Exploring the use of agile project management for infrastructure projects

Creating and using a serious research game to test the use of agile project management for infrastructure projects

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Developing and using a serious research game to test the use of agile project management for infrastructure projects

Thesis

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TU Delft

Balance
vooruitstrevend in projecten

I think we can all do better
~ Jim Jeffries

Preface

Leuk dat u mijn thesis leest, in de afgelopen maanden heb ik de thesis die voor u ligt geschreven. Het was een bijzondere ervaring en tekende het eind van mijn studenten tijd waar ik zeer van genoten hebt. Ik hoop dat u de lezer in ieder geval wijzer wordt en deze thesis u helpt om antwoorden op de vragen te vinden die u zoekt.

Als eerste wil ik graag mijn afstudeer commissie bedanken, zij hebben het mij mogelijk gemaakt om over dit interessant onderwerp te mogen schrijven. Hans voor de zijn wil en doorzettingsvermogen om mijn thesis door te lezen en alle spel fouten eruit te halen, dit waardeer ik zeer. Marian voor alle ondersteuning en mij hielp om wegwijzer te worden in de wondere wereld van onderzoek doen zonder alles voor te kauwen. Bauke die mij hielp nog kritischer na te denken door een andere invalshoek te belichten. Marco, die mij toegang gaf voor zijn bijzonder grote netwerk. En natuurlijk Hilde die dit proces al eerder heeft doorlopen en mij dus uitstekend kon ondersteunen in mijn keuzes. Mijn hartelijk dank hiervoor. Zonder de input van Heleen, Rob, Peter, Stefan, Steven, Servan, Patrick, Hidde, Max en Bert was dit nooit gelukt.

Natuurlijk ben ik mijn familie dankbaar die het mij überhaupt mogelijk hebben gemaakt om te studeren. Mijn geweldig civiel vriendengroep in specifiek natuurlijk Yoram omdat hij kosteloos bakken koffie voor mij faciliteerde door Floor het beheer over DE pas te geven. Al mijn vrienden van D.S.V. Nieuwe Delft die uren met mij aan de bar hebben door gebracht en waar bij we onder het genot van een biertje de wereld samen overleefde. Balance en alle collega’s ben ik dankbaar voor deze mogelijkheid. Anne, Roy en WJ natuurlijk voor het eten dat we wekelijks maakten. Tom voor de tweewekelijks Boulder sessies, om te ontspannen, en om de frustraties en energie kwijt te kunnen. En Luc die met mij hard werken tot een nieuwe betekenis heeft verheven. Leonie en Nadine de koffie en voor het sparren over het onderwerp.

Ik had dit onderzoek nooit kunnen voltooien zonder de geweldige mensen die hebben deelgenomen aan mijn het ontwikkelen en spelen van mijn serious research game onder meer, Laura, Barend, Roy, Frank, Jakob Matthea, Reinout, Bruno, Christiaan, Chris, Wim, Harold, Paul, Dieuwertje, Jasper, Harry, Erwin, Peter en alle studenten van het college van Hans. Marie en de andere voor het nakijken van mijn (delen) thesis. En natuurlijk Marks softwareprogramma eggplanned wat mijn dagelijks leven managend via backlogs. Als laatste wil ik graag Sander gelukwensen in de laatste maanden van zijn leven, zonder jou had ik nooit het meeste uit mijn leven gehaald.

Dan rust mij nog 1 ding, nasdarovje.

~ Boedi Diepersloot
Delft, Oktober

Summary

Construction projects are often faced with budget overruns, delays, and unsatisfied stakeholders. Furthermore, the success of these infrastructure projects is dictated by public opinion. To improve the performance of successfully delivering infrastructure projects, the use of agile project management has been proposed by researchers Owen, Koskela, Henrich, and Codinhoto (2006), and practitioners are also interested in this management approach for the realization of infrastructure projects of Dutch clients (Aangeenbrug, Eijkelkamp, van Biesum, van Steeg, & van der Veer, 2019). To that end, this thesis answers the question:

How might the Dutch clients use agile project management for the realisation of infrastructure projects?

Software companies which use agile project management have reported that their projects are more often finished on time and within budget and satisfy the customer. This is done using project management methodologies that fulfil the four values of the agile manifesto: often using an iterative design, prioritisation, and a fixed budget within a time limit managed through timeboxes to limit project scope. Timeboxes are defined periods in which task must be accomplished. The approach focusses on collaborating with the client and uses small teams that are self-organised. The teams react to changes due to the use of iterations. Evolving requirements are used to create a visualised intermediate result which is delivered at the end of each timebox and is used to aid communication between the customer and the project team. In this way, the customer can readjust the course of the project when needed, giving the user of agile project management the ability to react to changes and better understand customer needs.

In contrast, many Dutch clients make use of traditional project management. This sequential approach assumes that when a step is finished, it is not revisited again. This means, in turn, that the project scope must be fixed to control the budget and planning. Due to the fixed scope and inability to revisit previous steps, it is difficult to implement changes. A traditionally managed project also needs well defined requirements to understand when a task is finished.

The project management teams of Dutch clients often use this approach to realise infrastructure projects, which consist of two distinct phases: the front-end development phase, in which the plans and designs are made, and the construction phase, in which the plan is executed. Such project management teams are responsible for defining the project, finding a contractor, communicating with stakeholders about the project and results, and ensuring the project meets the needs of the client.

Moreover, the client's project management team controls five variables—cost, risks, scope, stakeholders, and time—which determine project performance. Communication and collaboration within the team and with the stakeholders act as mediating variables.

To research the effects of using agile project management for realising infrastructure projects, a serious research game has been created named 'Construction manager: bridge builders'. This research method is chosen to have the ability to put agile experts in a construction setting, it also mitigates the risk of project failure. Because, the game mimics a real-world bridge-building project and uses two teams utilising agile project management or traditional project management. The teams are tasked with developing a new bridge and constructing it from K'Nex. The game contains both a front-end development and a construction phase. In the former, the teams are tasked with creating a design that the city council actor must approve before the plan is executed and the K'Nex bridge is built. The design is limited by the chosen contractor, requirements identified through the player manual, and the interaction of the stakeholder actors, who represent the city council and the citizens of the city.

This game was designed to create immersion so that the teams would play as they normally would work. Creating immersion also improves the quality of the research due to reducing Hawthorne and learning effects. Hawthorn effects occur when observed participants alter their behavior and learning effects are when participants ability is improved during the course of the study.

A player survey, an actor survey, a focus group discussion, and data created by the players, like drawings and notes, were used to gather data from the serious research game. The focus group discussion is essential in gathering information on the behaviour of the players. During the discussion, the decisions of the teams were explored with the team members, observers, and actors, and the player data was used to strengthen the claims made by the teams. If a team used an agile project management approach, the decision was aided by the focus group discussion, player-created data, and the players' expertise.

This game satisfies the eight serious game criteria: flexible and reusable, authoritative, dynamic, transparent, fast and easy, integrative, interactive, and communicative. In addition, the factors of realism, player identity, complexity, communication, collaboration, clarity, fairness, and locational influences are considered important serious research game design criteria.

