the purpose of this paper the general model will be assessed in more detail.

FIG. 2.1.: *Risk Management Circle*
[own representation]

The different steps of the process serve different purposes and have different side effects. Risk identification helps to create awareness and to initiate action in general. It is also a phase during which the project team and stakeholders can share their concerns regarding the project and clarify their expectations to form a common view [12].

To actually perform the identification different techniques can be used. Two commonly used ones are the checklist and brainstorming [9], [12]. Checklists rely on past experience to identify known risk factory which are applicable to the project at hand. Another variant of procedure is to use a questionnaire instead which covers characteristics of the project to find specifically corresponding risks. Brainstorming is ideally done together with project

stakeholders to gain different perspectives. Risk identification techniques are not mutually exclusive and combinations may result in more comprehensive results [9].

Risk analysis serves to create acceptance of the previously identified risks as well as to indicate their impact [12]. During this phase the likelihood of risk occurrence and the impact are estimated. This can be done in a qualitative manner by assigning ordinal values for both dimensions. The scales for likelihood can for example go from rare to almost certain. Impact can be described from low to catastrophic. Such estimates are subjective and my produce unclear results however trying to apply quantitative techniques can be unreliable as well since estimations based on past data may not be applicable anymore in a rapidly changing environment such as IT [9].

Risk response planning serves to reduce threats and to enhance opportunities [11]. Dealing with risks can be approached in different manners. Measurements can be defined to either avoid or prevent the risks or to deal with the impact should the risk occur. Another alternative can be to simply accept the risks or to outsource the risks [9]. Another practice used is to assign risk owners to establish clear responsibility for later control efforts [13].

Risk control serves to initiate action on the monitored risks and to direct action [9]. Monitoring the risks enables responding to changes via new cycles of the risk management process as well as triggering the measurements defined during the previous phase if necessary [11]. Techniques employed during this phase can be risk audits, trend analysis or regular status meetings [9].

TBL. 2.2.: *Summary effects and practices of the different phases of risk management*

Phase	Effects on the project	Risk management practices
Risk identification	Initiate action Create awareness Stakeholder communication Common view on the project Clarify expectations	Checklists Brainstorming
Risk analysis	Create acceptance Identify risk impact Estimate risk occurrence likelihood	Qualitative estimation Quantitative analysis
Risk response planning	Reduce threats Enhance opportunities	Contingency plan Risk avoidance or prevention Risk acceptance Outsourcing Risk ownership
Risk monitoring and controlling	Initiate and direct actions React to changes	Risk audit Trend analysis Status meeting

Different studies have been undertaken to evaluate the effect of risk management on project success [5], [12], [14], [15]. The results vary regarding which part of risk management or which tools and techniques contribute to projects success but some sort of positive impact is reported from all of them.

However, in practice risk management is often neglected [14]. Even if there is initial investment into risk management during the planning phase of a project there are tendencies to let efforts slide once the project is running and time pressure picks up [13]. Another attitude towards risk management that has been observed is to view it as additional work and cost which can hinder the adoption of any such practices [11].

2.1.4. Conclusions for Risk Management Software

For the development of a software tool to facilitate risk management in IT projects the following conclusions can be drawn from the above presented:

- The tool should provide functionalities for all four phases of risk management
- To address the project stakeholders the tool should facilitate risk management practice and provide transparency
- The tool should be easy to use as to speed up risk management processes
- The tool should be engaging to prevent negligence in times of pressure

Further aspects to pay attention to when developing a risk management tool as presented by Keshlaf and Hashim [16] are:

- Documentation and building on that graphical preparation and usage of the documented risks
- User assistance for the risk estimation process
- Versatile applicability
- Comprehensiveness
- Automation

As presented above the topic of risk management in IT projects is widely covered in the literature. Risk management tools are available on the market and also discussed on a theoretical basis as seen in Keshlaf and Hashim. The novelty of this project is that we emphasize user engagement by employing gamification techniques as presented in the following chapter.

2.2. Gamification

The following chapter's aim is to clarify the main theory behind human motivation, gamification and the corresponding patterns and methods. Therefore, first of all the term Gamification is defined and explained (chapter 2.2.1), furthermore there is an introduction to human motivation (chapter 2.2.2) and motivational design patterns (chapter 2.2.3). Moreover, the Gamification Design Process is introduced (chapter 2.2.4). Finally the effectiveness of gamification in terms of business software is discussed. (chapter 2.2.5).

2.2.1. Definition

The term gamification is defined by Kumar and Herger as follows:

> *"Gamification is the application of game design principles and mechanics to non-game environments. It attempts to make technology more inviting by encouraging users to engage in desired behaviors and by showing the path to mastery. From a business viewpoint, gamification is using people's innate enjoyment of play."*
>
> GAMIFICATION [1, P. 8]

Based on the above definition gamification aims to motivate the user to do something [1, p. 8]. That is why the next chapter provides a more comprehensive introduction on motivation.

2.2.2. Human Motivation

The game design principles and mechanics which are used in the context of gamification are a specialization of motivational design patterns used in Human Computer Interaction. [1, p. 59]

Therefore this chapter provides an introduction to the ground of gamification from the areas psychology of motivation, behavioral psychology and behavioral economics - all three dealing with Human motivation.

Psychology of motivation Human motivation is one of the main topics of psychology. Some questions which arouse are: What motivates humans for doing something? What intentions do they pursue with their doing? Which activities are a pleasure for them? [17, p. 1]

There are two types of motivation: extrinsic and intrinsic motivation. On the one hand intrinsic motivation is based on an internal drive to do something. Humans are doing this task on their own. Possible motivational factors are gained autonomy, mastery or freedom. [17, p. 2, 3, 4], [1, p. 60, 61]

Deci describes intrinsic motivation as follows: "One is said to be intrinsically motivated to perform an activity when he receives no apparent rewards except the activity itself." [18, p. 105]

On the other hand extrinsic motivation is based on motivational factors from the outside, such as money, throphys or the comparison with others (for example with points, levels or leaderboards). [17, p. 2, 3, 4], [1, p. 60, 61]

One theory dealing with the core psychology behind motivation is the self-determination theory by Ryan and Deci. According this theory human motivation depends on the satisfaction of the three psychological basic needs:

1. Autonomy
2. Competence
3. Relatedness

Based on Deci and Ryan whenever humans feel autonomous, competent and related then motivation arises. [19, p. 416-432]

Flow is another concept based on intrinsic motivation. It describes the situation when different actions steps run and merge smoothly without any problems. The entire attention belongs to the current task and no concentration is necessary to focus on the task. The basis for being able to experience flow are a clearly defined aim, concrete action steps and the tasks submit feedback regarding their correctness. [17, p. 19, 20, 21]

Interest describes a current state of mind supporting knowledge building. It can be explained by a general preference for specific topics (e.g. specific school subjects), or by situational factors (e.g. interesting educational topics). Interest can be a catalyst for intrinsic motivation. [17, p. 22, 23, 24]

Behavioral psychology Behavioral psychology studies the way how humans behave and tries to find underlying patterns which trigger a specific behavior. There is a constant stream of inputs (stimuli) to our body. In the field of behavioral psychology human behavior is seen as a response to these inputs. [20, p. 10]

A concrete application, where behavioral psychology can be observed are learned processes, also known as operant conditioning. Prominent Experimental Research in the area of operant conditioning was done by Skinner and his experiments known as Skinner box. For a deeper insight into his experiments, his book "The behavior of organisms" [21] is referred. By rewarding desired behavior and punising undesired behavior humans get conditioned to display specific desired behaviors. Rewards and punishments are the stimuli causing responses. [20, p. 11]

Moreover the timing when rewards are provided, influences how the interaction works. Based on Lewis [20, p. 10] there are four different strategies:

1. Fixed Ratio: After a fixed number of responses rewards are provided (e.g. coffee card: the tenth coffee is for free)

2. Variable Ratio: Reward frequency is not firmly defined, the reward is offered on average after a couple of responses (e.g. gambling machine)

3. Fixed Interval: Rewards are provided after a fixed period of time (e.g. coffee machine)

4. Variable Interval: The interval in which rewards are offered is variable (e.g. fishing)

The highest response over time is generated by variable ratio strategy. In case of designing engaging applications, connecting the user with this application one should consider the use of rewards in a variable ratio. [20, p. 11]

To conclude it can be stated, that large parts of the gamification principles are based on rewards (e.g. increasing points, levels) and punishments (e.g decreasing points and levels). However the application of these principles should always be done carefully. This can be illustrated by a thought experiment by Schell called "chocofication". First of all there is the fact that chocolate tastes good. Adding chocolate to peanut butter makes it taste good. But nevertheless the conclusion that everything tastes good with chocolate is wrong. For example hot dogs with chocolate are a disaster. To conclude you can say, that based on the thought experiment chocolate is not the magic bullet for food, similarly gamification is not the magic bullet for application design. [20, p. 12]

Behavioral economics Behavioral economics explores, which effects affect economic decisions. In general whenever a resource (e.g. time, money) is gained or lost it is the consequence of a decision. So behavioral economics could also be seen as the theory behind decision making. Moreover in the context of Human Computer Interaction whenever a user interacts with an application lots of decisions are made. Engaging application design tries to include aspects of behavioral economics to influence the users decision to spend more time with the application. Human decisions could be rational or irrational. Rational decisions are made to reach a concrete aim such as happiness and can be logically explained. Irrational decisions are not necessarily comprehensible. Nevertheless irrational decisions can be triggered by external influences. For example people tend to use memberships, even if they don't profit (e.g. injured people going to the gym to make use of the membership). Referring to the relationship between behavioral economics and application design the application can be designed to trigger the user to make an irrational decision (e.g. spend more time with the application than needed). [20, p. 19]

Patterns which motivate the user to do something by using the theoretical background of motivation, behavioral psychology and behavioral economics are described in the following chapter 2.2.3.

2.2.3. Motivational Design Patterns

The theoretical concepts above are used in various motivational design patterns. In Lewis [20] and Kumar and Herger [1] motivational design patterns are described. In the following some patterns which may be relevant for the conception of the risk management application are introduced. The selection criteria was the applicability of the pattern in the context of a business application for risk management. For more comprehensive insight into motivational design patterns please refer to [20] and [1].

Based on [20] patterns can be classified. The presented patterns are out of the classes: Gameful Patterns, Social Patterns, Interface Patterns and Information Patterns. Gameful Patterns focus on operating methods known from games, Social Patterns, enable the users to satisfy their social contact needs, Interface Patterns are dealing with the influence of the interface on the user's behavior and Information Patterns study the way how content and information can be presented. [20, p. 4, 5, 6]

Gameful Patterns

- Collection: Collecting and owning virtual items (e.g. Forza Horizon, Pokémon). [20, p. 4, 35]
- Specialization—Badge: The user has reached a goal which is now visible through a badge (e.g. Xbox 360). [20, p. 4, 37]
- Growth: User owns something which was reached over time (e.g. SimCity). [20, p. 4, 40]
- Increased Responsibility: Trust in a user is the underlying basis for getting responsible tasks (e.g. Stack Overflow). [20, p. 4, 41]
- Leaderboard: Ranking users based on specific metrics (e.g. Doodle Jump). [20, p. 4, 44]
- Score: Based on the reward principle. By performing desired behavior the user normally achieves points, presenting his/her achievement level (e.g. Pac-Man) [20, p. 4, 46]

- Challenge: Challenges motivate users by giving them the feeling of reaching something great (e.g. Runkeeper) [1, p. 77, 78]
- Constraints with urgent optimism: Urgent Optimism combined with deadlines leads to a motivational effect. It is an extreme form of self-motivation combined with the belief in the reachability of the aim. [1, p. 78]
- Journey (Onboarding, Scaffolding, Progress): Journey describes the adaptability of the application based on different usage phases. One can think about a specific onboarding process providing an introduction and help regarding the application. The next phase after onboarding is scaffolding. The user is still inexperienced leading to a risk of operating errors. By providing support and constant feedback the bounce rate is minimized. Finally the user is onboarded and knows the main concepts of the application and is able to use them. Nevertheless constant user engagement is still desirable. It can be implemented with elements clearly showing users their current progress and feedback loops. (e.g. Setup process for LinkedIn) [1, p. 80, 81, 82]

Social Patterns

- Activity Stream: Representation of current events as never ending stream of news (e.g. Facebook). [20, p. 4, 52]
- Broadcast: Information can be shared between different users (e.g. Facebook, Twitter). [20, p. 4, 53]
- Social Feedback/Feedback loops: Users are able to easily feedback something. Furthermore multiple feedback loops are possible (e.g. Facebook). [20, p. 4, 54]

Interface Patterns

- Notifications: The user can be alerted by the application when a change occurs (e.g. Android, iOS) [20, p. 5, 70]

- Praise: Rewards for performing desired behavior (e.g. FarmVille) [20, p. 5, 72]
- Predictable Results: The results of an action are clearly predictable for users. (e.g. Google Search always provides search results) [20, p. 5, 74]
- State Preservation: The current state of the application is stored at any time, no matter when the application is left (e.g. Google Docs) [20, p. 5, 75, 76]
- Undo: The user is able to revert actions (e.g. Google Docs) [20, p. 5, 79]

Information Patterns

- Organization of Information: When information is presented ordered and organized the retrieval afterwords is simpler (e.g. Outlook) [20, p. 6, 85, 86]
- Personalization: Based on the individual user preferences the application adapts itself (e.g. Amazon) [20, p. 6, 87]
- Reporting: Reporting inappropriate content by users is possible (e.g. Facebook) [20, p. 6, 90]
- Search: Huge content is easily searchable (e.g. Google Search) [20, p. 6, 90, 91]
- Task Queue: Presents tasks which can be done next by a user trying to keep the user using the application (e.g. Setup process for LinkedIn) [20, p. 6, 93]

2.2.4. Gamification Design Process

According to [22, p. 5, 6] and [1, p. 27, 28] a well established design philosophy is User Centered Design. The center of the whole design and development of the application is the user. With this approach it is getting possible to match the users needs. The developed application is intuitively operable for the user and increases the user's productivity.

In the context of gamification the User Centered Design Process can be adapted to be a Player Centered Design Process.

Based on [1, p. 29-32] it consists of five steps:

1. Player

   Firstly it should be clearly defined who is the user, respectively the player. Based on a profound knowledge of the player and his needs the application can be designed. Therefore user/player personas are created, describing different user/player types, interacting with the application. The following user/player persona template is based on [1, p. 38-45]:

2. Mission

   Secondly the main goal of the gamification process is identified, the so called mission. Figure 2.3 represents the S.M.A.R.T Mission process to identify the mission. First of all the current situation is analyzed and the target business outcome is studied. Based on the gained knowledge a mission for the gamification process is set. It should be specific, measurable, actionable, realistic and time-bound. [1, p. 49-52]

3. Human Motivation

   Thirdly based on the theory behind human motivation (chapter 2.2.2) the concrete motivational factors for the different user personas are defined. [1, p. 59-67]

4. Game Mechanics

   Game mechanics represent the area of adding concrete gameful patterns to a non game environment. As part of motivational design patterns gameful patterns are described in chapter 2.2.3. While implementing gameful patterns in non game environments one

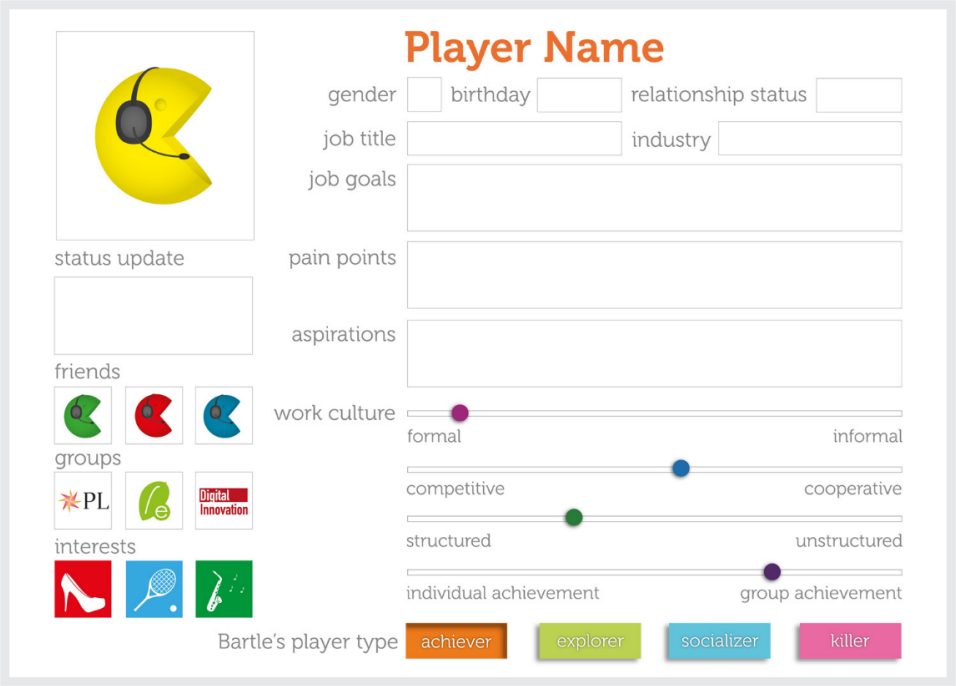

FIG. 2.2.: *Player Persona Template*
[1, p. 46]