The game was played four times (with the fourth session only used to improve the in-game economy). The first session, the alpha test, was needed to make improvements to the game and understand the playability. The beta test was done with civil engineering students; teams had a leader with experience in either agile or traditional project management. The third session was played with experienced project and programme managers who realise infrastructure projects for Dutch clients and software developers and with experience of agile project management.

These sessions show that when agile project management is applied to the game setting, the stakeholders are involved early in project conception and become design experts. This is caused by the need for constant communication and collaboration with stakeholders, which is mainly done through visualisation of the project. This differs from the traditional project management approach in which the project team starts with identifying the requirements before making a design to convince the stakeholders that it is the right solution. Due to the variations in approach between traditional and agile project management, differences emerge in the execution of the project.

With the agile project management approach, stakeholders are taken on a journey to evolve their requirements through the use of evolving requirements. First, a minimal viable design is created, which is developed until the construction phase begins. The traditional approach starts with identifying requirements that form the design.

The use of the agile project management approach makes stakeholder engagement and feedback essential throughout the front-end development phase. This is caused by the four values of the agile manifesto, which highlight the importance of collaboration and interactions between the team and stakeholders, welcoming changes to the plan and visualising results to aid communication. In contrast, the traditional approach relies heavily on the project management team and the ability to convince the stakeholders that their design is the right solution.

The serious research game shows that Dutch clients can use agile project management but that its use is limited because it can only be applied to projects where the stakeholders can become design experts early in the project realisation process. Figure 29 gives the hypothesised approach for project management teams of Dutch clients to use agile project management. It illustrates the process of creating a visualised intermediated design or prototype with the stakeholders, who give frequent feedback to adjust it. This cycle is continued until either the stakeholders come to a consensus or the pre-set time limit runs out. In addition, the agile mindset of realising the four values must be adopted, meaning that the project managers must change from a stage-gate mindset.

This thesis reduces the scope of using agile project management for the realisation of an infrastructure project to understand. By showing that agile project management can be used but only in project where stakeholders can become the experts over the design early in project conception. Nonetheless, its application seems promising in relevant projects because it improves collaboration and communication with the involved stakeholders. Furthermore, it is recommended that Balance continues their efforts of using agile project management for the realisation of infrastructure projects by testing and improving the hypothesis presented in Figure 29.

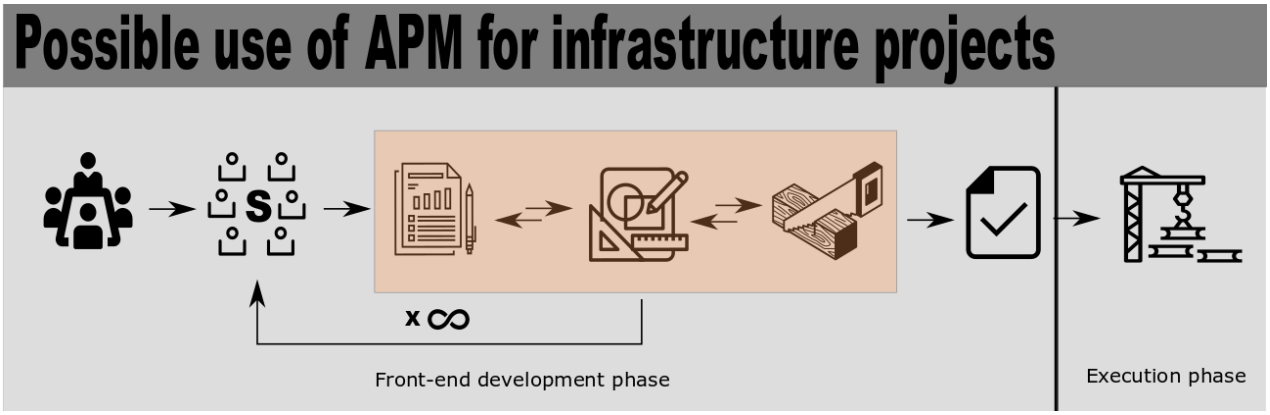

Figure 29: Hypothesised APM approach to infrastructure projects (own illustration)

Figure 29 depicts the proposed, agile project management approach to realising infrastructure projects. It shows an iterative design process, requirements, design, and prototype influence each other to create a visualised result (orange block). This intermediate result is shared with the stakeholders to gain their feedback (arrow back). This is done until the stakeholders are satisfied with the result or until a set deadline is reached. Then construction starts. The first pictogram represents the project management team of Dutch clients.

Samenvatting

Nederlandse bouwprojecten worden vaak geconfronteerd met uitstel, kostenoverschrijdingen en ontevreden stakeholders. Het succes van bouwprojecten wordt vaak bepaald door publieke opinie. Om de prestaties van deze projecten te verbeteren, wordt het gebruik van agile projectmanagement voorgesteld door Owen et al., (2006). Ook de private sector is geïnteresseerd geraakt in het mogelijk gebruik van agile projectmanagement voor het realiseren van infrastructuur projecten van de opdrachtgever (Aangeenbrug et al., 2019). Daarom is de volgende onderzoeksvraag beantwoord:

Hoe kunnen de Nederlandse opdrachtgevers agile projectmanagement gebruiken voor het realiseren van infrastructuurprojecten.

De interesse komt voort uit het gemelde succes van softwareprojecten die agile projectmanagement gebruiken. De projecten worden vaker op tijd, binnen budget met een tevreden klant afgeleverd. Dit wordt gedaan door het gebruik van agile projectmanagementmethodieken die voldoen aan de vier waarden van het agile manifesto. Vaak zijn deze methoden gebaseerd op het gebruik van een iteratief ontwerpproces. Het gebruik van timeboxes, prioritering en een vast budget met een vastgestelde tijdslimiet. Timeboxes worden gebruikt om het project te managen. De aanpak is gericht op samenwerking met de klant. Maakt gebruik van kleine zelf-organiserend teams. De teams reageren op veranderingen door een iteratief proces. Gebruikers eisen worden gebruikt om een gevisualiseerd tussenresultaat te maken aan het einde van elke timebox. Dit tussenresultaat wordt gebruikt om de communicatie en samenwerking tussen de klant en het projectteam te ondersteunen. Op deze manier kan de klant het verloop van het project indien nodig aanpassen, waardoor agile projectmanagement gebruiker de mogelijkheid heeft om op veranderingen te reageren en beter te begrijpen wat de klant nodig heeft.

De Nederlandse opdrachtgever maakt gebruik van traditioneel projectmanagement. Bij deze sequentiële benadering wordt een stap afgerond en daarna aangenomen dat deze stap niet meer wordt heroverwogen of overnieuw gedaan. Dit betekent dat de projectscope wordt vastgezet om het budget en de planning te beheersen. Omdat de scope is vastgezet en voorgaande fases voltooid zijn, is het moeilijk om wijzigingen door te voeren. Een traditionele project aanpak heeft technische eisen nodig om te begrijpen wanneer een taak is voltooid.

De projectmanagementteams van de opdrachtgever gebruiken deze aanpak om hun infrastructuurprojecten te realiseren, die bestaat uit twee fasen. De ontwikkelingsfase, waarin plannen en ontwerpen gemaakt worden, en de bouwfase, waarin het plan wordt uitgevoerd. De projectmanagementteams zijn verantwoordelijk voor het definiëren van het project, het vinden van een aannemer, communiceren met de stakeholder en zorgen ervoor dat het project voldoet aan de behoeften van de opdrachtgever.

Het projectmanagementteam managet vijf variabelen: kosten, risico's, scope, stakeholder en tijd. De variabelen bepalen de prestatie van het project. Communicatie en samenwerking binnen het team en met de stakeholders fungeren als een bemiddelende factors.

Om het effect van agile projectmanagement voor het realiseren van infrastructuurprojecten te onderzoeken, is een serious research game gemaakt genaamd "Constructie manager: bruggenbouwers". De game bootst een bruggenbouwproject na en wordt gespeeld met twee teams. Een team gebruik agile projectmanagement het andere traditioneel projectmanagement. De teams moesten een nieuwe brug ontwikkelen en deze bouwen van K'Nex. De game bevat twee fasen, een ontwikkelingsfase en een bouwfase. In de ontwikkelingsfase maken de teams een ontwerp dat gemeenteraad acteur goedkeurt en de K'Nex-brug kan worden gebouwd. De ontwerpvrijheid werd beperkt door gekozen aannemer, de ontwerp eisen worden geïdentificeerd via het spelershandboek en de interactie met de stakeholder acteurs, die de gemeenteraad en de omwonende vertegenwoordigde.

Deze game is ontworpen om immersie te creëren zodat de teams zouden spelen zoals ze normaal zouden doen. Het creëren van onderdompeling verbetert ook de kwaliteit van het onderzoek door het verminderen van Hawthorne en leereffecten. Hawthorne treden op wanneer geobserveerde

deelnemers hun gedrag veranderen en leereffecten zijn wanneer de deelnemers in de loop van de studie worden verbeterd.

Een spelersenquête, acteursenquête, focusgroepdiscussie en data gecreëerd door de spelers zoals tekeningen en aantekeningen worden gebruikt om data te verzamelen. De focusgroepdiscussie was essentieel bij het vaststellen van de keuzes van de spelers. Tijdens de discussie werden de beslissingen van de teams toegelicht door de teams, waarnemers en acteurs. De door de speler gecreëerde data worden gebruikt om de claims te versterken. De onderzoeker zelf besloot of een team agile projectmanagement gebruikte, zijn beslissing werd geholpen door de focusgroepdiscussie, de speler gecreëerde data en de expertise van de spelers.

De serious research game voldoet aan de acht serious game-criteria: flexibel en herbruikbaar, analytische en politieke standaarden, dynamisch, transparant, snel en gemakkelijk te gebruiken, geïntegreerd noodzaak van beslissingen en levels, interactief en communicatief. De factoren realisme, speler identiteit, complexiteit, communicatie, samenwerking, duidelijkheid, eerlijkheid en locatie invloeden beschouwd als belangrijke criteria.

Uit de evaluatiegegevens die zijn verzameld via de enquêtes en de observaties, werd vastgesteld dat alle factoren zijn gewaarborgd en verbeteringen zijn mogelijk. Met name voor het verbeteren van realisme en de duidelijkheid van het spel. Het verminderen van de hoeveelheid informatie die spelers in aan begin krijgen, kan mogelijk deze factoren verbeteren. De in-game economie kan beter uitgebalanceerd worden.

Het spel is vier keer gespeeld (de vierde sessie is alleen gebruikt om de economie in het spel te verbeteren). De eerste sessie, de alfatest, was nodig om het spel speelbaar te maken. De bètatest werd uitgevoerd met civiele techniek studenten waarin de teams een teamleider hadden met projectmanagementervaring in agile- of traditioneel projectmanagement. De derde sessie werd gespeeld met ervaren project- en programmamanagers die infrastructuurprojecten realiseren voor Nederlandse opdrachtgever en softwareontwikkelaars met ervaring in agile projectmanagement.

Deze spelsessies laten zien dat wanneer agile projectmanagement wordt toegepast op het spel, de stakeholders vroeg bij de projectconceptie worden betrokken en de ontwerpexperts worden. Dit wordt veroorzaakt door de behoefte aan constante communicatie en samenwerking met de stakeholders. Communicatie en samenwerking vinden voornamelijk plaats via visualisatie van het project. Dit verschilt van de traditionele projectmanagementbenadering waarbij het projectteam begint met het identificeren van de eisen, daarna wordt er een ontwerp gemaakt. Dit ontwerp wordt gebruikt om de stakeholders te overtuigen dat het ontwerp de juiste oplossing is.

Het gebruik van de agile projectmanagement maakt betrokkenheid en feedback van belanghebbenden essentieel tijdens ontwikkelingsfase. Dit wordt veroorzaakt door de vier waarden van het agile manifesto dat samenwerking en interacties tussen het team en de stakeholder belangrijk vindt, veranderingen aan het plan verwelkomt en resultaten visualiseert om de communicatie te ondersteunen. De traditionele aanpak is sterk afhankelijk van het projectmanagementteam en het vermogen om de stakeholders te overtuigen dat de ontwerpoplossing de juiste oplossing is.

Door de serious research game te spelen, is aangetoond dat de opdrachtgevers agile projectmanagement kan gebruiken, maar het gebruik is beperkt omdat het alleen kan worden gebruikt voor projecten waarbij de stakeholders al vroeg in het projectrealisatieproces de ontwerpexperts kunnen worden. Figuur 27 geeft de hypothetische aanpak van het gebruik van agile projectmanagement door de projectmanagementteams van de opdrachtgever weer. Het illustreert het proces van het creëren van een gevisualiseerd tussenontwerp of prototype met de stakeholder. De stakeholders geven regelmatig feedback op dit gevisualiseerde, tussenresultaat om het aan te passen. Deze cyclus wordt doorlopen totdat de stakeholders tot een consensus komen of de vooraf ingestelde deadline verstreken is.

Daarnaast moet de agile denkwijze en het realiseren van de vier waarden uit het Manifesto waarden worden gewaarborgd. Dit betekent dat de mindset van de projectmanagers moeten veranderen van een stage-gate-mindset naar een agile mindset; dit kan uitdagend zijn.

Om agile projectmanagement in de bouwsector te begrijpen en te gebruiken, is meer onderzoek nodig. Deze thesis verkleind de mogelijkheden om agile projectmanagement in de bouwsector te

gebruiken, aan raad het alleen aan wanneer stakeholder vroeg betrokken kunnen worden en ze de experts over het ontwerp kunnen worden. Het gebruik ervan lijkt veelbelovend in projecten waarbij agile projectmanagement kan worden gebruikt, omdat het de samenwerking en communicatie met de betrokken stakeholders verbetert. Bovendien groeit het vertrouwen. Balance wordt aanbevolen om hun inspanningen voort te zetten om agile projectmanagement te gebruiken voor de realisatie van infrastructuurprojecten door de hypothese in figuur 27 te testen en te verbeteren.