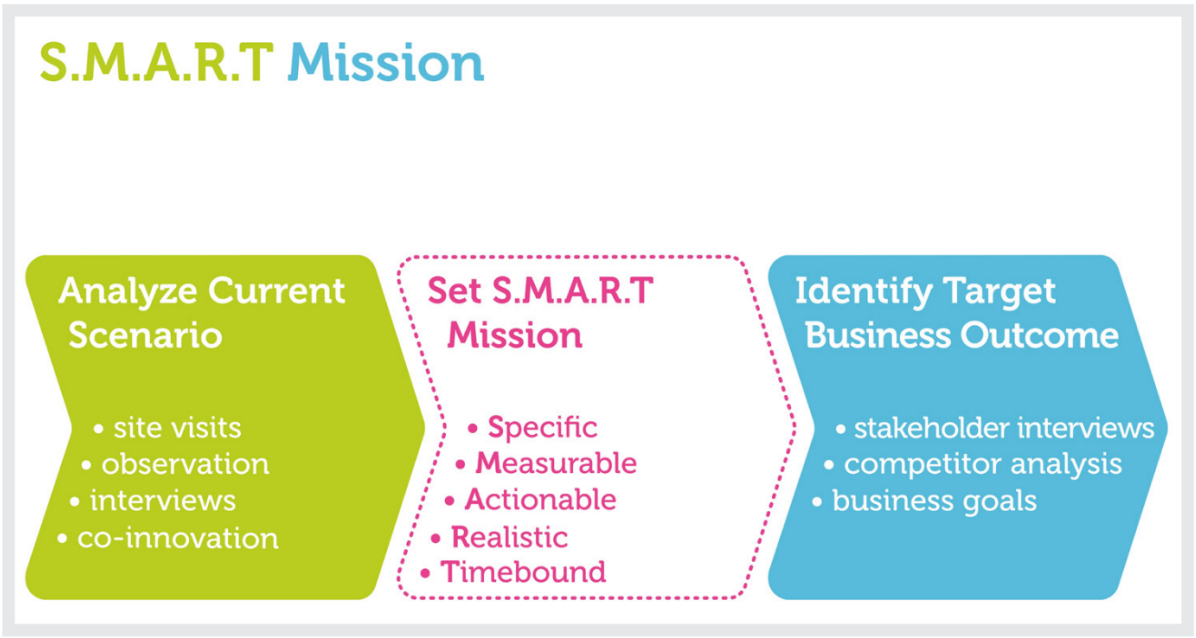

FIG. 2.3.: *S.M.A.R.T. Mission*
[1, p. 50]

should take into account that adding all patterns to an application normally doesn't reach the resumed aim. Hence the selection of fitting patterns must be adapted to the prescribed context. The main aim behind adding gameful patterns is to build a positive engagement loop centering the user/player. Figure 2.4 shows the four main steps of the engagement loop, starting with a motivating emotion. [1, p. 69-71]

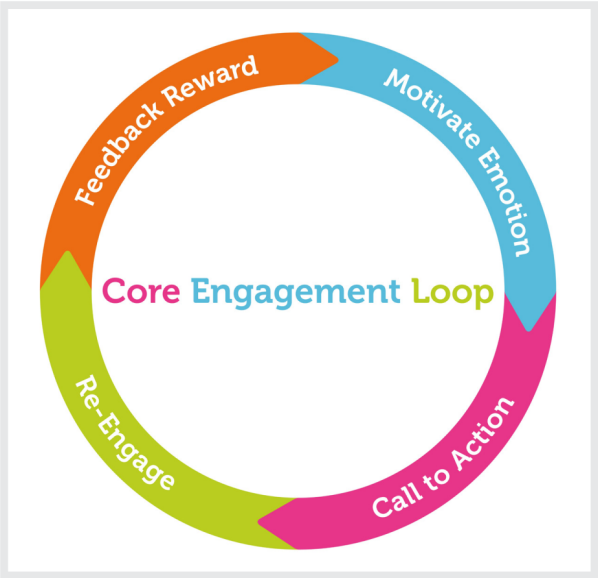

FIG. 2.4.: *Engagement Loop*
[1, p. 88]

5. Manage, Monitor and Measure

   After applying specific game mechanics to an application there are few points left, which should be observed in production. On the one hand the mission should be managed. Based on the S.M.A.R.T. Mission process the identified mission should be checked frequently and if needed adapted. On the other hand the user/player behavior should be monitored and measured to evaluate the effectiveness of the implemented patterns. This can be done qualitative by surveys and interviews and quantitative by tracking and data evaluation. Based on the acquired knowledge the application can be enhanced in the future. [1, p. 92-96]

2.2.5. Discussion

A literature review from Hamari, Koivisto and Sarsa [23] tries to answer the question if gamification works. Therefore quantitative and qualitative studies on this topic had been analyzed, resulting in the statement that quantitatively there are positive effects of gamification, but the gamification elements are only partly responsible for these effects. The analysis of qualitative studies resulted in the statement that gamification is more versatile than often assumed. [23, p. 3029, 3030]

The next question arising from this is: What are the reasons for these results and which disruptive factors harm the effectiveness of gamification? Therefore the study's conclusions are analyzed resulting in two aspects: Influence of the gamified context and user qualities. [23, p. 3029, 3030]

Influence of the gamified context The context which should be gamified influences the prospects of success. Hamari, Koivisto and Sarsa name three contextual factors [23, p. 3029, 3030]:

1. Social environment:
   In order to form behaviors one key for success is the voluntariness of doing something. [23, p. 3030]

2. Nature of the system:
   Systems which should be gamified can be hedonic or utilitarian. Hedonic systems support their users reaching desire and pleasure. [23, p. 3030] They are based on the philosophical concept of hedonism, which centers the human pursuit of desire and pleasure. Only the steady pursuit can reach intrinsically motivation. [24, p. LV]

   On the contrary utilitarian systems are purpose-oriented. The underlying philosophical concept is called utilitarianism. It is based on the principle that an action is morally correct when it maximizes the aggregated overall benefit, that is the sum of the welfare of all concerned. [24, p. 3]

3. Involvement of the user:
   Depending on the application's context there are two types how a user can be involved: cognitive or affective. [23, p. 3030] Cognitive involvement describes the user's interest respective an application. When being affectively involved, one evolves specific feelings regarding the application. In the context of business application normally the user's are involved cognitively. [25]

The overjustification effect describes the consequences how intrinsically motivated users change their behavior when extrinsic incentives are added. By adding extrinsic motivation the intrinsic motivation decreases. [17, p. 9-13]

Moreover there is the risk of false incentives. When applying gamification patterns without really thinking about the consequences it can lead to misguided behavior. E.g. when every user who contributes a risk to the project gets points, that will create a false incentive, leading to lots of contributed risks, but little attention to the risk management of each risk. [1, p.69]

User qualities The different abilities and qualities of users have a decisive influence on the user's behavior while using the application and thus the success of gamification. Each user interacts differently with the application. E.g. positive gamification effects where only measurable inside a specific context or with specific users. [23, p. 3029, 3030]

2.3. Progressive Web Apps

As of today, devices such as mobile phones and personal computers come with their own app store. Microsoft offers their own Store, Google their Play Store and Apple the App Store. Users often find themselvews worrying about an app they once saw running on another platform not being available for their platform (e.g. Apples iOS and Googles Android) [26, p. 3].

Progressive Web Apps (PWAs) approach these concerns by trying to move away from app stores onto a platform which is available on most devices – the web browser. This means that PWAs are regular web apps at their core but can progressively leave the web browser. For example, PWAs can be installed on the underlaying operating system and be accessed from the app switcher or the taskbar and be executed in full screen mode without the browsers interface being visible [27, p. 26]. Further characteristics of PWAs and how exactly a PWA can leave the web browser are granularly described in the following chapter.

2.3.1. Characteristics of a Progressive Web App

To transform an existing web app into a PWA or build one from scratch one must implement different criteria instead of including a new framework or library [26, p. 6]. While the following eight characteristics represent Mozilla's (Firefox) ideas of a PWA, other web browser manufactures such as Microsoft (Edge) or Google (Chrome) have roughly the same idea about PWAs and describe eight or ten characteristics respectively within their developer documentations [27, p. 90], [28].

1. **Progressive**: The first characteristic defines that a PWA should not exclude the user from using the core functionality but extend the user experience by embracing new features implemented by the web browser manufactures [27, p. 100], [29, p. 2]. For example, a web app to check mails should not exclude the user from checking their inbox or sending mails but could provide push notifications to inform about incoming mails. In this example the user is not excluded from using the core functionality of a mail app (checking the inbox and sending mails) and user experience is enhanced by push notifications. To avoid

unexpected failures a developer should follow the *Feature Detection* principle which says an application should not blindly use a non-standardized feature before checking its existence [27, p. 101].

2. **Network Independent**: Using a regular web app on the go can be a problem, especially in regions with little to no mobile reception or no stable Wi-Fi being around. Thus, the dynamic content of a web app does not load within a tolerable timeframe or a user is inhibited to perform actions like sending a mail [27, p. 106]. On these grounds a technology called *Service Worker* has been established and implemented by many browser manufactures. In short, a service worker is a script that is able to listen to the network traffic caused by a PWA and therefore is able to cache possible answers fetched from a server and serve them to the web app when no stable network connection is available or do background syncing by running code even when the web app isn't in use. For more information about the service worker see chapter 2.3.3 [26, p. 43].

3. **Safe**: As mentioned in the previous paragraph, service workers can run code independently from the PWA. To avoid harmful service workers from running malicious code, browser manufactures expect PWAs to be served by a trusted host over a secure connection. To be more precise, over an HTTPS connection [26, p. 24]. *HTTPS* stands for Hypertext Transfer Protocol Secure and is based on *TLS* (Transport Layer Security). Once the host has obtained a digital certificate for its domain, this certificate is being transferred to the client where it can be verified by the web browser. On success an HTTPS connection can be established and every upcoming network traffic will be encrypted [27, pp. 112-113].

4. **Re-engageable**: A feature which native apps are using for a while now are push notifications. Push notifications are a common way to inform users about the newest events such as a new mail in the user's inbox. Thanks to the Push API that is implemented on top of the service worker, just like native apps, PWAs can keep the users engaged by sending notifications as can be seen in figure 2.5 [29, p. 201].

5. **Responsive**: This characteristic specifies that the PWA render its user interface corresponding to the devices used to access it. This is necessary as the available space and

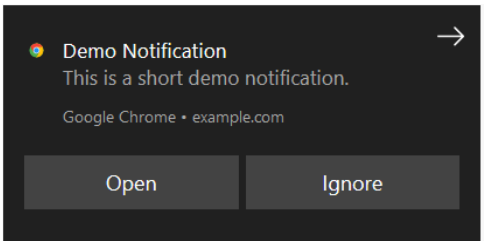

FIG. 2.5.: *Push notification to keep users engaged*

input method can change from device to device. The screen of a phone on average is way smaller than the screen of a notebook. Furthermore, using fingers to interact with a phone is less precise than using a mouse on a notebook [27, pp. 115-116]. In figure 2.6 for example one can see how the content and navigation arrange differently on each device. Due less space the navigation bar on the mobile version (extract on the right side) is completely collapsed and can be accessed by clicking the so-called burger-like icon while on the desktop version the whole navigation bar is visible.

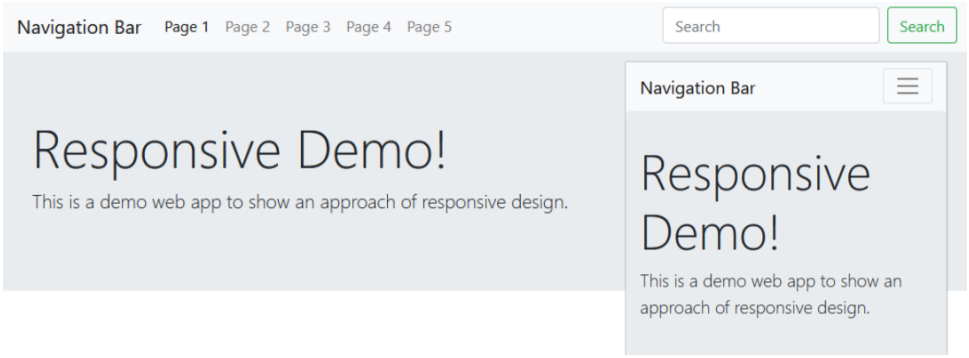

FIG. 2.6.: *Responsive design*

6. **Discoverable**: As PWAs are not a new framework or library but regular web apps at their core, there needs to be a method to distinguish between a PWA and a regular web app. This is necessary for web browsers to provide additional features to PWAs such as an option to install (see next paragraph). To make a PWA discoverable a "Web Manifest" file (see chapter 2.3.2), which contains information like the name of the PWA, needs to be provided [27, p. 118].

7. **Installable**: To take things even further, besides offline functionality, a PWA should be installable to the user's device. In detail, a user should be able to install the PWA from within the web browser to the underlaying operating system like Android or iOS. From this point on the user can launch the PWA directly from the devices home screen like it is shown in chapter 2.3.2. Different browser manufactures expect different requirements to be fulfilled before they provide an option to install. Mozilla's Firefox for example expect that the PWA is network independent, safe and discoverable [30].

8. **Linkable**: The last characteristic implies that a PWA is referable by a *URL* (Uniform Resource Locator, e.g. "www.example.com") instead of requiring to be installed via any app store. Ideally, the URL should also point to different views of a PWA like a profile page for a specific person. Hence, the current view can be easily shared between users. As PWAs are being run by a web browser, which needs a URL to access the web app in first place, this characteristic, in its fundamentals, does not require any further attentiveness by the developer [27, pp. 126-127].

2.3.2. Web Manifest

The web manifest is a *JSON* (JavaScript Object Notation) file. Its primary task is to make a PWA discoverable and installable (see chapter 2.3.1, p. 22) by providing descriptive information, like a short app name and paths to icons, about the PWA. The following listing shows a minimal web manifest:

LISTING 2.1: *Example Web Manifest*

```
{
  "short_name": "PWA Demo",
  "name": "Progressive Web App Demo",
  "description": "A simple Progressive Web App Demo.",
  "icons":
    [{"src": "favicon.ico",
      "sizes": "64x64 32x32 24x24 16x16",
      "type": "image/x-icon" },
    {"src": "logo192.png",
      "type": "image/png",
      "sizes": "192x192" },
    {"src": "logo512.png",
      "type": "image/png",
      "sizes": "512x512" }],
  "start_url": ".",
  "display": "standalone",
  "theme_color": "#dddddd",
  "background_color": "#ffffff"
}
```

The `(short-)name` represenst the name of the PWA which is used on the app switcher or home screen, depending on how much space is available. `icons` contains various file paths to app icons with different sizes which are used in different scenarios like the app switcher, home screen or the apps splash screen. For each use case the most appropriate size is chosen automatically. `start_url` defines the entry point of the PWA, `display` holds information about how the PWA will be displayed once it is installed (e.g. `standalone` for no web browser elements) and finally `theme`- and `background_color` which determine the primary color of the user interface and the background color of the splash screen respectively [30].

Figure 2.7 shows the effects of this web manifest on an example PWA. On the left one can see the use of the icon and name field in Googles Chrome "Add to Home Screen" prompt. In

the middle the short name is used due the given space. Once the PWA is launched, like on the right, the standalone display mode is used which hides all elements of the web browser.

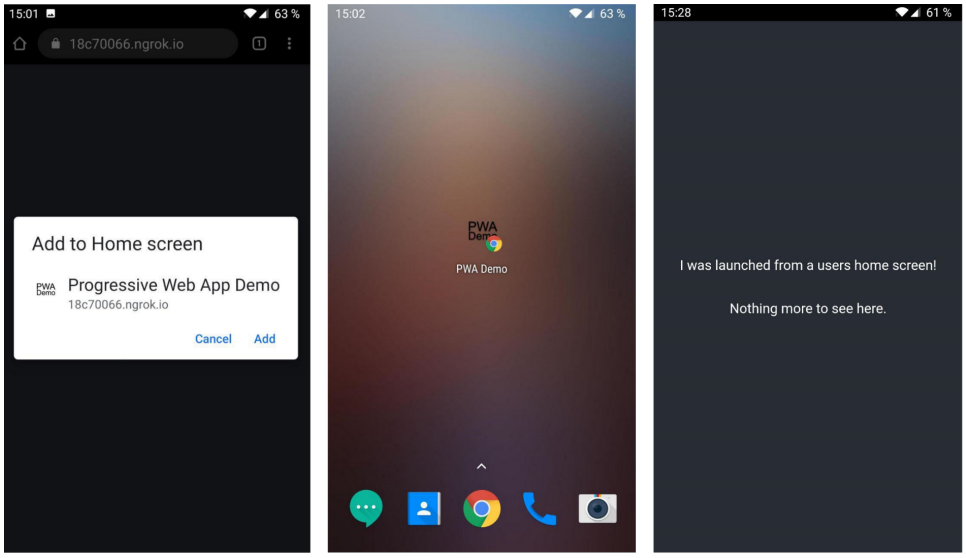

FIG. 2.7.: *Outcome of the web manifest*

2.3.3. Service Worker

A service worker is a script written in JavaScript, running in the context of the web browser. Its primary purpose, as mentioned in chapter 2.3.1, is to cache content and provide it to the PWA whenever a slow or no connection to the internet exists. Background syncing as well as sending push notifications can also be realized with a service worker. To achieve this, a service worker has three specific traits: being *controller*, *interceptor* and a *proxy* [27, p. 176].

After being registered by the web browser, which means that a HTTPS connection is established and it has been requested by the PWAs source code, it has full control to all in- and outgoing network traffic, hence the trait of a controller. Interceptor means that the service worker can manipulate and inspect the network traffic and proxy as the service worker is able to decide if the outgoing traffic should be redirected to the requested resource or completely avoid any outgoing traffic by answering with data it stored in a cache previously. The latter is the exact reason why a service worker is indispensable for the Network Independent characteristic (chapter 2.3.2, p. 25) of a PWA [27, p. 176-177].