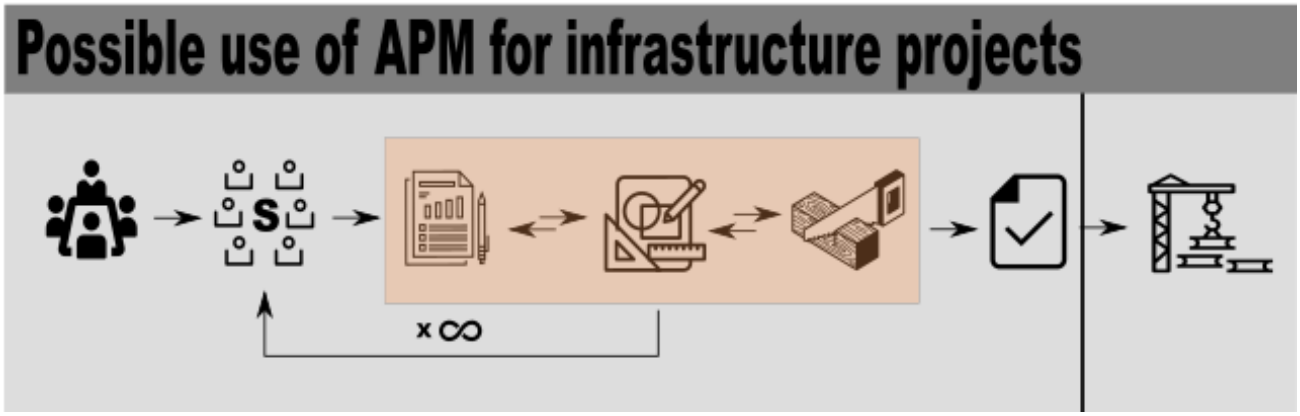

Figure 29: Hypothesised APM approach to infrastructure projects (own illustration)

Figuur 27 geeft de voorgestelde, agile projectmanagementbenadering weer voor het realiseren van infrastructuurprojecten. Het toont een iteratief ontwerpproces, eisen, ontwerp en prototype beïnvloeden elkaar om een gevisualiseerd resultaat te creëren (oranje blok). Dit tussenresultaat wordt gedeeld met de stakeholders om feedback te krijgen (pijl terug). Dit gebeurt totdat de stakeholders tevreden zijn met het resultaat of totdat een vastgestelde deadline is bereikt. Dan begint de bouw. Het eerste pictogram vertegenwoordigt het projectmanagementteam van de opdrachtgevers.

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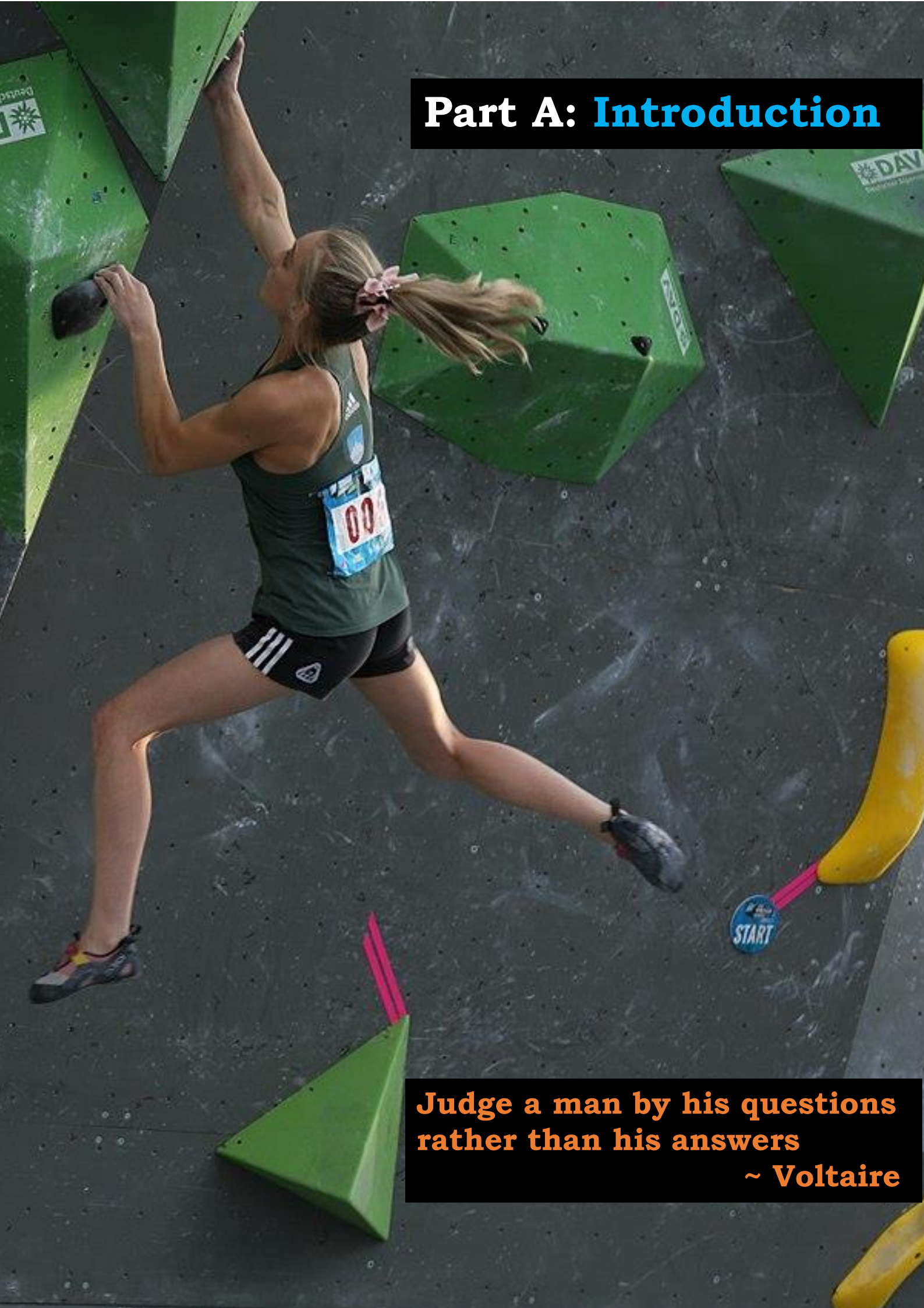


Part A: Introduction

Judge a man by his questions rather than his answers

~ Voltaire

1 Introduction

This first chapter introduces the research study and the context in which it has been completed (section 1.1). Section 1.2 presents the motivation for this research as well as its aim, scope, and significance. In addition, the structure of the thesis is included (section 1.3).

1.1 Context, knowledge gap, and research objective

Infrastructure projects are often behind schedule or over budget, or stakeholders are dissatisfied with the results (Koenen, 2018; NOS, 2019a, 2019b; RTVOost, 2019). In addition, communication between the project management teams of Dutch clients[1] and the stakeholders is often lacking (Hoezen, Reymen, & Dewulf, 2006). This causes a problem for an industry in which public perception dictates if a project is successful.

Small profit margins often force stakeholders to behave in strategic and calculating ways, resulting in a lack of trust, which discourages parties from improving their communication habits (Hoezen et al., 2006). This mistrust is further enhanced by the need for control and the involvement of numerous consultants (Hoezen et al., 2006).