The upcoming listing demonstrates how a service worker can manipulate and proxy outgoing network traffic. Before, lets assume that a cache called `pwa-demo` was already created by the service worker.

LISTING 2.2: *Cache First Service Worker*

```
1 self.addEventListener('fetch', event => event.respondWith(
2    caches.open('pwa-demo')
3      .then(cache => cache.match(event.request))
4      .then(response => response || fetch(event.request))
5   )
6 );
```

In the first line one can see the service worker is referencing itself and adds an event listener for all fetch-events (requesting data from outside of the web browsers context). The event listener gets passed the fetch `event` as its second argument on which it calls the `respondsWith` method. Within that method, it opens the cache called `pwa-demo` in line two to then check if the requested event matches the data stored in the cache in line three. If it does match, it then directly returns the data back to the PWA. Otherwise it executes the right part of the conditional OR expression `||` and calls the `fetch` method to get the data from the requested resource [27, p. 60].

This strategy is called *Cache First* as the service worker will look up the cache before requesting resources outside of the browser's context. Once cached, the data will available much faster and offline but if the resource changes its content, the service worker will still return the old, cached version. On the other side the *Network First* strategy exists that will always fetch data when a connection to the resource (e.g. the internet) can be established. Thus, the user will always receive the newest content and has a slightly older version available when being offline. On the downside, if the connection is slow the content may take a while to be fetched. Therefore, the *Cache and Network* strategy combines both, the Cache- and Network-First, strategies. To bridge the time of fetching new content, the user is presented the cached content until the result

is available and then be presented by refreshing the user interface. These are just a few but popular strategies and each has their own scenarios where they work best [29, pp. 109-111].

2.3.4. Compatibility

As with every new specification introduced it takes some time for every manufacturer to fully implement it in their products. In this chapter a short overview is given over which feautures web browsers currently support, in terms of PWAs. The following figures are taken from www.CanIUse.com (17/10/2019). They show to which grade a web browser version supports a given specification. Red means no support, dark green fully supported and light green supported to a degree.

In figure 2.8 one can see the web browser compatibility of the web manifest for richer offline experiences - like being installable.

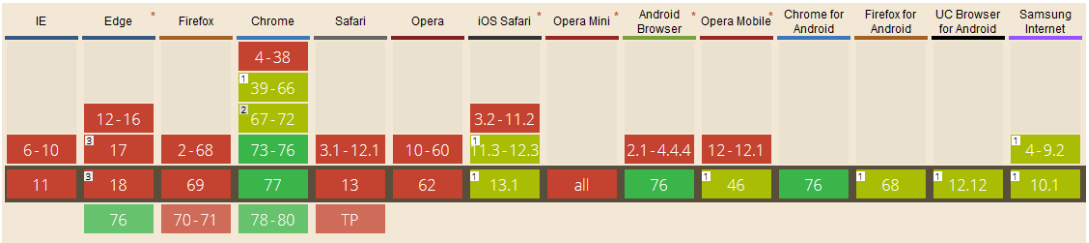

FIG. 2.8.: *Compatibility of the web manifest*

The web manifest is currently not widely supported on the desktop versions of many browsers. Currently only Googles Chrome fully supports it, in return though, most major mobile browsers (except Opera Mini) at least partly support the web manifest.

Figure 2.9 shows the web browsers support for the service worker whose primary goal is the offline functionality. Regardless of desktop or mobile platform, it is currently supported by every major web browser except Internet Explorer and Opera Mini.

If the PWA should use push notifications to inform its users about new occurrences and fulfill the re-engageable characteristic (see chapter 2.3.1) it can use the Push API which is another specification that needs to be implemented by the web browsers manufacturer.

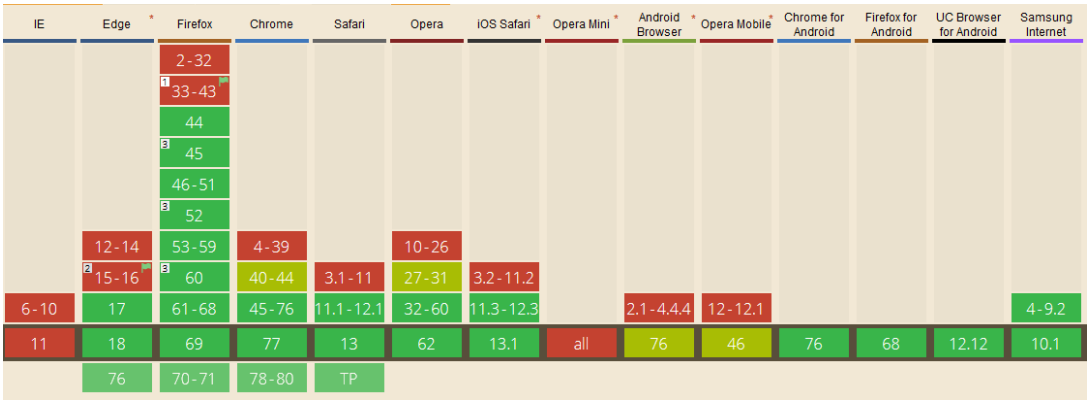

FIG. 2.9.: *Compatibility of the service worker*

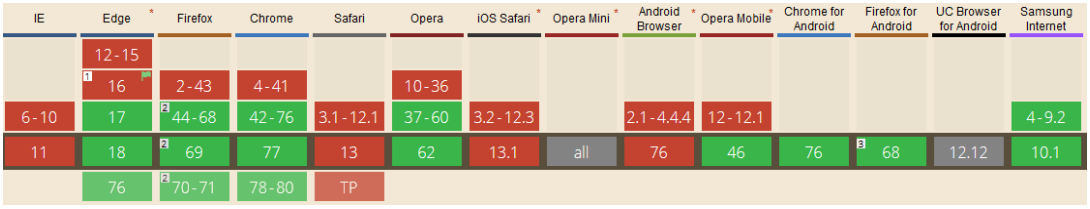

FIG. 2.10.: *Compatibility of the Push API*

As seen in figure 2.10, most manufactures have implemented this feature, Apple falls behind with their desktop and mobile web browser Safari as well as Microsoft's Internet Explorer.

Thinking back on the first characteristic of a PWA, being progressive, a non-supported feature (e.g. the web manifest in Mozilla's Firefox) won't lock the user out of the app as all these specifications should only enhance the user experience and not lock the user out from using the core functionality of a web app.

3. Conception

This chapter comprises the foundation work for our project. Beyond our initial literature driven conclusion about the software design we engaged with potential end user early to shape our software's specifications and gamification design. We consider this chapter the core of our contribution.

3.1. User Feedback

To validate the conclusions we drew from literature research we also gathered potential user feedback to guide our development efforts. First we conducted a short survey to figure out which phases of the risk management process and which platforms we should pay special attention to. We then developed an interactive mock-up to illustrate the core functionality of our application and did some user interviews based on that. We used the feedback to determine the focus areas and features of the application.

3.1.1. Survey

The survey was conducted among project managers in two big German IT companies. The first sample was collected in December 2019 and amounted to ten answers. The second sample was gathered in January 2020 and contains of 18 project managers. Due to the small sample size our results are not generalizable. To draw any scientific conclusion the findings would have to be

verified with a larger sample. However the results are still useful for guiding our development efforts.

We asked the PMs about their previous project experiences in terms of risk managment practice and risks encountered. We also included questions about the importance of different risk managment phases and the usefullness of tool support for them. Finally we gathered information about the platforms they used and on which they would want a risk managment tool. The full questionnaire can be found in the appendix.

The majority of the PMs we surveyed did undertake risk managment efforts for their projects which they oversaw during the last year. Those who did not mostly cited project size as their reason, however some said they usually didn't do it and two even thought it not useful at all as can be seen in FIG.3.1 and FIG.3.2. We take from that the PMs are generally aware and do undertake risk management efforts given sufficent project volume.

FIG. 3.1.: *Engagement in risk management*

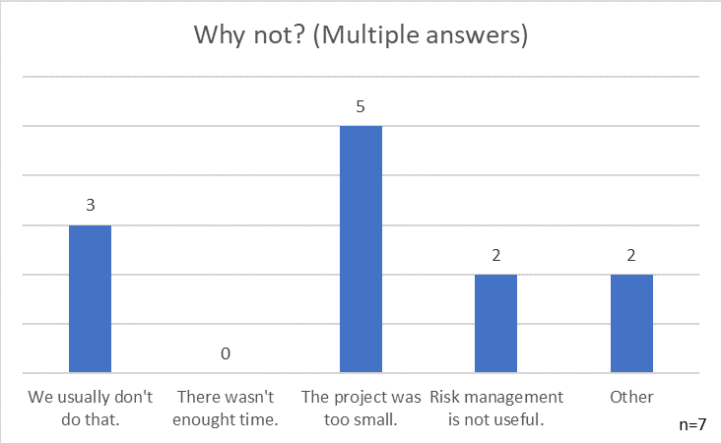

FIG. 3.2.: *Reasons for no engagement*

In accordance with the literature all participants who did undertake risk management made an initial commtiment to risk analysis but fewer reported to have to have engange in long term activities for risk monitoring and controlling as depicted in FIG.3.3. Also when asked about the importance of the different phases the PMs placed a stronger emphasis on the initial phases. Knowing and understanding the risks seem to appear slightly more important than actually dealing with it over the course of the project (see FIG.3.4). We therefore believe it is necessary to re-engage the project members throughout the project lifetime so that the less practiced phases of risk management are not overlooked. As argued in the beginning all stages are relevant and should be supported by the software.

FIG. 3.3.: *Engagement across process stages*

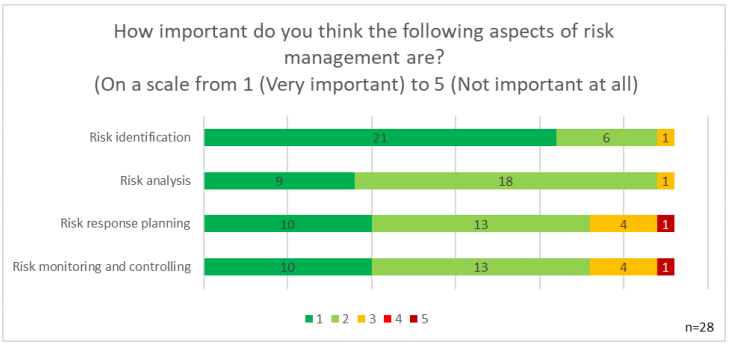

FIG. 3.4.: *Importance of process stages*

We also found that the project managers in general were open towards software support for risk management. Many had already used a tool for their efforts and those who didn't were mostly open to the idea (see FIG.3.5). Some used specific risk management softwares whereas others had customized excel sheets. We thus assume that our chances to gain acceptance for our software are high as long as we provide a good user experience because the PMS are in general open to software support.

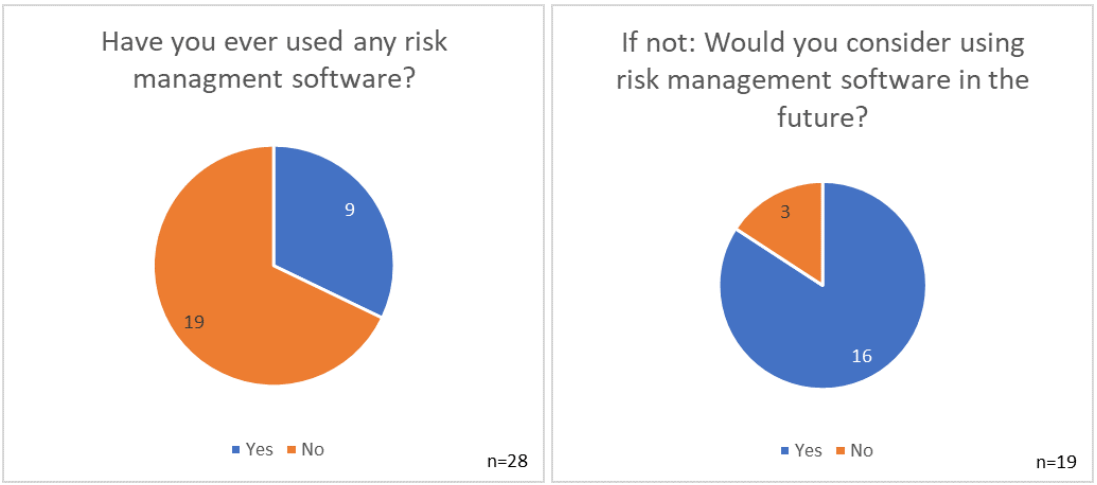

FIG. 3.5.: *Willingness to use software for risk management efforts*

We again find our conclusion supported that risk managment software can be especially useful for keeping efforts alive long-term with the next survey question. We specifically asked the PMS who were open for tool support which phase of the process would in their eyes benefit

most from tool support[1]. Monitoring and controlling is the most frequently picked option as FIG.3.6 shows.

FIG. 3.6.: *Tool usefulness across process stages*

Finally we asked the PMs on which platforms they would want to use a risk management tool on (see FIG.3.7). Mainly they preferred desktop computers with different operating systems (MacOS, Windows and Linux were all mentioned). Roughly a third would also like to have a mobile solution, however. It is noteworth that all who picked mobile also chose desktop aswell. From this question we derive that our PWA approach is a good way to cover all usage preferences.

FIG. 3.7.: *Grouped answers: Platform preference for tool usage*

From these results we developed a basic clickable prototype of the software which can be found at: No Risk No Fun - Interactive Prototype. It is an initial sketch of how we intended to realize the above described conclusions in our software. We used the prototype to gain further

[1]Unfortunately filtering issues occured at the second company for the last questions which is why not all participants who should have received the question can be reported.

feedback for refining our designs. This feedback can be found in the following section, the refined software specifications are described in 3.2.

3.1.2. Interviews

For the interviews we managed to secure further support from the company surveyed in December. Three project managers agreed to test our mock-up prototype and give us feedback. Two of the PMs were male, one was female. All three were provided with a convertible device and requested to explore the prototype while thinking out loud. We asked them to speak out whatever came to their minds while using the mock-ups and to pose any questions that came up. Afterwards we asked them for their overall assessment of the tool, which parts of it they deemed useful and where it was lacking.

All project managers rated the tool as useful for risk management efforts though for different reasons. Two of them said it was helpful in focusing their activities. One said that usually risk management was more of a minor activity that happened on the side. The other described the initally discussed pattern of risk management happening at the beginning of the project and then being neglected, forgotton or tedious to come back to. He expected that activity tracking and easy notification of team members via delibarte push notifications could actually turn risk managment into a process instead of a one-time activity. This supports our focus on motivation and long term commitment.

The third PM was more skeptical of these kinds of features. He said that with some or perhaps more considerable effort he could build such a process into his task managing tool and thus preferred not having to manage two tools. However, he saw much use in the risk pool feature which collects and persists the experience of many projects and thus would provide valuable guidance. The risk pool was also deemed useful by the other two PMs. We thus conclude that the risk pool is pracitcable way to adress the need of documentation and knowledge persistance identified in 2.1.4.

All PMs also appreciated that risk evaluation was a group task and not determined by individual opinions. The fact that adjustment and re-opening of risk evaluation was possible after the inital risk assessment.

All three PMS requested more visual reporting aid to gain a clearer view of project health status. We take from it, that the activity graph does not sufficently cover the need for visualization and that further reporting graphics should be devised.

Furthermore some functionalities or positioning was not understood, which we will work on improving in the actual application. Also many small additional features were suggested which are listed in the appedix for future expansion.

3.2. Software Specification

3.2.1. Purpose and Scope

There are risk management tools on the market to support project managers in their risk management activities. Some tools have a similar focus to this work [31], [32] others are oriented towards company risk managment [33] wheareas again others are project management tools with a risk managment section [**https://www.ntaskmanager.com/**]. Those programs contain similar features as discussed in **??** and **??**. They do not cover user engagement however. To prevent negligence in the course of project life we want to add gamification elements as discussed in **??** to incorporate not only process support but to also consider the human factor. We want to develop a flexible application prototype to support project managers and their teams with their risk management activities. The app should cover all four phases of the risk management process, it should be able to learn with the teams' experiences and it should be engaging. We do not want to provide pre-defined risks or mitigations in the scope of this work. We also explicitly focus on project risk management, not on company risk management or IT security issues.

3.2.2. Functionalities

We have developed eleven use cases that describe the program functionalities. There are basic functionalities which cover the user and project administration. Risk management related functionalities cover the administration and evaluation of risks and risk responses. The learning aspect is covered by what we call a 'risk pool' and finally there are gamification use cases for user engagement. The detailed descriptions of these functionalities are subject of the following sections.

3.2.2.1. Overall Use Case Diagram

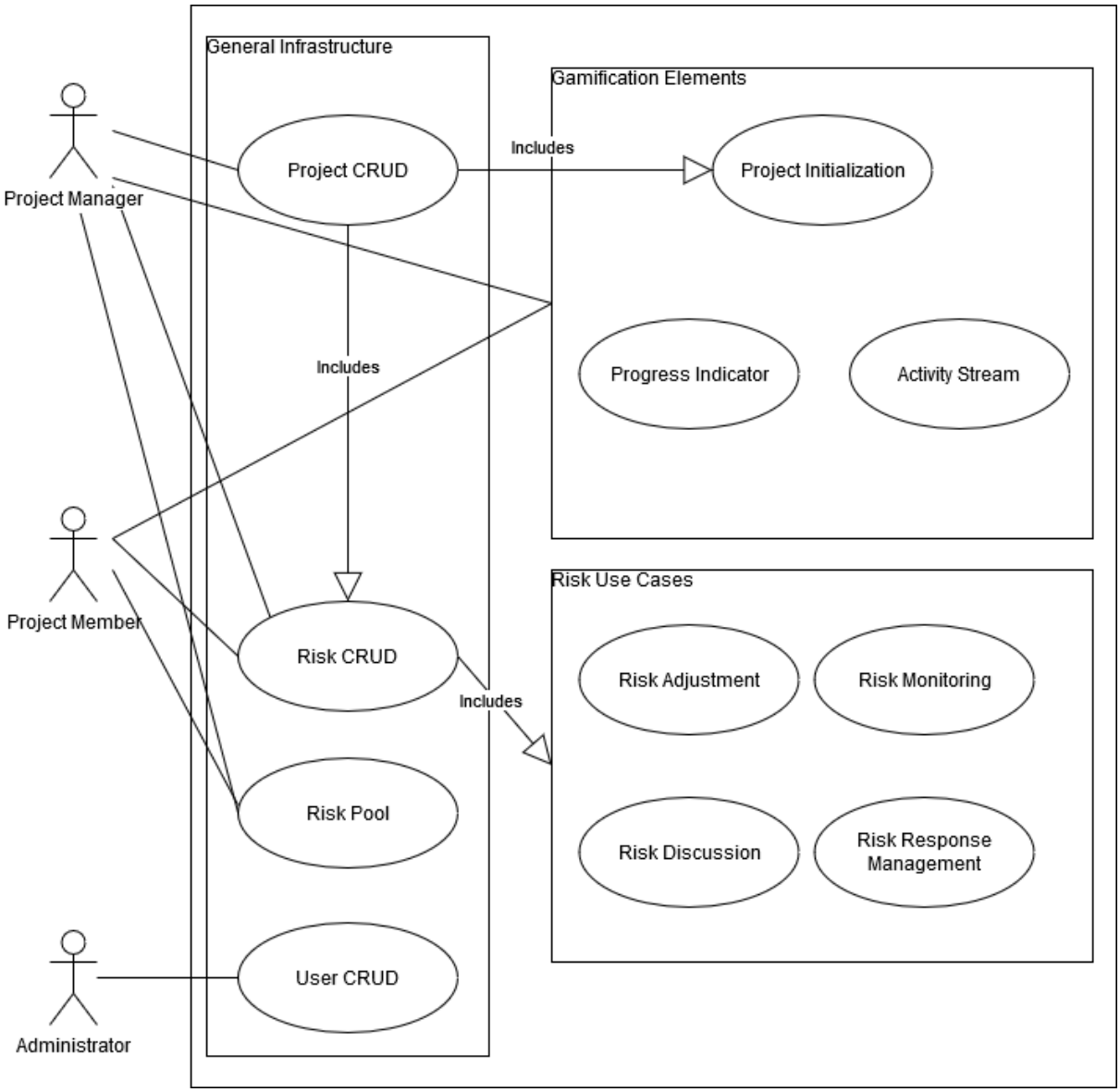

FIG. 3.8.: *Overall Use Case Diagram*

3.2.2.2. Use Case Specification: UC1 User CRUD

Description

This use case specifies how user accounts are being created, updated, deleted and are used for login and logout. These fields are required for the user account creation:

- e-mail adress (String)
- password (String)

Additionaly the user can set the following field while updating his account:

- language (enum)

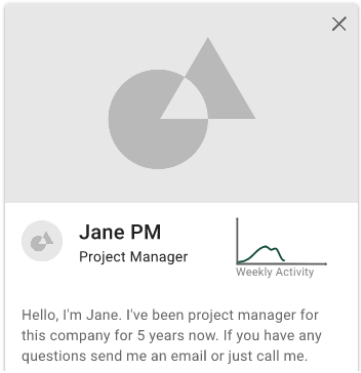

FIG. 3.9.: *Use Case 1: Mock Prototype*

Basic Flow

New Account:

- The visitor clicks the "register" button and fills in the fields mentioned in the brief description.
- Then clicks on the "register" button below the form to send the input to the server.
- If the visitors input fulfills the criteria of a username, email and password the account is being created on the server and a conformation e-mail is send to the given e-mail address.

The account itself can only be used after by clicking on the provided link in the conformation e-mail.

Update Account:

- The user is logged in and clicks on the "settings" button.
- After updating the the fields the user wants to change, the input is sent to the server.
- If the updated fields fulfill their criteria, those fields are updated on the server.

Delete Account:

- The user is logged in and clicks on the "settings" button.
- The user then clicks on the "delete my profile" button.
- After typing in the users password, the request to delete the profile can be send to the server by clicking on the "delete" button.
- If the given password match the user's password the account is being deleted on the server and user will be logged out.

Login:

- The visitor already created an account and wants to log in.

- Therefor the "login" button must be clicked and the e-mail and password fields have to be filled in.
- The visitor can then click the "login" button below the form.
- If the e-mail and password match an entry of the list of registered users, the visitor will be logged in and can act as an user.

Logout:

- The user is logged in and wants to log out.
- By clicking the "logout" button the client removes all information used to authenticate to the server and forces the user interface to render without any user specific information fetched from the server.

The user is now able to login again.

Activity Diagram

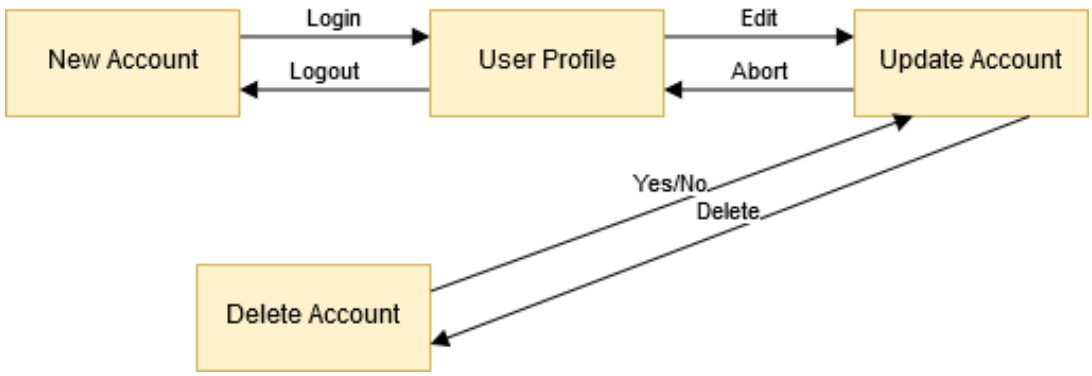

FIG. 3.10.: *Activity Diagram UC1 User CRUD*

Alternative Flows

Invalid input:

- The user / visitor fills in the required fields (username, e-mail, password, language).
- If one field does not meet its criteria (e.g. an e-mail should contain the @-sign), which is validated by the server after submitting the input, the user / visitor will be informed next to the input fields.

In this case the user account won't be created nor updated.

Invalid user credentials:

- If a visitor wants to login into an existing user account or if an account should be deleted by a user, the user accounts credentials have to be submitted (e-mail and password for login, password only for deletion).
- If the account credentials do not match any entry on the server, the user / visitor will be informed next to the input fields.

In this flow the visitor won't be logged in and neither will the account be deleted.

Special Requirements and Preconditions

Different flows require different preconditions.

1. If a visitor wants to log into an user account has to exist or created beforehand.
2. If a user wants to log out, the user has to be logged in.
3. If a user wants to update or delete the account,the user has to be logged in, too.

Postconditions and Persistance

Mentionable postconditions are:

1. After deleting an account, the account can not be restored and therefor not being used anymore.
2. Furthermore logging in allows a user to then access user related content from the server and logging out hides all user related content respectively.

The persistence guidelines are:
Creating, updating and deleting a user account or logging in by filling in the required fields and then submitting the input leads to a POST request to the server. If the fields fulfill their criteria, the information will be persisted on the server. Logging out will only delete the users authentication information on the client side and will not send a request to the server.

3.2.2.3. Use Case Specification: UC2 Project Access Management CRUD

Description

This use case specifies how projects are being created, updated, deleted and are used for grouping a pool of users and risks. The fields in the list below are required for the project creation:

- projetc name (String)
- project description (String)
- start date (Date)
- end date (Date)

Besides the required fields the project owner can set the following field while updating a project:

- project members (Strings: Usernames, E-Mails)

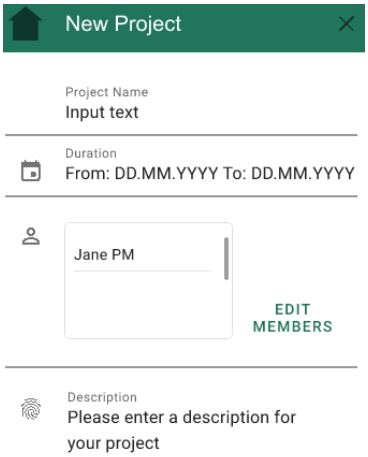

FIG. 3.11.: *Use Case 2: Mock Prototype*

Basic Flow

New Project:

- The user is currently on the project page and clicks the "new project" button and fills in the required fields.
- Then clicks on the "create" button to send the input to the server.
- If the users input fulfills the criteria of a name, description and time span, the project will be created on the server and be available in the project list.

Update Project:

- The user opened the detailed project page by clicking on it on the project list and then clicks the "edit" button.
- After updating the fields the user, to be more precise the project owner, intended to change, those updated fields are send to the server by clicking the "save" button.
- If the updated fields fulfill their criterias, those fields are updated on the server and in the user interface.

Adding users while updating a project is the basis to work on risks together as described in chapter 3.2.2.4

Delete Project:

- The project owner opened the detailed project page by clicking on it on the project list and then clicks the "edit" button.
- The owner then clicks on the "delete" button.
- After typing in the users password, the request to delete the project will be send to the server once the "delete" button is clicked.
- If the given password match the owner's password the project, including all related risks, is being deleted on the server and removed from the project list in the user interface.

Activity Diagram

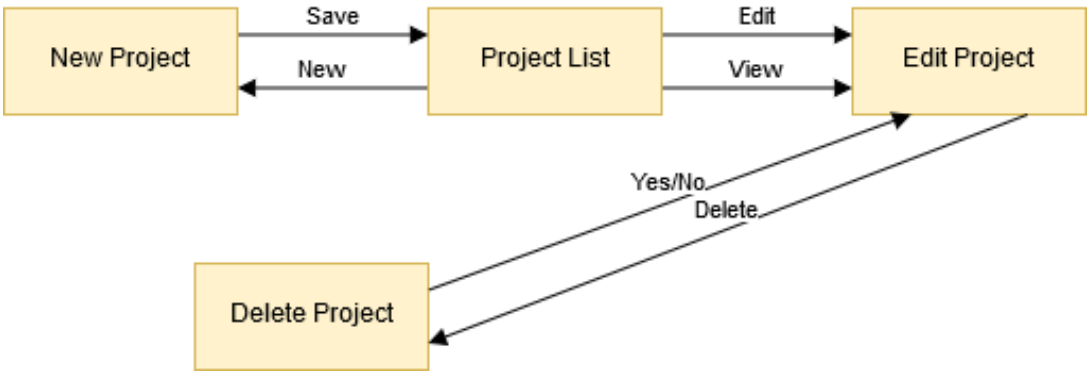

FIG. 3.12.: *Activity Diagram UC2 Project CRUD*

Alternative Flows

Invalid input:

- Like chapter 3.2.2.2 "Invalid Input", but for project creations and updates.

Invalid user credentials:

- Like chapter 3.2.2.2 "Invalid user credentials", but for project deletion.

Special Requirements and Preconditions

Generally, the user who created the project is automatically the project owner.

1. The user has to be logged in to create a project.
2. The user has to be the owner of a project to edit it.

Postconditions and Persistance

Mentionable postconditions are:

1. When deleting a project, the project including all related risks can not be restored.
2. After creating a project and adding users, users will be able to access it and create risks within.

The persistence guidelines are:
All mentioned basic flows above create POST requests to the server and additionally, if the fields meet their criterias the data will be persisted.

3.2.2.4. Use Case Specification: UC3 Risk CRUD

Description

This use case allows users to create, read, update and delete risks. A risk consists of the following fields:

- name (String)
- description (String)

Following fields are filled later and are not part of the input form:

- probability of occurence (Enum)
- impact (Enum)
- risk factor (Enum)
- response (Objects)
- person in charge (User)
- public risk (boolean)

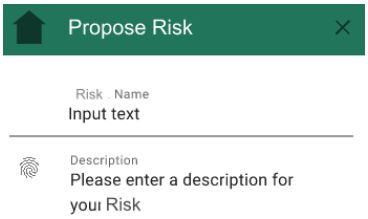

FIG. 3.13.: *Use Case 3: Mock Prototype*

Basic Flow

Creating a risk:

- When the user clicks the "+" button at the project overview page.
- Then the screen for adding a new risk is opened.
- When the risk form is filled by the user.
- And the user clicks on the "Propose risk" button.
- Then the risk is synced with the server.

Reading a risk:

- The user is on the project overview site with all project risks.
- By clicking on a risk a detail risk view is opened.
- For exiting the risk detail view a return button ("Close" button) is clicked.

Updating a risk:

- The user is on the project overview site with all project risks.
- By clicking on a risk a detail risk view is opened.
- On the detail view there is a pen button, enabling editing and changing the "Close" button to a "Save" button.
- When clicking the "Save" button the changes are syncronized with the server.

Deleting a risk:

- The user is on the project overview site with all project risks.
- By clicking on a risk a detail risk view is opened.
- By clicking a "Delete" button the risk is deleted. This behavior is changed in UC6 Risk Discussion described in chapter 3.2.2.7.

Activity Diagram

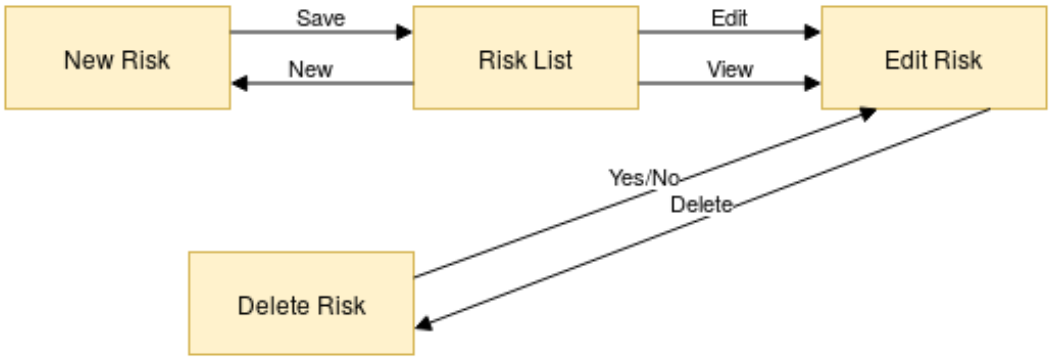

FIG. 3.14.: *Activity Diagram UC3 Risk CRUD*

Special Requirements and Preconditions

The preconditions for this use case are:

1. A project exists.
2. The user is member of the project.
3. The user has clicked the "+" button at the project overview page to add a new risk.

Postconditions and Persistance

The postconditions for this use case are:

1. The risk is immediately part of the projects risk table (this behavior is changed within UC6 Risk Discussion described in chapter 3.2.2.7).

The persistence guidelines are:
The risk form was completely or partly filled by the user. When the user tries to leave the page now, there should be a prompt for exiting. When the risk form is filled out and the button "Propose risk" is clicked a POST request syncs the status with the server.

3.2.2.5. Use Case Specification: UC4 Project risk adjustment

Description

After a risk has been submitted and evaluated by the team it is grouped into three categories. However, within these categories the initial order is simply that the risks submitted first will be placed at the top. This use case allows the teams to prioritize risks according to their perceived risk urgency. On the project risk overview page the after the initial risk evaluation users will find a button they can use to adjust the ranking. They will then enter adjustment mode where they can arrange the risks according to their perceived urgency and submit their ranking. Then they will return to the overview where the risks will be displayed according to their average relative ranking positions. The adjust button will be disabled until new risks are added to prevent manipulation. The user will be notified that they cannot rank multiple times when they first go through the adjustment process.

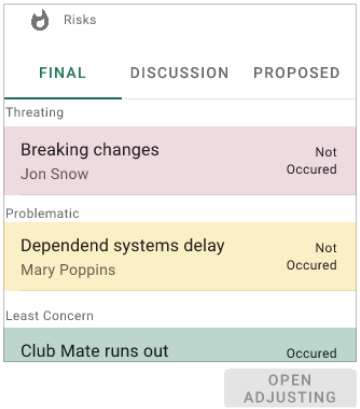

FIG. 3.15.: *Use Case 4: Mock Prototype*

Basic Flow

- The user is on the project overview site with all project risks.
- By clicking on a "Rank Risks" button the ranking view is enabled and the button becomes a submit button.
- The user can order the risks according to his personal priority.
- The user submits their preferred order.
- This order is submitted to the server and the average rank for every risk according to the current submissions is calculated.
- The risks on the risk overview page are displayed accordingly.
- The adjust button is disabled for users who have already submitted a ranking.