Still, infrastructure projects are vital to the liveability of the Netherlands and are mostly realised by a governmental agency and their project teams. These teams often use traditional project management methods to realise these essential undertakings (de Jong, 2018). However, a different project management approach is already emerging within the construction industry.

In an interview with project manager Heleen Wijtmans of the Smakkelaarsveld project[2], she expressed that she works with a different project management approach. Communication and collaboration with the stakeholders form the focus, combined with an unusual tender procedure where contractors are selected on their ability to collaborate rather than on a design or vision. The city of Utrecht was given the opportunity to provide feedback on the project before a design was made. The project team did this by going to the project location and asking people why they would go to Smakkelaarsveld in the future. From this feedback, a design was made.

The approach to the Smakkelaarsveld project resembles that of an agile project management approach (see appendix D for an analysis of the use of agile project management in the Smakkelaarsveld project) rather than the traditional approach.

Agile project management was developed for and is applied to software and IT projects. It gained popularity in the past decade due to its promise to deliver better projects to customers. Agile project management methodologies have been credited with delivering projects on time and within budget and have a high customer satisfaction rate (Standish Group, 2015; State-of-Agile, 2019). This is accomplished by developing close collaboration with the customer, focussing on individuals and interactions, dealing with project change, and delivering working software (Beck et al., 2001a).

Due to its successful use in the IT sector, Owen et al., (2006) have proposed the use of agile project management for the realisation of infrastructure projects, hypothesising that the most promising use is in the pre-design phase. Because agile project management gives the phase structure and allows the freedom to seize opportunities. In addition, if early project delivery is important, it might benefit from the use of agile project management (Owen et al., 2006). According to van Kralingen (2017), the agile themes—deliveries, process, planning, teams, project, customers, attitudes, documentation, and location—might add value to the early project phases of construction projects. Streule et al. (2016) have also stated that construction design teams using the agile methodology ‘Scrum’ feel more efficient and believe that it improves transparency, collaboration, and communication; the flow of information; and faster project development. In addition, an iterative design process (sprints) can be useful to increase value.

[1] In Dutch, *de opdrachgever*.
[2] Area development project next to the central train station in Utrecht (CU2030.nl, n.d.)

In APM, understanding the needs of the customer allows an in-depth overview of any problem (Adut, 2016). Padalkar (2015) has also stated that while the use of agile methods in construction projects might be negligible, trust might be a valuable factor.

Adut (2016) has argued that the milestone/stage-gate mindset limits the usefulness of agile project management. According to Adut (2016), uncertainty is not reduced by its use but is only handled. Sohi et al. (2016) have shown that a combination of lean and agile methodologies could be used in construction projects to cope with the complexity of construction projects. Sohi (2018) has also stated that practitioners have a favourable opinion of agile project management practices because they might improve customer satisfaction through close customer collaboration, reduce the amount of rework due to early detection through the daily stand-up, improve team spirit, allow visualisation of and insight into the project's progress to all team members, and deliver more realistic planning. Furthermore, Owen et al. (2006) believe that agile project management practices could work in the planning of the execution phase; however, this would require a cultural change in the construction sector.

In the white paper published by the Dutch secondment company Balance, written by Aangeenbrug, Eijkelkamp, van Biesum, van Steeg, and van der Veer (2019), the possible use of agile management for infrastructure projects is investigated. However, interviews identified bottlenecks and limitations of its use for the construction sector.

Nonetheless, using agile project management might improve the performance of infrastructure projects, though the implications are not yet fully understood. Thus, using agile project management to realise an infrastructure project is risky. Issues that may occur due to a change in project management approach could have huge impacts on the realisation of the project and can be fatal to the bottom line in an industry where the profit margins are already low (Hoezen et al., 2006).

To mitigate this potential failure of an infrastructure project and to ensure the use of APM in an industry that is lacking this knowledge. A simulated environment is created through a serious research game. In which, APM experts are put in a safe environment to realise an infrastructure project.

Therefore, to explore this possible new field of project management for the construction sector, the following research question is investigated and answered:

How might the Dutch clients use agile project management for the realisation of infrastructure projects?

This study gives an insight into the possible application of agile project management for infrastructure projects, thus creating the possible new field of agile project management for the construction sector. It gives both practitioners and researchers new information on which future research can be founded and potential applications of agile project management for the realisation of infrastructure projects. This study could also give practitioners ideas and a starting point on how to apply agile project management for infrastructure projects and scholars the ability to further their understanding of the applicability of agile project management through the use of serious research gaming. Due to the use of serious research gaming, this uncommon research approach also provides a better understanding of creating simulated environments through gaming.

1.2 Research and constraints

This thesis (to acquire an engineering title and complete the master's degree of construction management and engineering) is written in collaboration with Technical University Delft and the company Balance. Balance has a range of different activities but mainly focusses on infrastructure projects and interim management for Dutch clients which are (de-) central governmental agencies like Rijkswaterstaat, provinces, municipalities and water boards. These are the agencies responsible for the realisation of infrastructure projects in the Netherlands. This is why the research focusses on the Dutch client and not on the contractor's side of infrastructure projects. Infrastructure projects are fundamental physical structures and facilities like roads, hydraulic structures and bridges.

The research was conducted in approximately six months with a focus on the front-end development phase but not excluding the execution phase, in which the project management teams of the Dutch clients have a minor role. The use of agile project management is pilot tested through a created simulation which analyses the approach of a project management team by creating and playing a serious research game. More specifically, the research focusses on the use of agile project management for the realisation of infrastructure projects to improve project performance.

Specific agile methodologies are not considered because they are tailored for software development. Traditional methods are used to visualise the differences, but their performances are well understood. Systems engineering is excluded to reduce the scope of the study. The study is exploratory and limited due to the use of a simulated environment and has a high risk of criticism due to its exploration into a new field and use of an uncommon research method (Remenyi & Money, 2004).

A project is considered to be a temporary endeavour to create a unique object that carries risk due to unfamiliarity and has a defined goal and a temporary organisation that uses people and other resources from different organisations and functions (Nicholas & Steyn, 2017). The realisation of infrastructure projects consists of the front-end development and the execution phases (Sohi, 2018). Front-end development involves initiation, planning, and design. The execution phase comprises the construction and delivery of the project.

Projects are realised through the use of management methods. Munns and Bjeirmi (1996) have defined project management as the act of defining the requirements of work, establishing the extent of work, allocating the resources required, planning the execution of the work, monitoring progress, and adjusting deviations from the plan. According to Zandhuis and Wuttke (2019), ‘project management is the application of knowledge, skills, tools and techniques to meet project requirements’. Špundak (2014) has defined project management as a framework that represents rules, processes, methods, and templates used during the project lifecycle.