Activity Diagram

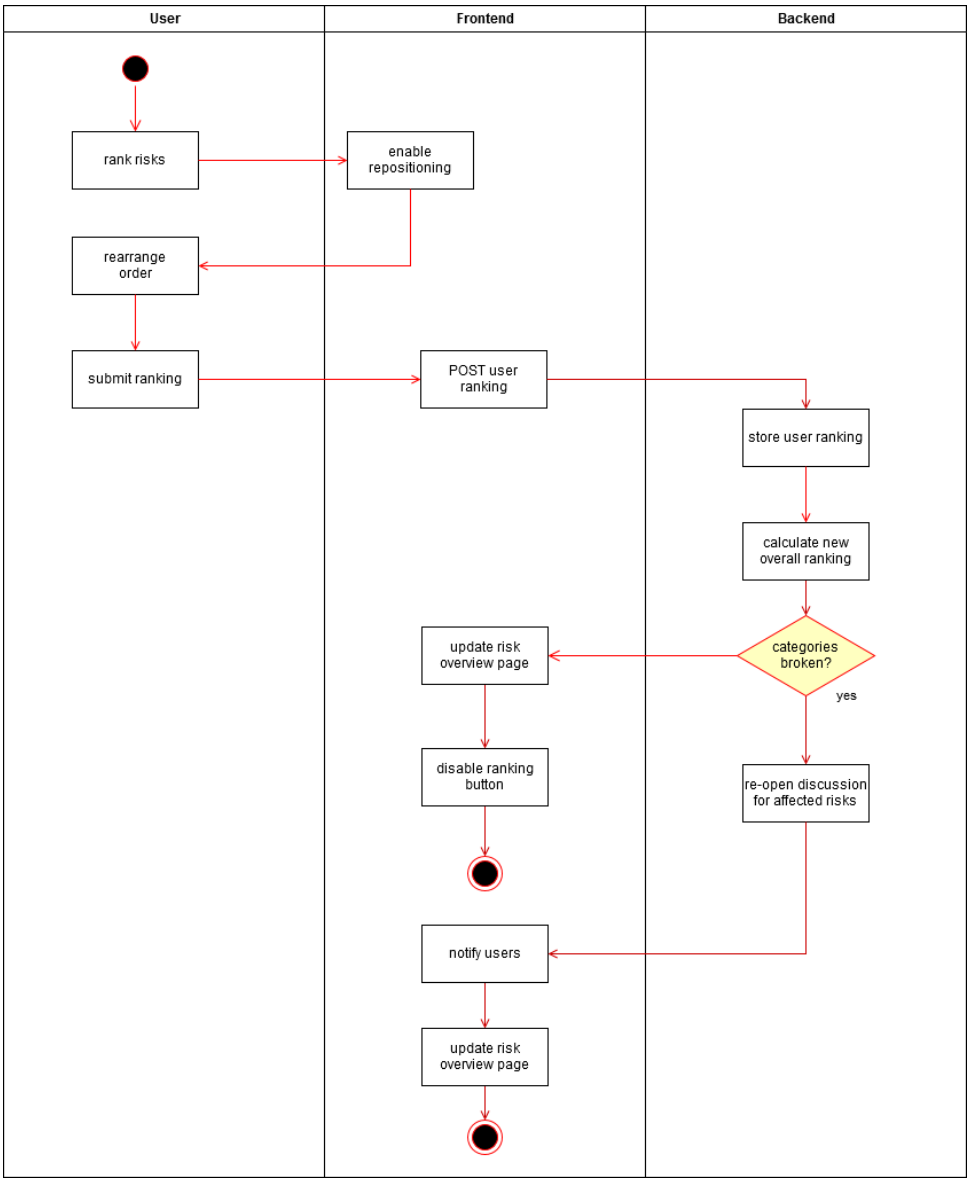

FIG. 3.16.: *Activity Diagram Use Case 4*

Alternative Flows

The following steps will be added if the user enters the ranking process for the first time or has not participated in a ranking process for a prolonged period of time:

- When the user presses the ranking button before the ranking mode is enabled an explation prompt will be shown.
- The user will be informed that they can submit their ranking only once.
- The user can either choose to confirm or they can choose that they do not want to be notified again doubling the time before the notification is shown again.

The following steps will be added should the risk adjustment contradict the intital risk assesment:

- A risk is ranked outside its category due to the average ranking process.
- The risk discussion on the risks which are now out of category is re-opened.
- The team members receive a notification to re-evaluate those risks.

Special Requirements and Preconditions

This use case has the following preconditions:

1. The user is part of a project which contains risks.
2. The initial risk discussion is finished.
3. The user has either not yet ranked the risks or
4. the risk adjustment has been re-opened by the project manager.

Postconditions and Persistance

The postconditions for this use case are:

1. The risk order will be updated for all project members.
2. The ranking option will be disabled until new risks are proposed or the ranking is manually reset by the project manager. The ranking results are persisted in the database. The user ranking is transmitted to the backend via post request where the project risk ranking is handled accordingly.

3.2.2.6. Use Case Specification: UC5 Risk Pool

Description

The risk pool serves to share knowledge among different teams and to store experiences. Users can vote for project risks to be added to the risk pool. After a certain quorum is reached the risk will be moved to the risk pool and will be persisted together with its responses there. Whenever a new risk is created the user will then have the option to check the pool risks if their risk is already present. They can then add a reference to the pool risks to their project risks. Pool risk can already have responses attached to them and will display the average occurrence probability and impact severity estimates of their project references giving an indication of how other teams evaluated the risk. The individual project risk evaluation process will still be undertaken for pool risks.

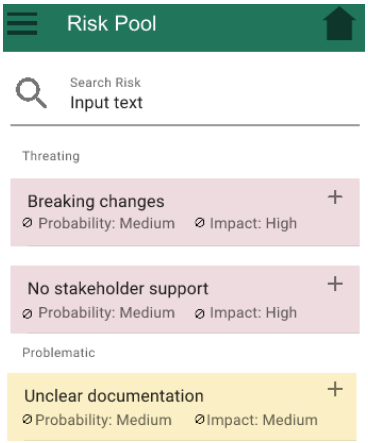

FIG. 3.17.: *Use Case 5: Mock Prototype*

To remove risks from the risk pool a user will have to request a voting process on the pool risk. They can choose to either have the risk deleted (because it is outdated for example) or to merge it with another risk. All users will then be notified that a pool risk is up for discussion and will be invited to vote. If the vote is favorable the risk will be deleted and in case of a merge request its responses and references will be moved to the merge risk.
Quorums can be adjusted by project managers however there will be a notification that the change affects all teams and other project managers will receive a notification should a quorum be changed.

Basic Flow

Add flow:

- A user clicks on the "nominate for risk pool" button on a project risk's detail page.
- Other users on the project team will be notified that a risk has been nominated.
- The nomination button will be replaced by a support button for these users.
- Once a pre-defined quorum of users has supported the nomination the risk will be moved to the risk pool and the project risk will become a reference to the pool risk.

Remove flow:

- A user nominates a pool risk for being removed on the pool risk's detail page.
- All users who are part of a project that references the pool risks will be notified.
- The nomination button will be replaced by a support button for those users.
- If a pre-defined quorum of users supports the nomination the project references will be turned into copies of the original risk and the copies risk will be removed from the risk pool.

Duplicate flow:

- A user marks a pool risk as being a duplicate.
- The user will be shown a list of pool risks to mark the corresponding risk.
- All users which are part of projects that reference either risk will be notified.
- The nomination button will be replaced by a confirmation button for those users.
- If a pre-defined quorum of users confirms the duplication the risks will be merged.
- All references of the second risks will be redirected to the first, the response list will be merged and the duplicate will be deleted.

Activity Diagram

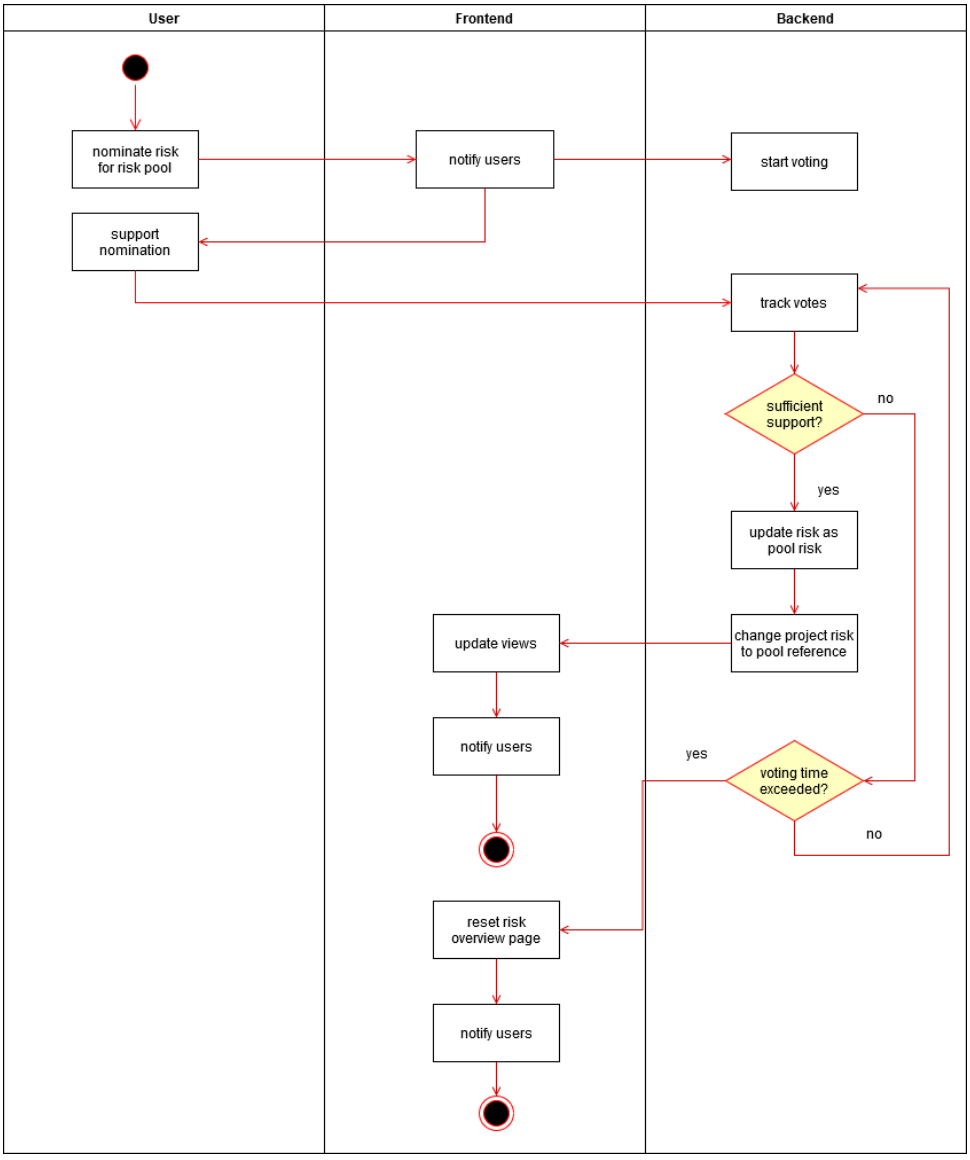

FIG. 3.18.: *Activity Diagram Use Case 5*

Alternative Flows

The last steps of the above described flows will change if the quorum is not met within a pre-defined timeframe.

- The risks will not be changed and the status from before the nomination will be restored.

Special Requirements and Preconditions

This use case has the following preconditions:

1. The user is part of a project which contains risks. Or
2. There is a risk in the risk pool. Or
3. There are two similar risks in the risk pool.

Postconditions and Persistance

The changes are instantly reflected in the database. Once the changes are confirmed corresponding PUT and DELETE requests update the database.

3.2.2.7. Use Case Specification: UC6 Risk Discussion

Description

The process of adding risks to a project is based on three steps:

1. A project member proposes a risk (name and description). (UC3 Risk CRUD defined in chapter 3.2.2.4).
2. A specified number of project members review the proposed risk. After the review process the risk is ready for discussion.
3. The whole project team discusses and defines:
   - probability of occurence
   - impact
   - risk factor (defined by probability of occurence and impact)
   - response(s)
   - person in charge

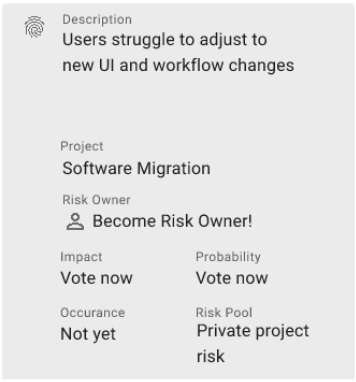

FIG. 3.19.: *Use Case 6: Mock Prototype*

Basic Flow

1. A project member proposes a risk (name and description as defined in UC3 Risk CRUD chapter 3.2.2.4)
   - The proposed risk is visible in the section proposed risks at the project overview page ("Proposed risks").
   - All members of the project receive a notification (in their activity stream) about the new proposed risk and the request to review it.
2. A specified number of project members review the proposed risk. After the review process the risk is ready for discussion.
   - When the specified number of project members have positively reviewed the risk, it is visible in the section ("Risks open to discussion").
   - The project owner is able to manually start an estimation session for the risk (not recommended). The recommended way is to wait until a specified number of

risks open for estimation are collected. Then an estimation session for all risks is automatically started.

3. The risk is estimated by the whole project team:
   - All project members receive a notification (in their activity stream) to estimate the risk in terms of (probability of occurrence, impact) and to add response(s). Probability of occurrence and impact are mandatory fields, response(s) are optional.
   - The risk factor is determined by the probability of occurrence and the impact.
   - It is checked if at least one response is defined. If not the project members are notified to add a response.
   - In the last step the person in charge is defined. Therefore a notification where the user is able to sign up for being responsible for the risk is sent to all project members.
4. Finally the risk appears at the project risk table ("Project risks").

Activity Diagram

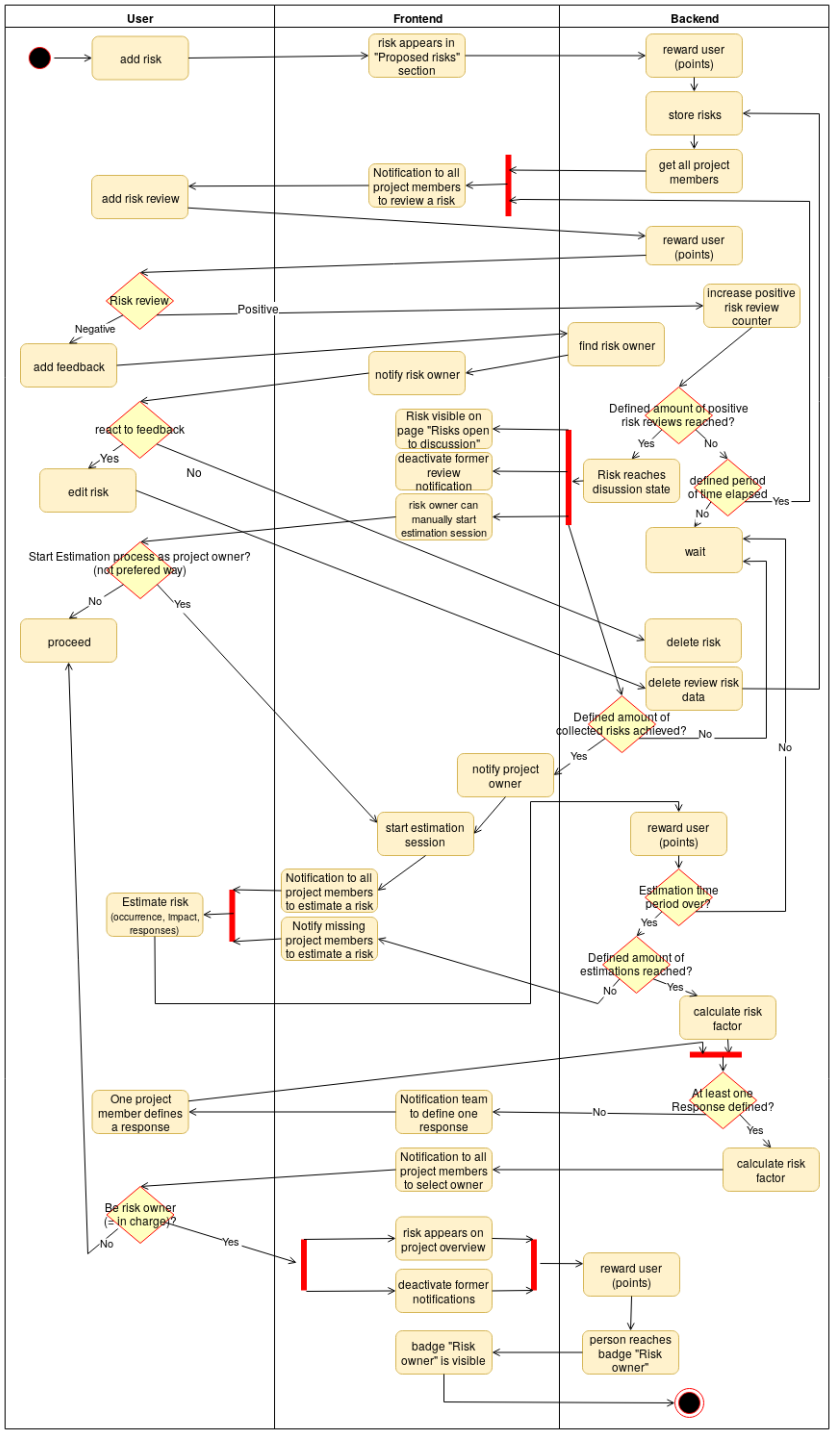

FIG. 3.20.: *Activity Diagram UC6 Risk Discussion*

Alternative Flows

Proposed risk receives negative reviews:

- A project member negatively reviews a risk.
- The reviewing person adds feedback for the risk which is sent to the risk owner.
- The risk owner can edit or delete the proposed risk.
- When the risk is deleted it is removed from the section proposed risks.
- When the risk is edited the review process data is removed and the message for reviewing is sent again.

Project members doesn't react to their notifications to:

1. review a risk: When the needed amount of reviews is not achieved the notification is sent again.
2. estimate a risk: When the needed amount of estimations is not achieved the notification is sent again.
3. define a person in charge: When no person volunteers the notification is sent again. For finding a risk person in charge fast the Gamification concept Challenge is used.

Special Requirements and Preconditions

The preconditions for this use case are:

1. A project exists.
2. The user is member of the project.
3. The user has proposed a risk.

Postconditions and Persistance

The postconditions for this use case are:

1. The proposed risk was reviewed and estimated.
2. The risk contains all relevant data.
3. The risk is visible as part of the projects risk table.

3.2.2.8. Use Case Specification: UC7 Risk Monitoring

Description

This UC deals with the monitoring of risks. It enables to remind the project team and its members to treat the defined risks.

Basic Flow

The risk's response defines if the defined action is done one-time or on a regular basis.

One-time:

- When adding a response to a risk which is only processed one time the user can set a fixed date due to the response should be done.
- Before the deadline the person in charge is notified. "Have you already done <the response> (Yes | No)".

Regular basis:

- When adding a response to a risk which is processed on a regular basis the user can set an interval in which the response should be done.
- The person in charge is notified in this interval. "Have you already done <the response> (Yes | No)".

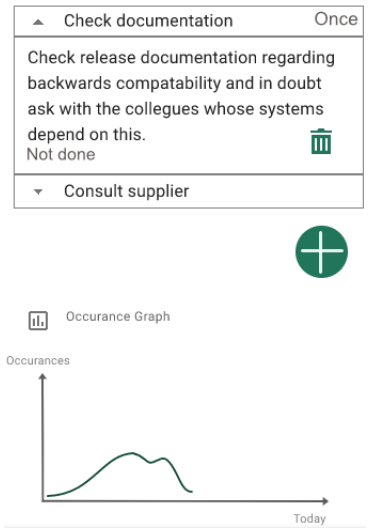

FIG. 3.21.: *Use Case 7: Mock Prototype*

Activity Diagram

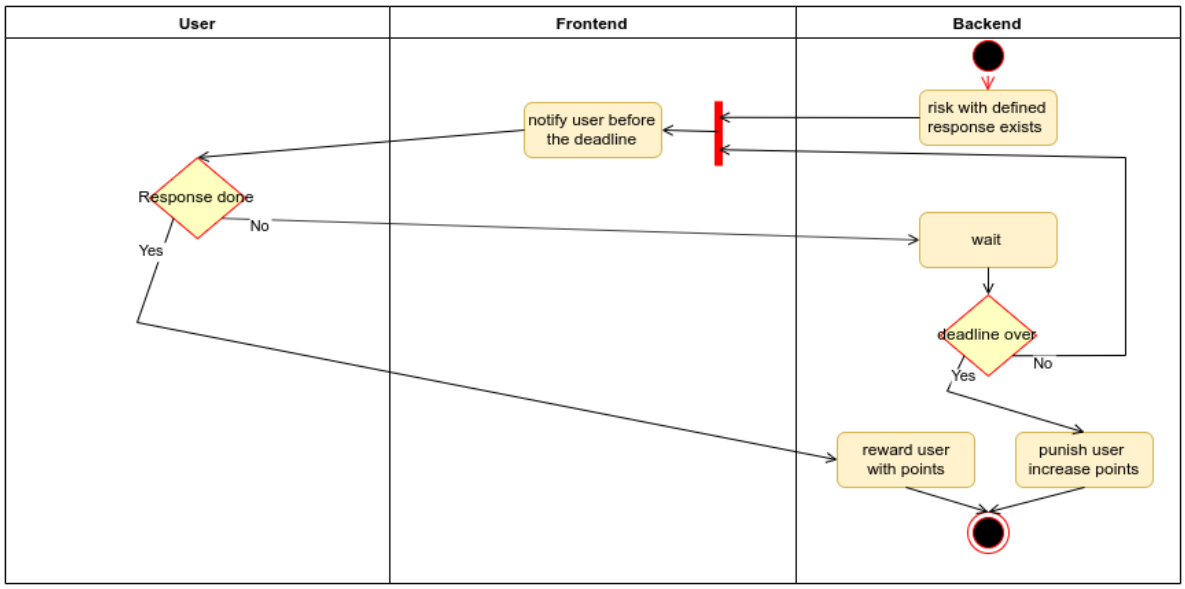

FIG. 3.22.: *Activity Diagram UC7 Risk Monitoring*

Special Requirements and Preconditions

The preconditions for this use case are:

1. A project exists.
2. The user is member of the project.
3. The user is person in charge of a risk.

Postconditions and Persistance

The postconditions for this use case are:

1. Best case: The risk's response was done and the user in charge is rewarded.
2. Undesired case: The risk's response was not done due to the deadline and the user in charge is punished.

3.2.2.9. Use Case Specification: UC8 Risk Response Management

Description

Responses are ways to react to a risk. A new response can be added to a risk from the risk detail page. A response contains a name, a type and a description as well as the information whether the described steps have already been undertaken or not. Depending on the Type of risk a reminder can be set to remind the risk owner to repeat the response tasks.
The risk owner can remove a response on a project risk if the project manager concurs.
If the risk is a pool risk the response can also be a pool response. Pool responses can only be removed if all project managers who currently reference the risk concur. However, pool responses can be deactivated for the current project with only the current project manager agreeing to prevent situationally unsuitable response reminders.
A new response to a pool risk can be turned into a pool response via a voting process among team members. This is a CRUD use case.

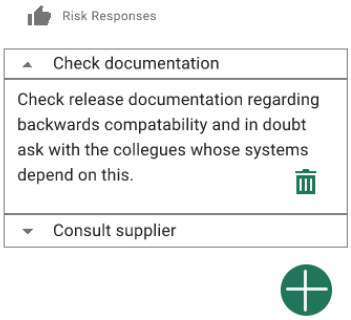

FIG. 3.23.: *Use Case 8: Mock Prototype*

Basic Flow

Creating a response:

- When the user clicks the "+" button at the risk detail page in the response section.
- Then the screen for adding a new response is opened.
- When the response form is filled by the user.
- And the user clicks on the "Add response" button.
- Then the risk is synced with the server.

Reading a response:

- The user is on the risk detail site for a project risk.
- By clicking on a response a detail view is expanded.
- For exiting the detail view a minimize button is clicked.

Updating a response:

- The user is on the risk detail site for a project risk.
- In the risk response section there is a pen button, which opens an editing form.
- By clicking the "Save" button the risk owner is notified of the changes.
- If the owner concurrs the changes are syncronized with the server.

Deleting a response:

- The user is on the risk detail site for a project risks.
- By clicking a "Delete" button the project manager receives a notification.
- If the project manager concurrs the response is deleted.

Activity Diagram

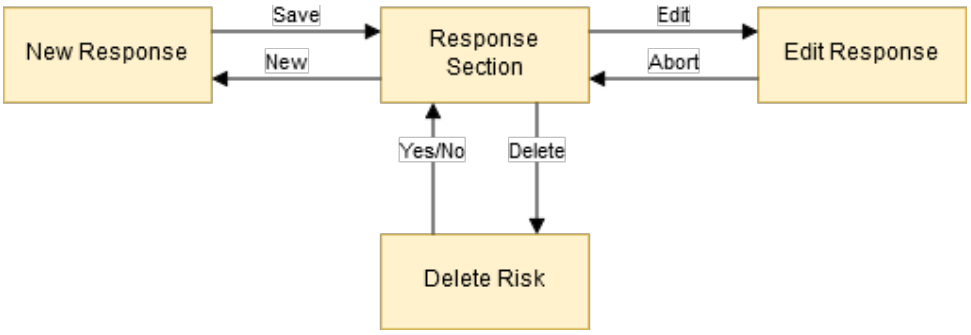

FIG. 3.24.: *Activity Diagram Use Case 8*

Alternative Flows

In addition to the crud functionalities responses attached to a risk that references a pool risk can be nominated for becoming a pool response and thus being attached to pool risk permanently. The voting process is the same as for pool risk nomination described in UC 53.2.2.6. The update and delete flows change if the response is a pool response attached to a pool risk.

- Updating a pool response requires project manager concurrance.
- Deleting a pool response will trigger a voting process as described in UC 53.2.2.6. However it will be limited to project managers to prevent users from deleting unpleasant responses.

Special Requirements and Preconditions

The preconditions for this use case are:

1. A risk exists.
2. The user is member of the project containing the risk.
3. Deleting requires the user to also be the owner of the risk.

For pool responses the following preconditions replace the above described:

1. The response is attached to a pool risk.

Postconditions and Persistance

Changes are directly reflected into the database via corresponding POST, PUT and DELETE requests.

3.2.2.10. Use Case Specification: UC9 Project Initialization

Description

To begin with the risk management process inital risk contributions are needed. Therefore a project is initialized with a starting challenge. The project manager sets an initial number of risks to be contributed, a deadline for them and a minimum number of supporters for a risk to be accepted into the discussion, as well as a deadline for the initial discussion process.

Basic Flow

- The project manager opens an unitialized project.
- They enter the above described paramters.
- They press the initialize button.
- All project members are notified.

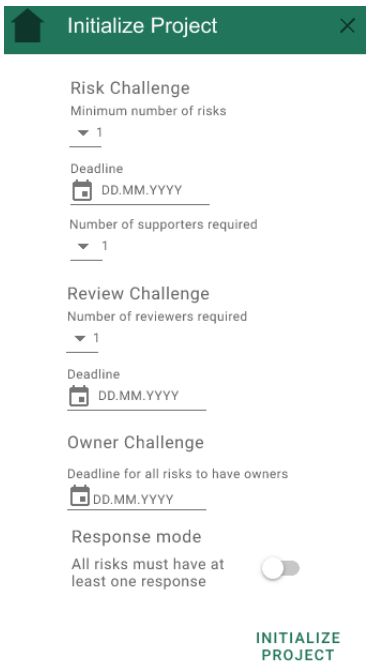

FIG. 3.25.: *Use Case 9: Mock Prototype*

Activity Diagram

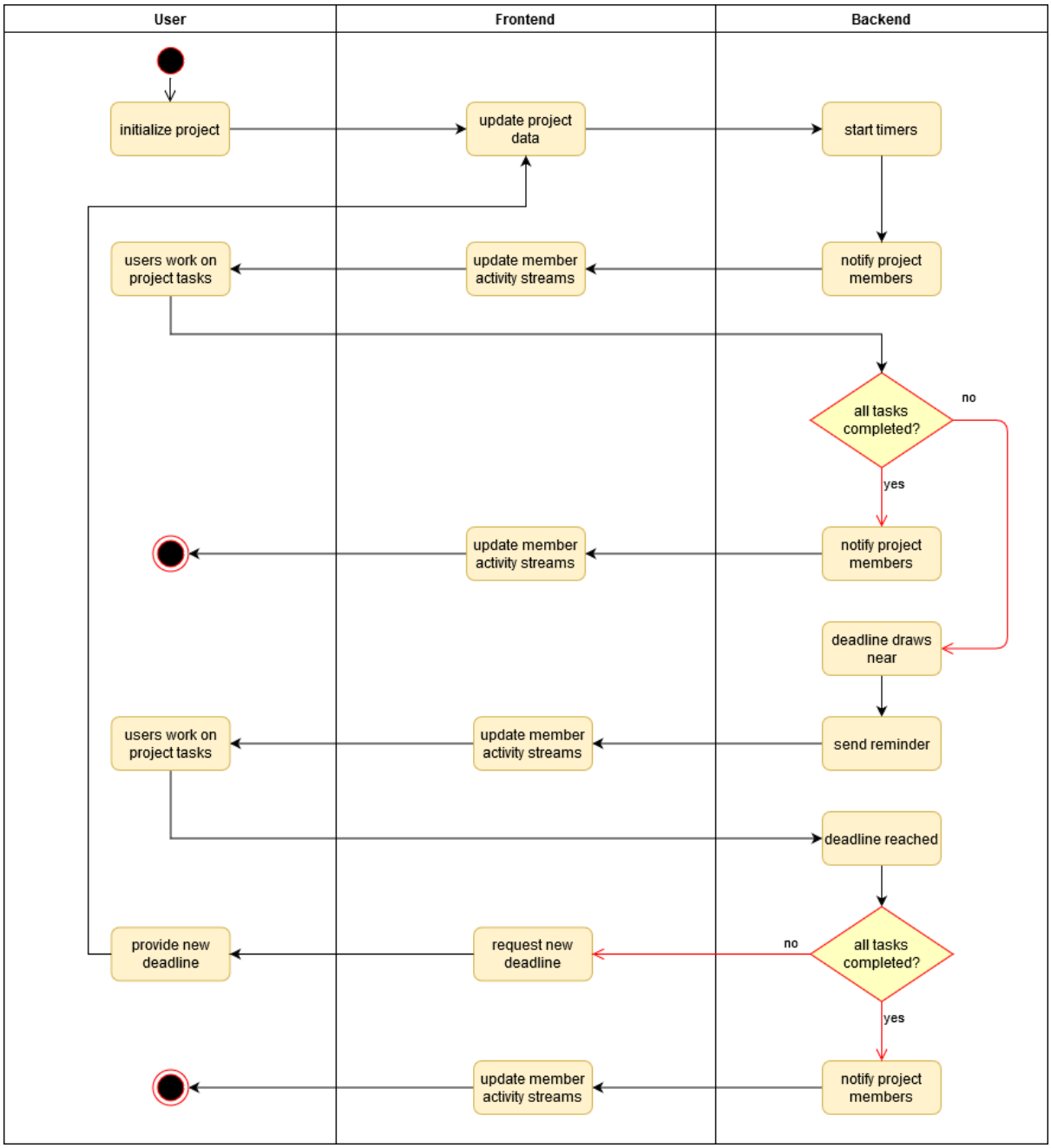

FIG. 3.26.: *Activity Diagram UC9 Project Initialization*

Alternative Flows
The initalization is canceled.

Special Requirements and Preconditions

1. The user is a project manager.
2. The project manager has already created a new project.

Postconditions and Persistance
The project will only be accessible and contain all its other described functions after being initialized.

3.2.2.11. Use Case Specification: UC10 Activity Stream

Description

A user should be able to see the latest activity (see chapter 2.2.3) in the given enviroment.

Basic Flow

Activity Stream:

- The user opens the home page where the activity stream can be found.
- Within the activity stream the user can then find the latest activities (examples mentioned above).
- Depending on the activity the user has the chance to interact with it and will be redirected to the specific item (e.g. a user can click on a new risks shown in his activity stream to open it).

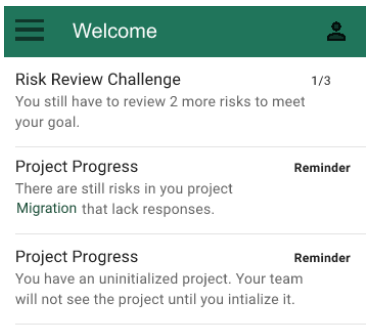

FIG. 3.27.: *Use Case 10: Mock Prototype*

Activity Diagram

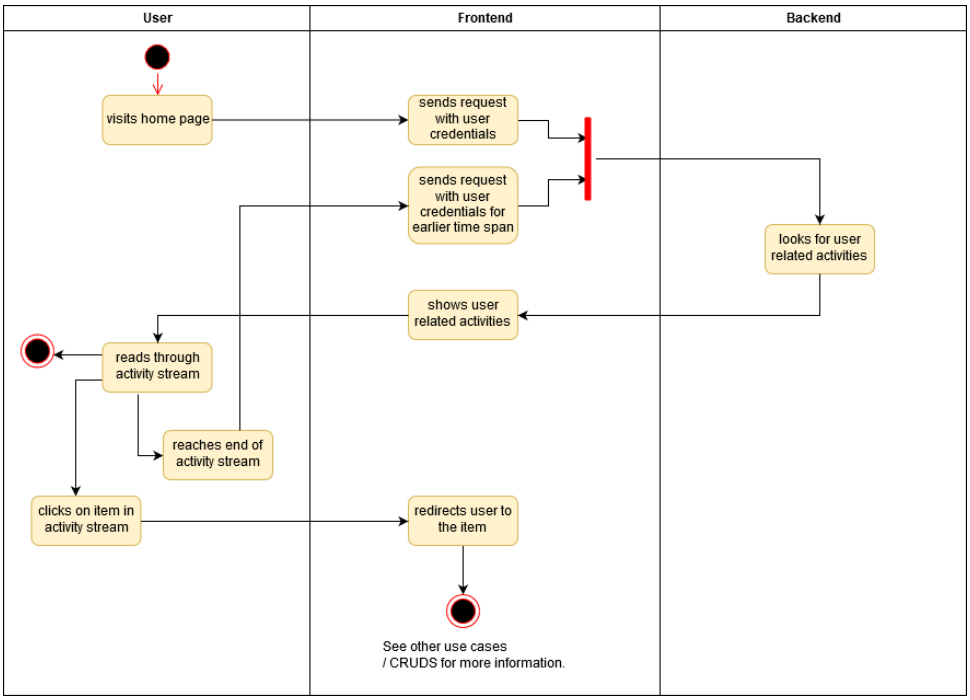

FIG. 3.28.: *Activity Diagram UC10 Activity Stream*

Special Requirements and Preconditions

As the activity contains personalized information, the following preconditions have to be fulfilled.