1.3 Thesis guide

This thesis contains four parts, as shown in the overview in Figure 1. The first chapter is the introduction; its sole purpose is to introduce the subject, research, and constraints of the study. The second chapter discusses the design of the research and its justification. Part B explains the literature needed to understand essential concepts; therefore, chapter three explores the role of the Dutch client, traditional and agile project management, and how these two methods differ. The fourth chapter introduces serious research gaming and design. Part C, chapter five, starts with the creation of a game as the main research tool. Chapter six presents the results of the serious research game session. In chapter seven, the research game is evaluated on design principles and other related factors. Part D begins with chapter eight discussing the limitations and interpretations of the study. Chapter nine concludes the study by answering the research question. The last two chapters include recommendations for future research, the possible use of agile project management and the researchers own reflection.

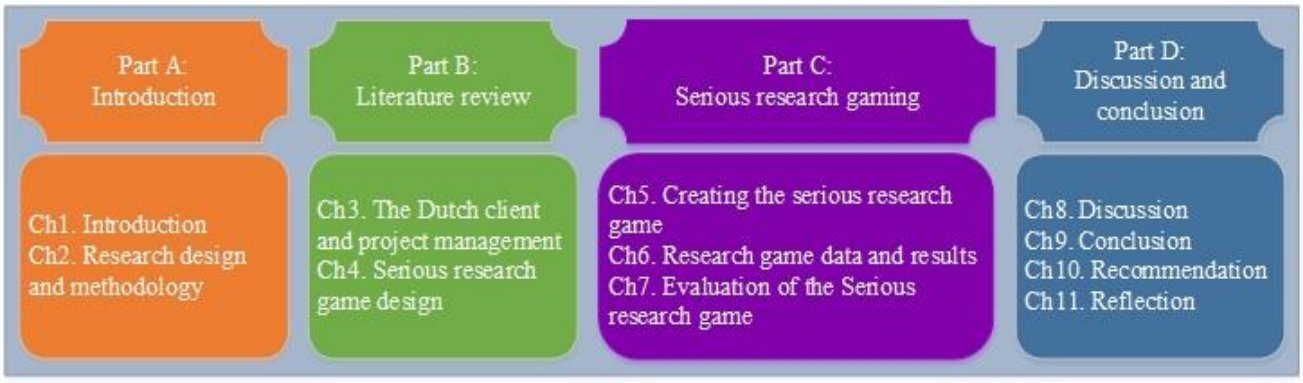


Figure 1: Thesis guide (own illustration)

2 Research design and methodology

This second chapter introduces the research, the route that is taken to deliver an answer to the research question, and a justification of the research design. This is done by first describing the research objective (section 2.1) and then the research question and sub-questions (section 2.2). In section 2.3, the research strategy is explained. The chapter is summarised in section 2.4.

2.1 Research objective

The objective is to investigate the possible use of agile project management (APM) for the realisation of infrastructure projects. Owen et al. (2006) were the first to propose the possible use of APM in infrastructure projects, but they only hypothesised its usefulness. This thesis takes the next step and tests the use of APM on an infrastructure project in a simulated environment. Therefore, this research aims to:

> Explore the possible use of APM for the realisation of infrastructure projects from the Dutch client's perspective through a simulated environment.

2.2 Research question

With an understanding of the research aim, the knowledge gap, and the interest of the company Balance, the following research question is posed:

How might the Dutch clients use agile project management for the realisation of infrastructure projects?

To answer the main research question, the following sub-questions (SQ) are proposed:

SQ1. How does the project management approach of the Dutch clients look like?
SQ2. What is the agile project management approach, and how does it differ from the current project management approach of the Dutch clients?
SQ3. How can an infrastructure environment be simulated to research project management approaches from the Dutch client's perspective?
SQ4. What is the difference between using the current and agile project management approaches in the simulated infrastructure project?

2.3 Research strategy, approach, and methodology

This section focusses on the different methodologies used in this research and the choices that were made regarding research design. Answers to the sub-questions are found through a literature study and the creation of a serious research game to simulate an infrastructure project. Furthermore, the literature study is used to understand the task of the Dutch clients, traditional project management (TPM), APM, and serious research gaming and design. A serious research game was created to test the use of APM for infrastructure projects. Figure 2 summarises and depicts the route taken to answer the research question. This research is qualitative, exploratory, and possibly first in a line of other research projects by Balance and the TU Delft on the use of APM for the construction sector.

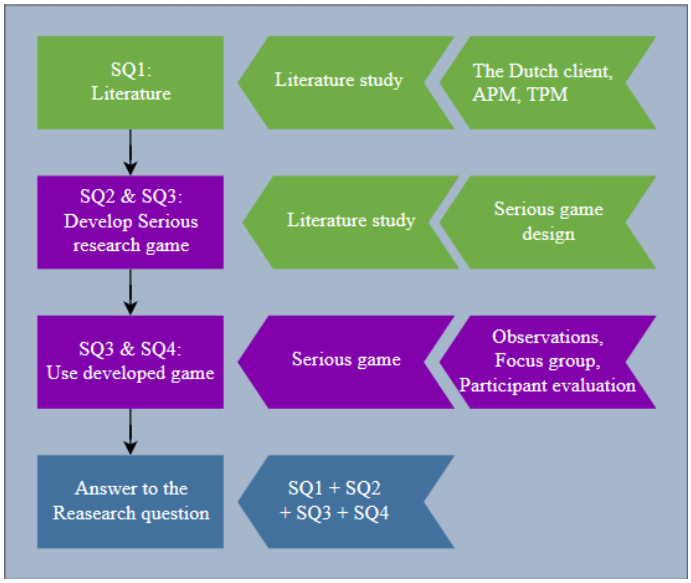


Figure 2: Approach to answering the research question (own illustration)

2.3.1 Method elaboration: Literature study

A literature study is needed to understand TPM and APM and to create a serious research game. For the literature study, Google Scholar was primarily consulted in combination with the TU Delft repository. A snowballing technique[3] was used to further the understanding of the subjects (Verschuren, Doorewaard, & Mellion, 2010). Four different subjects were analysed: current use of APM in infrastructure projects, APM, TPM, and serious games.

To understand TPM, the project management books *Project Management for Engineering, Business, and Technology* (Nicholas & Steyn, 2017) and *Management of Engineering Projects: People Are Key* (Bakker & Kleijn, 2014) were consulted. These books form a starting point for the snowballing approach. The searched keywords can be found in Table 1, where the left keyword was put into the search engine. The right-side keywords were used as complements.

Table 1: Keywords about TPM used for the literature study

Standard keyword	Expanded
Project management	Waterfall, traditional, modern, history, theory, principle(s), fundament, collaboration, communication, construction, infrastructure, principles
Gantt chart, the iron triangle	
Project lifecycle	PLC, success, early phases
Methods	IPM, Prince2, PMBOK

The snowballing approach was used for the literature study on TPM and APM. For the latter the books *Scrum: The Art of Doing Twice the Work in Half the Time* (Sutherland, 2015), *Agile with a Smile* (Kotteman, Portman, & Hedeman, 2017), *Agile Project Management Handbook Vol. 2.0* (DSDM Consortium, 2014), *Managen van Agile Projecten* (Hedeman, Portman, & Seegers, 2014), and the thesis "A Project Manager's Journey towards Agile Project Management (Verbruggen, 2017) were consulted, as was the agile manifesto. The keywords used are listed in Table 2.