1. The user has to be logged in.
2. Alternatively a visitor can login to be redirect to the personal home page.

3.2.2.12. Use Case Specification: UC11 Progress Indicator

Description

This UC deals with the user's journey through the application. It can be divided into three phases:

1. Onboarding
2. Scaffolding
3. Progress

The UC's aim is to adapt the application to the different needs of the user in each phase.

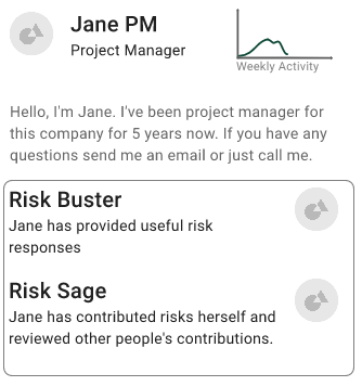

FIG. 3.29.: *Use Case 11: Mock Prototype*

Basic Flow

1. Onboarding
   - The user has registered and logs in for the first time.
   - A welcome dialog is displayed. It contains some minimal information about the application. At the end of this dialog there's a list of activities which can be done next by the user. The list of possible activities should be adapted dynamically to the user's status (e.g. already member of a project or not).
2. Scaffolding
   - Info boxes providing help about the usage and behavior of the application.
   - Progress bar, displaying and motivating new tasks which can be done by the user next.
3. Progress
   - The reached badges are displayed prominently at the start page and on the user detail page. The conception of badges in detail is described in TODO: ref auf gamification conception **??**.
   - The user is rewarded for desired behavior by points, which represent an activity indicator for each user. This is visualized for the user by a chart of reached points over time.

Activity Diagram

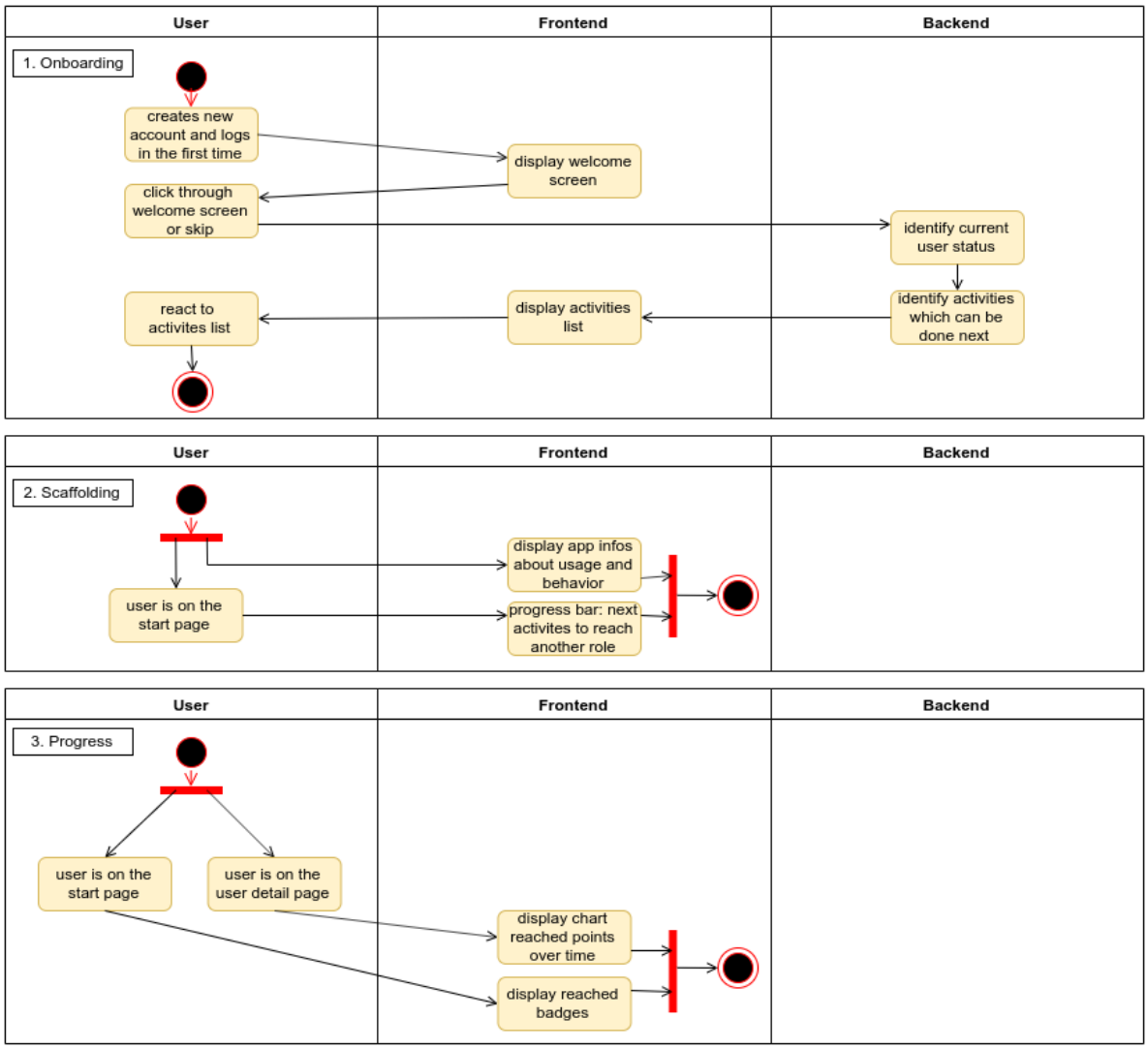

FIG. 3.30.: *Activity Diagram UC11 Progress Indicator*

Special Requirements and Preconditions

As a precondition the user has to create an account and login for the first time.

Postconditions and Persistance

The user was accompanied from beginner to an expert user. Therefore as a postcondition the user is advanced in using the application.

3.2.3. Requirements

This project is being developed as a student research project and part of the authors' curriculum and thus subject to the regulations of the Duale Hochschule Baden-Württemberg [34]. Given the limitations due to this circumstance we still aspire for our software to meet the following requirements.

Usability For the application to be usable on desktop and mobile device we use responsive design. We also aim for intuitive design using known symbols and functionalities to ensure user comfort. We adhere to design guidelines and we used a mock-up prototype to receive early user feedback.

Reliability We do not intend to provide hosting for the software. As project health is sensitive information for a company so this data is best left under the repective company's control. Therefore in terms of reliabilty we aim to provide a stable software but have no further service level agreements. To ensure software stability we make use of state of the art technology such as React with Redux, Spring Boot and a Postgre SQL database.

Performance To make our application fast and scalable we use RESTful apis. Our front end is designed as a single page application for faster in-app performance. For future development this also offers the option to develop offline functionalities. Our back end uses a container based approach using docker and docker compose.

Supportability We use sonar to ensure code quality for future maintance and expandability. We work with contious integration, deployment and delivery to maintain program stability using appropiate unit and integration tests. Furthermore we do code reviews and follow the SOLID design principles.

3.2.4. Design Constraints

The software is designed as a web application so internet access will be required. As a PWA the application can support offline functionality however that will not be implemented within the scope of this project. Due to the chosen technology we also cannot guarantee all features to be available for every webbrowser, howver the application is designed to provide the core functionalities even without additional PWA features.

3.2.5. Interfaces

3.2.5.1. User Interfaces

The application will start on the home screen. After registration and login the home screen will transform into the specific user's activity stream page which covers all recent events relevant to the user. From there the user can navigate to their project screen which lists all their project. The project detail view also covers the risks for the respective project. The risk detail view incorporates risk responses. When adding new risks users can open the risk pool to view all pool risks available to the company.

3.2.5.2. Further Interfaces

Since our PWA is supposed to be re-engaging we use push notification to enhance user commitment. To do so we use Google's Firebase Cloud Messaging. Documentation for Firebase can be found at https://firebase.google.com/docs/cloud-messaging.

3.3. Architecture

In this chapter the used architectural patterns, technologies, frameworks and libraries are briefly explained. First, an overall composition is given whose individual layers will then be explicitly described.

3.3.1. Overall composition

Based on the Model-View-Controller (Model View Controller (MVC)) architectural pattern the application is split into three major parts: the frontend, backend and the persistence layer. As seen in figure 3.31 the frontend is in charge of the view and the backend of the model and controller.

In terms of the MVC pattern, the view / frontend is a presentational layer accessible by the user – traditionally a user interface. The model is equivalent to the data of an application which can be persisted with any appropriate technology (e.g. a database). The data itself can be accessed, updated or deleted by the controller. Furthermore, the controller is in charge of the logic of the application [35, p. 7].

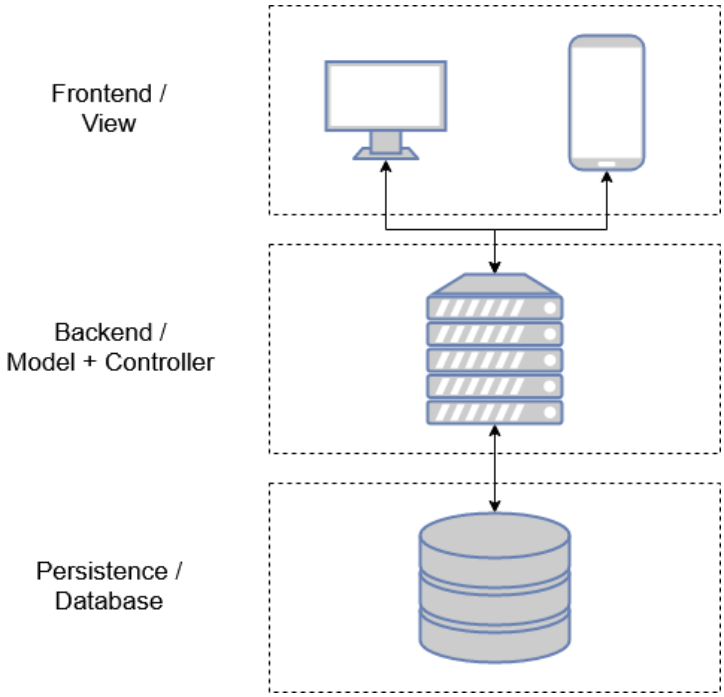

FIG. 3.31.: *Overall Composition*
[own representation]

3.3.2. Frontend / View

The view of the application is primarly developed with React (Version 16.8.5, 19/11/2019) and Redux (Version 6.0.1, 19/11/2019).

React is a JavaScript library written by Facebook Inc. for developing user interfaces (typically web apps). The major benefits from using React are components and their states. Components (e.g. an alert) are written in JavaScript XML (JSX) and reusable which means when written

once they can be reused anywhere else in the user interface, thus duplicate source code can be avoided. In React a component can hold its own state (e.g. the alert message or alert duration) which can be used for the user interface. If the state of a component changes and is involved in the user interface React automatically updates the user interface with the new state, making the development of the user interface easier as elements do not have to be addressed manually and then adjusted with the new content [36, p. 7-8].

Even though components can pass their states in hierarchical order, having a central store for the state of the components has several benefits as simplifying the overall project structure and easier testing. Redux is a JavaScript library providing such a store and introducing further terms described in the following list:

- **Action**: An action typically leads to changes in the store but does not directly adjusts it. In fact, an action is responsible for fetching data from any resource (e.g. via the controller of the backend). The collected data will then be passed to a corresponding reducer.
- **Reducer**: A reducer contains the business logic about how exactly the data from the action should be saved to the store (e.g. filtering the action for only necessary information).
- **Store**: The store contains the state of the application and can be accessed by React components [37, p. 531-534].

Figure 3.32 visually explains the Redux pattern.

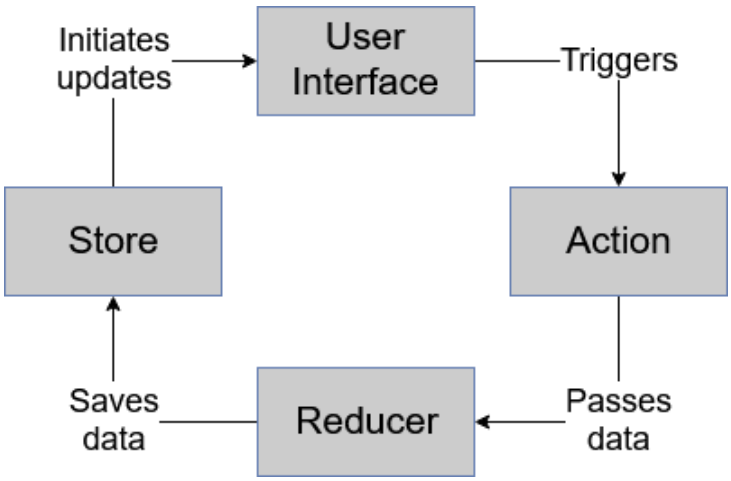

FIG. 3.32.: *Redux Pattern*
[own representation]

3.3.3. Backend / Model + Controller

The controller and model are mainly implemented with the help of Spring Boot 2 (Version 2.1.9, 20/11/2019) and the underlaying Spring Java framework (Version 5.1.10, 20/11/2019)

developed by Pivotal Software. JHipster (Version 6.5.1, 20/11/2019), a tool for generating Spring Boot and React applications, is used for a fundamental setup.

The Spring Java framework is a popular framework to develop a variety of web applications with covering the needs for security and data persistence. As the needs of business applications are constantly growing, the Spring frameworks configuration became more complex [38, p. 1]. With focus on extensibility and autoconfiguration Spring Boot was developed. The autoconfiguration is achieved by providing opinionated defaults whereas the extensibility is enabled by the possibility of adding starter modules such as Web, Data-Java Persistence API (JPA) or Security [38, p. 21-22].

All of them are used in the risk management application for the following purposes:

- **Starter-Web**: This starter modules includes the Spring MVC Java web framework providing support for the MVC pattern and Representational State Transfer (REST) Application Programming Interfaces (API)s. For example, a Java class can be annotated as controller and methods within define what kind of Hypertext Transfer Protocol (HTTP) methods are allowed as well as the REST endpoint the controller can be addressed at [38, p. 107-109].

- **Starter-Data-JPA**: The Starter-Data-JPA module allows developers to access databases in their Spring Boot application without writing Structured Query Lanuage (SQL) statements. Instead an object oriented API can be used and thus developers don't have to switch between different languages. An important part of this module is Hibernate, a technology which can map Java objects to a database. Hence the whole model of the application can be realized as Java classes and the technologies in this starter module take care of the persistence to a database [38, p. 83].

- **Starter-Security**: As not everyone should be able to access the same information or perform the same actions via the controllers (e.g. project related risks, deleting projects) the Starter-Security module enables security features such as authentication against the REST endpoints or user specific roles like being an average user or application admin [38, p. 176-176].

Figure 3.33 clarifies the functional interaction between all Spring Boot starter modules. In the case of the risk management application requests to REST endpoints, implemented with features provided by the Starter-Web module, are performed by Redux actions (see chapter 3.3.2). If the controller behind the REST endpoint has restrictions to specific roles, specified with the help of the Starter-Security module, the roles are gathered from the user by the credentials which are sent with the request and if they match, the logic of the controller gets executed. In this example data should be retrieved which can be the gathered with the help of the object oriented JPA included in the Starter-Data-JPA module and then be returned to the frontend and be used for further purposes.

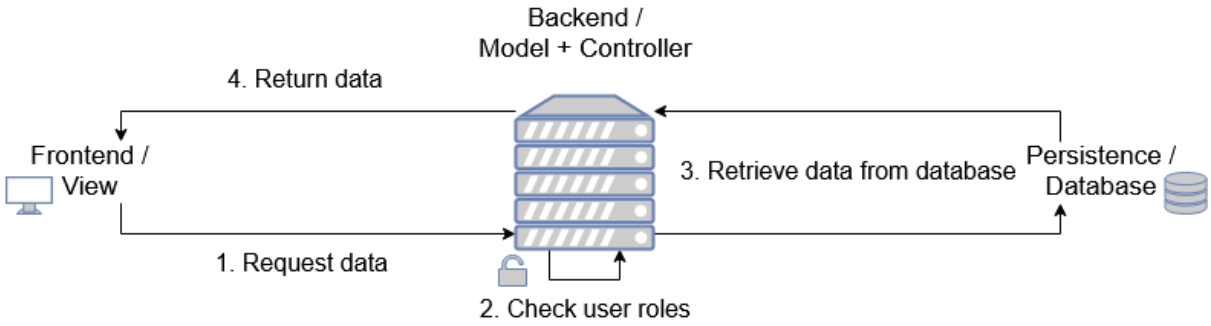

FIG. 3.33.: *Functional interaction of Spring Boot starter modules*
[own representation]

3.3.4. Persistence / Database

For persistence a relational PostgreSQL (Version 9.5, 20/11/2019) database is used and can be accessed by the backend.

The creation of necessary tables and relations is being done automatically by the technologies within the Starter-Data-JPA module. For further information about the Starter-Data-JPA module see chapter 3.3.3.

TODO: Add whole project UML here someday?

3.4. Gamification

The gamification conception is based on the gamification design process described in chapter 2.2.4. Therefore the following chapters deal with the player (chapter 3.4.1), the mission (chapter 3.4.2), the mechanics (chapter 3.4.3) and the evaluation (chapter 3.4.4).