Table 2: Keywords about APM used for the literature study

Standard keyword	Expanded
Agile project management	History, difference, construction, infrastructure projects, visualisation, communication, practices, principles
Methods	DSDM, Scrum, XP, FDD, crystal clear, lean start-up, LEAN, XP/Scrum hybrid, Spotify model, Kanban, agile up, SCRUMban
Success of agile project management	Definition of, state-of-agile
Agile manifesto	History
People	Highsmith, Jeffries, Sutherland, Cockburn
Self-organising teams	True, definition, real

[3] Snowballing technique is commonly used approach for literature studies in which the literature leads to other literature and so on until no new knowledge is found (saturation).

The literature study on serious research game (SRG) design used the theses of Keizer (2018) and Vissers (2016) as a starting point. In addition, the researcher's own experience and knowledge on game design were used to start the snowballing approach. Keywords used are listed in Table 3.

Table 3: Keywords about serious game design used for the literature study

Standard keyword	Expanded
Serious game/gaming	Design/designing, use of, business, definition, research
Game	Business, experimental, simulation, education, development, design, video, video…design, perks, complexity, immersion, *flow*, exposition, elements, pacing and flow, research
Using	K'Nex, Lego, Technical Lego
Game economy	Balancing, developing, designing, testing, ethical
Gameplay	Loops, complexity, flow and pacing, primary gameplay

The theses used are the most recent literature on the subjects. For the serious research game design, the theses of Keizer (2018) and Vissers (2016) led to the paper by Bressers et al. (2018), which generalises design principles for serious games.

2.3.2 Method elaboration: Serious research gaming

A real-world bridge-building project was simulated to let agile practitioners use their management approach in a construction context. For this, a serious research game (SRG) was created and played by agile and traditional practitioners to distinguish differences in project management approaches. Using a SRG allows the researcher to conduct an experiment in a contrived setting that mimics a real-world project but in which the researcher has control over the variables. In addition, a SRG is a low-cost, low-risk way of conducting research and is an unconventional research method which has similarities with (quasi-) experiments and simulations; the difference is that data is found through play, making the used method more innovative.

Action research is a possible approach but is considered to be too risky. An approach in which civil project managers are taught APM might work, but experienced practitioners are preferred and ensure the use of APM more. Interviews with project managers in the civil engineering sector are another option, but this is the same approach Aangeenbrug et al. (2019) used, and it misses the experience of agile project managers. Thus, interviews with agile project managers is also a possibility but misses input from civil experts.

The SRG produces qualitative and quantitative data through player surveys, stakeholder evaluation, focus group discussion, and data observation. Participants in the research were acquaintances of the researcher and colleagues from Balance. Team composition was decided by the participants' backgrounds. Multiple data collection methods were then used to strengthen the claims made in the memos and the transcribed focus group discussions, which took place directly after the completion of a game session. Player surveys were used to evaluate the game's quality and player experience. The stakeholder actors' evaluation survey was used to gather data on the teams' performance and game quality. Observers were 'observer as participant' (Scott & Medaugh, 2017) and logged the choices of the teams.

All quantitative data was processed with the use of Excel; averages and standard deviations were found with Excel functions. Missing data was sought by contacting the participant who did not fill in the answers. If the problem was solved through discussion, the data was added. If no consensus was reached, the data was not altered.

Qualitative data was analysed through content and thematic analyses. Predefined codes based on APM and TPM were used to aid the researcher in finding patterns and differences.

Whilst little is known about assessing the quality and validity of serious games (Mohan et al., 2014), the research should at least assess internal and external validity. This is based on Sekran's (2000) validity definition for experimental research. (Chapter 0 identifies important SRG criteria which the game in this study must satisfy.)

2.4 Summary: research methodology

Figure 3 gives an overview of the methods used to answer the research question:

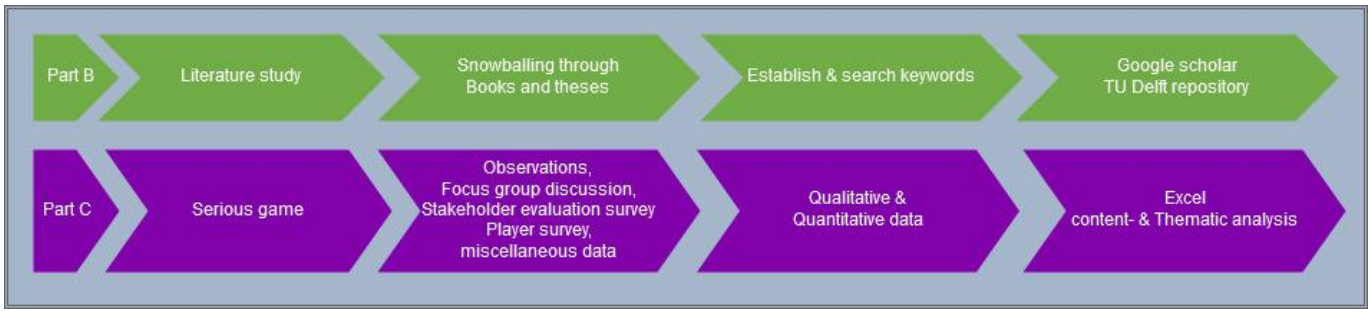


Figure 3: Summary of the research methodology (own illustration)

Whilst TPM for infrastructure projects is an established method, APM is not. Moreover, the use of SRG is uncommon as a research tool. Thus, this combination leaves the research open to a high risk of criticism as depicted in Figure 4 (Remenyi & Money, 2004). Still, the researcher argues that someone needs to take the next step and try to understand the use of APM for infrastructure projects. Else, the theory stays a thought experiment.