3.4.1. Player Personas

By the initial survey the application's target group was figured out (chapter 3.1). Based on this player personas for the group of project managers and project members were created:

Project Manager The following image 3.34 shows the key characteristics of the project manager persona. Project managers use a rather formal work culture, because of their position. They are a mixture of teamplayers and independent leaders. That's why they combine competitive and cooperative behavior. Furthermore they need to be structured in their work. As project managers they are fully responsible for all parts of the project. They need to manage the project's time and cost planning, the roadmap with milestones, the handling of potential stakeholders and the interaction with the project team. To put it in a nutshell it can be stated, that project managers are responsible for lots of different project parts. Based on this variety lots of risks can potentially occur from the different domains (e.g. stakeholder claims, technical complexity, project management), which couldn't be treated only by the project managers. They need the collaboration of their project team to handle these risks successfully.

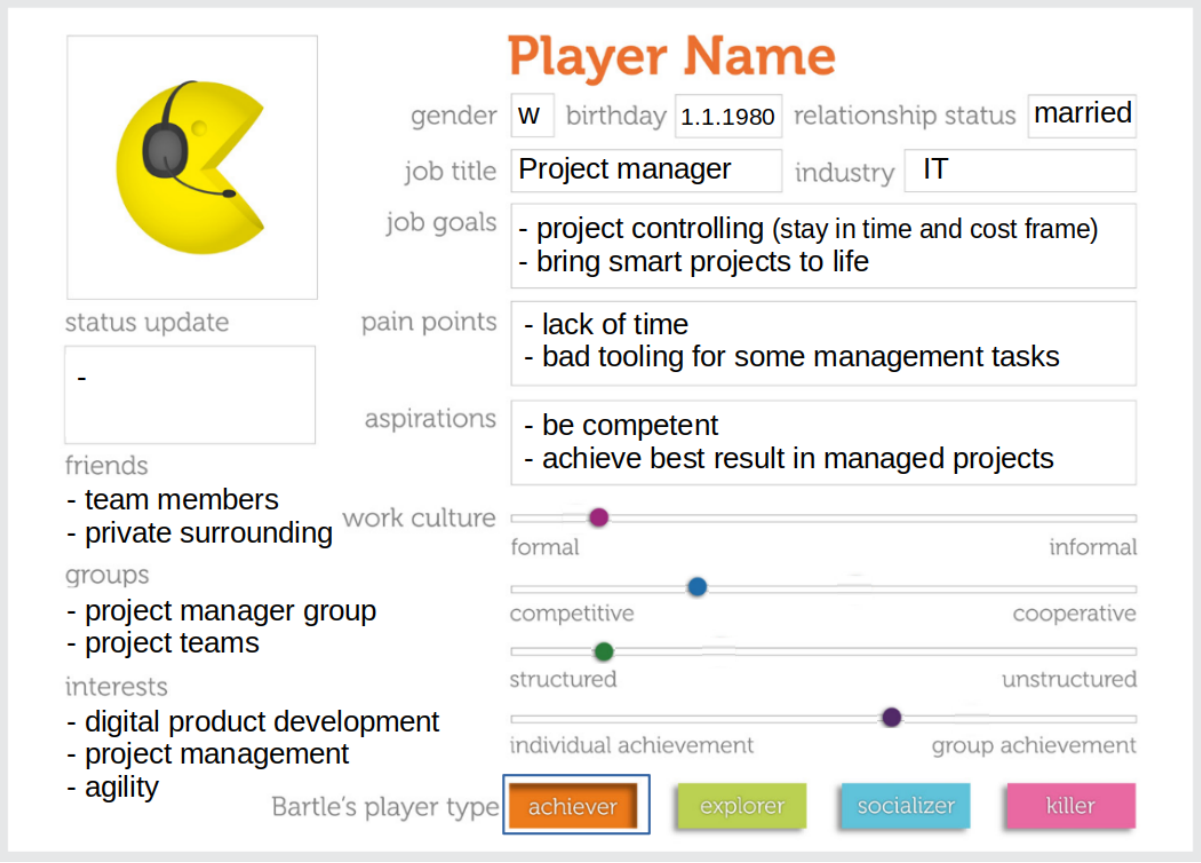

FIG. 3.34.: *Player Persona: Project Manager*

[1, p. 88, adapted]

Project Member The following image 3.35 shows the key characteristics of the project member persona. Based on their position within the team, team members tend to be rather cooperative then competitive. Their working culture is informal and the team is oriented in reaching goals together. As a developer he is not that much interested in project management and the successful project finish in time. His main attention is drawn by a personal gain of new knowledge and an involvement in interesting projects. If the projects finish in cost and time this is rather a spin-off and not the main goal. Nevertheless in terms of project risk management he is the expert for all technical risks of the project.

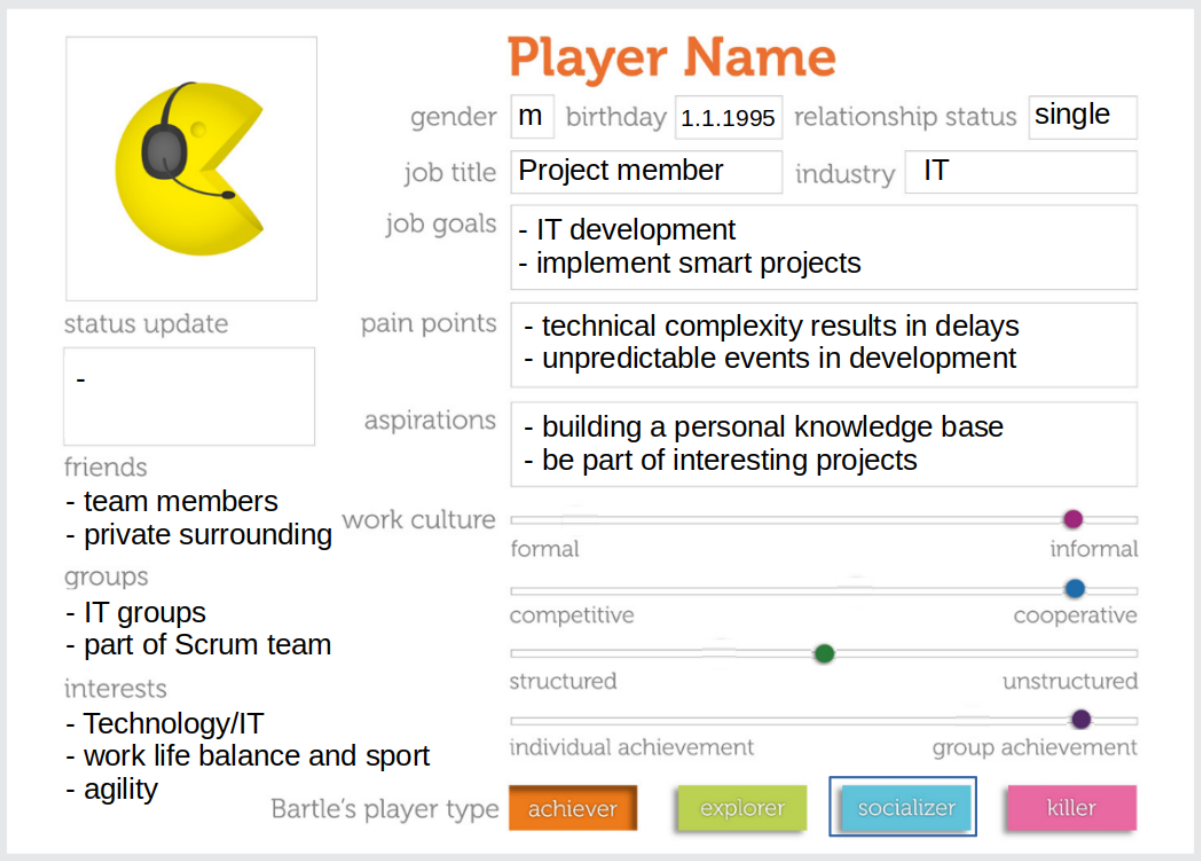

FIG. 3.35.: *Player Persona: Project Member*

[1, p. 88, adapted]

3.4.2. Mission

By defining the mission we aim to have a specific vision in mind, from which the following steps can be derived. As described in the theory chapter 2.2.4 the mission is defined. As first step the current situation was already considered in chapter 2.1. The next step deals with the business outcome. As target business outcome we would like to lower the number of projects failing because of risk management not considered. This should be achieved by the development of a gamified application for project risk management. Our mission is to increase the user engagement and support habit building in terms of project risk management. Especially we want to support the project managers as good as possible in their mandatory part of risk response management and monitoring (chapter 3.1).

3.4.3. Mechanics

This chapter describes the conception which mechanics from the chapter 2.2.3 motivational design patterns are applied. The following mechanics have been selected for the risk management domain by us and are described in detail:

- Activity Stream and Notifications
- Growth, Specialization—Badge and Increased Responsibility
- Self defined challenges
- Praise and Rewards (Score)
- Collaborative form of leaderboards
- Journey
- Social Feedback/Feedback loops
- Task Queue

- Additional minor patterns

Activity Stream and Notifications The activity stream represents the start page and is a key component of the application. By this the user is notified about relevant changes. Furthermore the messages sent can motivate the user to directly jump into a specific workflow or task. It is part of the application wide engagement loop and especially accountable for the initial motivating emotion and the call to action.

The patterns used are the activity stream as social pattern and notifications as interface pattern. The activity stream is implemented as part of UC10 Activity Stream (3.2.2.11).

Growth, Specialization—Badge and Increased Responsibility Depending on their level of interacting with the application users can be classified on the range between beginner and advanced. This can be mapped by the following five specialization—badges created by us:

project manager > risk buster > risk sage > risk master > risk owner > project member

1. Project member: basic project member without any specific rights
2. Risk owner: reached by owning a specific number of risks (being the person in charge).
3. Risk master: reached by being part of a specific number of risk ranking processes.
4. Risk sage: reached by reviewing and contributing a specific number of risks.
5. Risk buster: reached by successfully contributing a specific number of risk responses.
6. Project manager: highest achievable badge with right for creating new projects and managing existing projects.

Growth is achieved in two areas. On the one hand specialization—badges and on the other hand the further development of project risks.

Increased responsibility is used for the process of creating and managing a project. There are two workflows how a project can be initialized. The first possibility is that a user who has reached the project manager specialization—badge creates the project. The second possibility is that at least two members insure, that one person can be a project manager.

All three patterns (Growth, Specialization—Badge, Increased Responsibility) belong to the group of gameful patterns. They are implemented as part of UC1 User CRUD (3.2.2.2), UC2 Team Access CRUD (3.2.2.3), UC6 Risk Discussion (3.2.2.7), UC8 Risk Response Management (3.2.2.9), UC11 Progress Indicator (3.2.2.12).

Self defined challenges Applied challenges have a positive impact while doing and after completing. While doing the user is motivated to complete the challenge. By completing challenges the users are feeling competent and their self-efficacy is increasing. A possible risk could be challenges that are too difficult and therefore demotivating. That is why we use the concept of self defined challenges. By setting the challenges by their own the probability of success is increased.

Self defined challenges appear at several locations in the risk management application:

- Project initialization (e.g. project manager defines how many risks should be contributed in a self defined time period)
- Risk Monitoring (e.g. daily, weekly or monthly question if preventive action was done with reminder as notification before. This tries to support habit building).

The challenges mechanic is part of the gameful patterns. Self defined challenges are implemented as part of UC7 Risk Monitoring (3.2.2.8) and UC9 Project initialization (3.2.2.10).

Praise and Rewards (Score) Users are rewarded by points for performing desired behavior. This adds extrinsic motivational factors to the application. These mechanics are needed as a basis for a collaborative form of leaderboards (next paragraph). The collaborative leaderboard

provides the user direct feedback why it is worthwhile to collect points. So praise and rewards in combination with collaborative leaderboards are trying to achieve a positive conditioning.

Points can be achieved by performing desired behavior. Desired are:

- proposing risks
- reviewing risks
- be person in charge
- be active part of the community (e.g. contribute and manage pool risks and pool risk responses)

Praise is an interface pattern and score a gameful pattern. Praise and rewards are implemented as part of UC5 Risk Pool (3.2.2.6), UC6 Risk Discussion (3.2.2.7), UC7 Risk Monitoring (3.2.2.8) and UC8 Risk Response Management (3.2.2.9).

Collaborative form of leaderboards As described above the users are rewarded for desired behavior. Hence the slope of the graph (points over time) are a user activity indicator. Furthermore her/his own activity graph is easily visible for the user through the user profile page. Instead of comparing one individual against another individual based on the points score (classical form of leaderboards) we propose a team based comparison concept. In detail following features are planned:

- For each project team the **medium of the activity score of all project members** is calculated. This results in an activity score for each project and enables the comparison of different projects. This is done through an anonymized leaderboard (e.g. "Your project activity is currently at position X of Y projects"). Furthermore it is connected with concrete recommendations, how the position can be topped.
- The project can be classified based on the **sum of all points from each project member**. Based on this the project can be classified as "bronze", "silver" and "gold" project.

The important question cooperation vs. competition is already part of scientific research. Vegt et al. [39] have discovered, that based on the way how gamification mechanics are applied rather cooperative or competitive behavior is supported. Furthermore the team collaboration can be enhanced.

By comparing whole projects and their teams the competitive character of leaderboards is moderated and completed with cooperative elements. This strengthens the group spirit. The operativeness can be observed in team sports. The fact of being a member of a team and being able to achieve something together develops new motivation.

Leaderboards are a gameful pattern. The collaborative leaderboard is implemented as part of UC2 Team Access CRUD (3.2.2.3) and UC9 Project initialization (3.2.2.10).

Journey By individually supporting the user while using the application one can lower the probability of disappointed users. Based on the current phase of the user (beginner, medium, advanced) the application provides different assistance. The following list depicts the specific intended actions in detail:

Beginner level:

- Introduction to the application and its aims at the first application start.
- Explanation of the risk discussion process.
- Presentation of the risk pool concept.

Medium level:

- Show path to mastery through specialization—badges and task queues.
- Visible feedback of the current progress through progress bars.

Advanced level:

- No disturbing information boxes about basic tasks.

- Increased responsibility as a project manager, clearly visible as specialization-badge for the user.

The user journey is implemented as part of UC11 Progress Indicator (3.2.2.12).

Social Feedback/Feedback loops The core engagement loop is built onto the theory behind human motivation, behavioral psychology and behavioral economics. It tries to build a positive and motivating user experience centering the user/player. This is done by the four steps introduced in the theory chapter 2.4: Motivate Emotion -> Call to Action -> Re-Engage -> Feedback Reward.

By building use cases implementing these four steps the user's motivation for doing specific tasks can be increased. Some parts of the application using the core engagement loop are listed in the following:

- Risk discussion process (chapter 3.2.2.7): Risks traverse a review and discussion process before they are added as final risks. This process is built onto social feedback and interaction between the project members.
- Risk adjustment process (chapter 3.2.2.5): After adding risks they are classified by the team based on their threat probability.
- Progress indicators (chapter 3.2.2.12): The application clearly makes the current state and progress visible to the user. Based on specialization-badges it is clearly visible if a user is a beginner, medium or advanced. Based on this state different support is guided by the application. E.g. if you are new to the application the risk discussion process is in need of explanation, whereas for an advanced user the process is completely clear.
- Risk pool (chapter 3.2.2.6): The voting process for risks and risks responses to push it into the global risk pool makes use of the core engagement loop combined with social feedback.

Social feedback and feedback loops are implemented as part of UC4 Risk Adjustment (3.2.2.5), UC5 Risk Pool (3.2.2.6), UC6 Risk Discussion (3.2.2.7), UC7 Risk Monitoring (3.2.2.8), UC8 Risk Response Management (3.2.2.9), UC9 Project initialization (3.2.2.10), UC10 Activity Stream (3.2.2.11) and UC11 Progress Indicator (3.2.2.12).

Task Queue Task Queues provide tasks which can be done next. In best case this supports the flow experience (described in theory chapter 2.2.2). They are implemented in the following parts of the application:

- After proposing a risk: propose another risk, review a risk
- After adding a risk to the risk pool: add another pool risk, add risk response
- The whole process of initializing a project is guided and uses task queues
- After monitoring one risk: monitor another risk (if you are the person in charge)
- After setting a challenge: propose a challenge to a colleague

Task Queues are an Information Pattern and implemented as part of UC5 Risk Pool (3.2.2.6), UC6 Risk Discussion (3.2.2.7), UC7 Risk Monitoring (3.2.2.8), UC8 Risk Response Management (3.2.2.9), UC9 Project initialization (3.2.2.10), UC10 Activity Stream (3.2.2.11) and UC11 Progress Indicator (3.2.2.12).

Additional minor patterns

- Broadcast (e.g. Risks are shared between users)
- Predictable Results
- State Preservation
- Organization of Information
- Personalization (e.g. Risk Pool with Recommendation engine)

- Reporting (e.g. risks can be reported)
- Search (e.g. Risk Pool is searchable)

3.4.4. Evaluation

For evaluating the effectiveness of the gamified application for project risk management we have chosen a qualitative approach. After finishing the conception a clickable prototype was created. Based on this prototype we have evaluated the effect on real potential users through user interviews. The gained feedback and a detailed description and analysis of the user interviews can be found in chapter 3.1.2. The whole feedback was considered in the later development of the application.

4. Implementation

4.1. Unterkapitel -> Design, Evaluation, Methodisches, PM, ...

4.2. Unterkapitel2

5. Discussion

6. Conclusion and Outlook

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Appendix

A. Anhang1

A.1. Survey Questionnaire

A.2. Further Expansion Features

The following features were suggested by project managers during the interview for prototype feedback:

- Active Directory integration
- Microsoft Planner task export
- Altlassian Jira integration
- Risk export for operations team after the project is done
- Skill tags for team members
- Category tags for projects and risks
- Evaluation whether a project can be finished or risk cleanup should be done