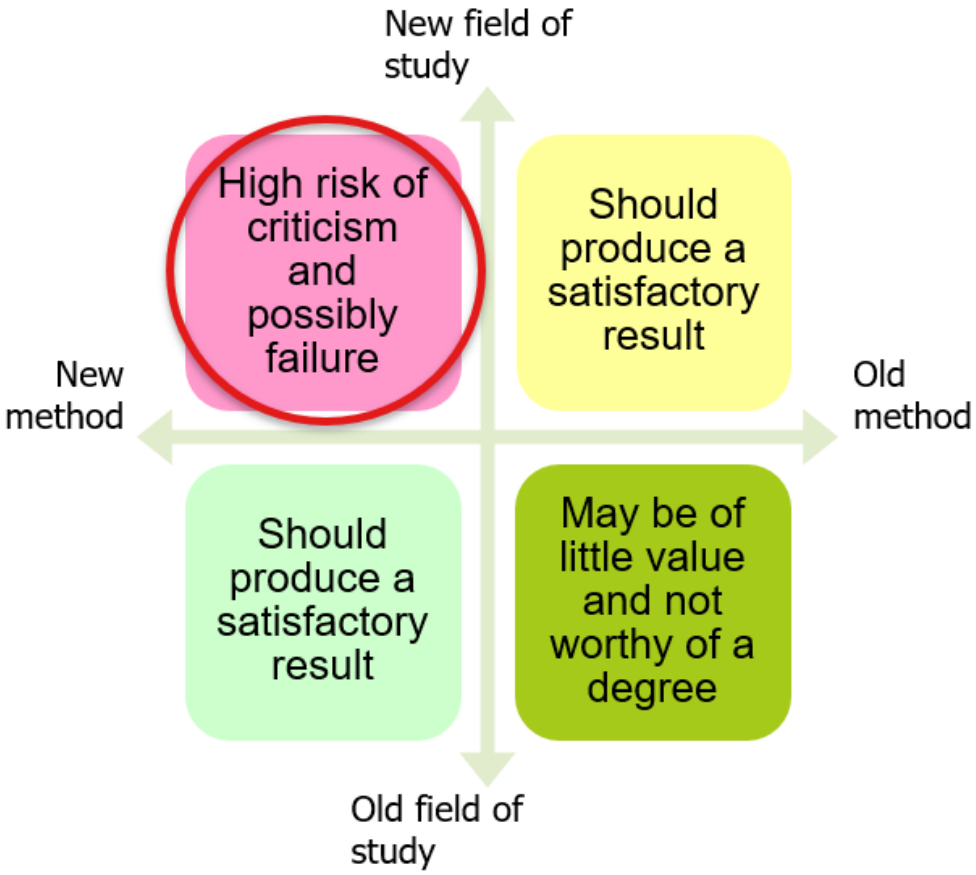


Figure 4: Risk profile research adapted from Remenyi & Money (2004)

Figure 5 depicts the route of safely starting to understand the use APM for infrastructure projects. The pyramid resembles a medicine-testing approach (Hawkins, 2005) in which the first two layers are fulfilled by the research of Aangeenbrug et al. (2019) and Owen et al. (2006), the simulation testing is done in this research.

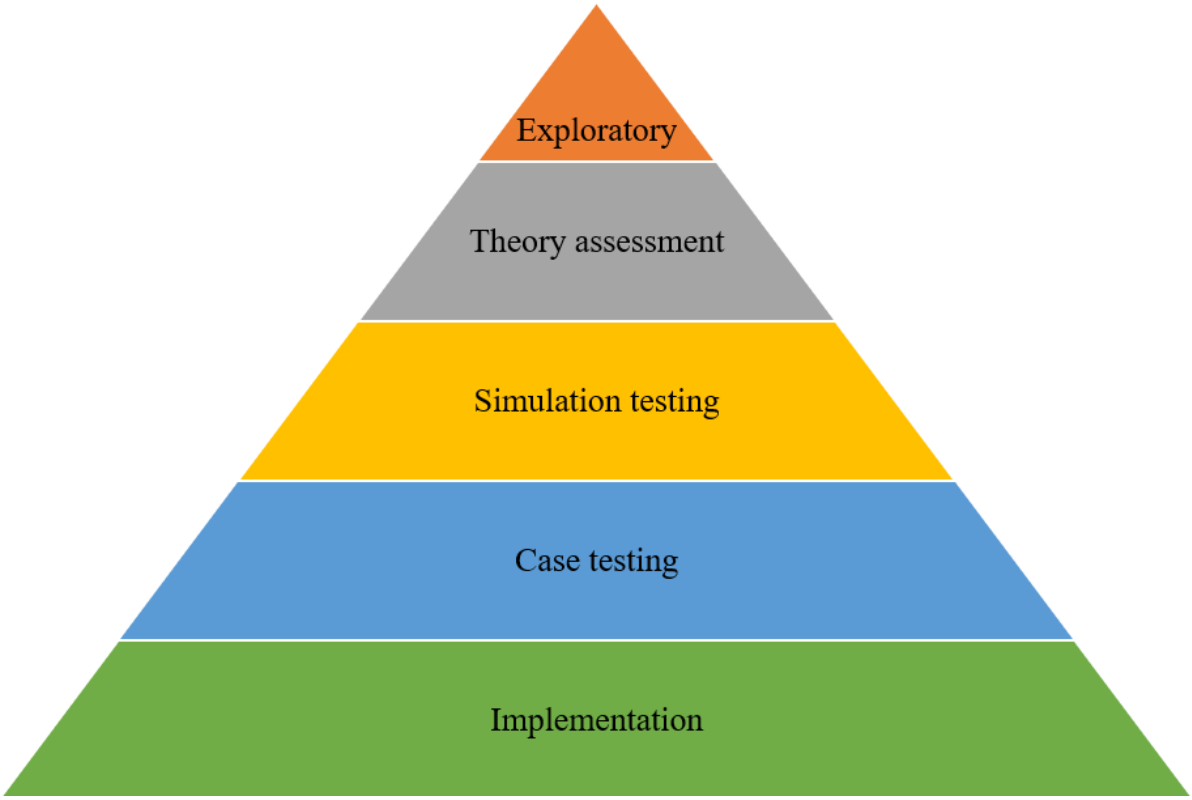


Figure 5: Pyramid steps for using APM in infrastructure projects (own figure)

Part B: Literature review

Think before you speak.
Read before you think.
~ Fran Lebowitz

3 Literature study: the Dutch clients and project management

The literature review forms the basis of the thesis. This chapter elaborates on the responsibilities of the Dutch clients as well as the concepts of traditional and agile project management. It also answers the sub-questions:

How does the project management approach of the Dutch clients look like?
&
What is the agile project management approach, and how does it differ from the current project management approach of the Dutch clients?

The following section discusses the responsibilities of the Dutch clients, and then agile project management (APM) is explained (section 3.2) and compared to traditional project management (TPM) (section 3.3). Differences between the two management methods are presented, and the chapter concludes by answering the sub-questions in section 3.4.

3.1 Dutch clients' infrastructure projects

In the Netherlands, the Dutch government, specifically the project teams of (de-)central government agencies, is mostly tasked with the realisation of new infrastructure. These agencies are usually but not limited to Rijkswaterstaat, provinces, municipalities, and water boards. According to the Twynstra Gudde institute (n.d.), the project teams' tasked with:

- Facilitating a good point of departure
- Describing the intended results of the project
- Ensuring that the project is carried out by the parent organisation
- Selecting and supporting a contractor
- Making agreements about when and how to report
- Deciding and accepting intermediate results
- Deciding and accepting project progress
- Deciding on unexpected changes
- Ensuring that the project is supported by the affected stakeholders
- Shielding the contractor and the project from unwanted, disturbing environmental factors
- Deciding who will use, maintain, and manage the finished project
- Terminating/ending the project[4]

In addition, in most cases, the Dutch clients' project management teams are responsible for risk management (Verhees, van Marrewijk, Leendertse, & Arts, 2015).

According to Morssinkhof, (2007), the most recent recorded building approach of Dutch clients is sequential and similar to Figure 6, the waterfall model by Hass (2007). In this approach, the project phases are completed in sequence; thus, one phase must be completed before the next phase can begin (Nicholas & Steyn, 2017; Turner, 2009). Once a project step has been completed, it is assumed that the phase is not revisited (Hass, 2007). These moments are called stage gates. Diversions are expected to be resolved in such a way that the original plan can still be followed; changes to the plan are, therefore, challenging to implement (Owen et al., 2006).

[4] This text is translated from Dutch to English. Appendix C provides the original texts.

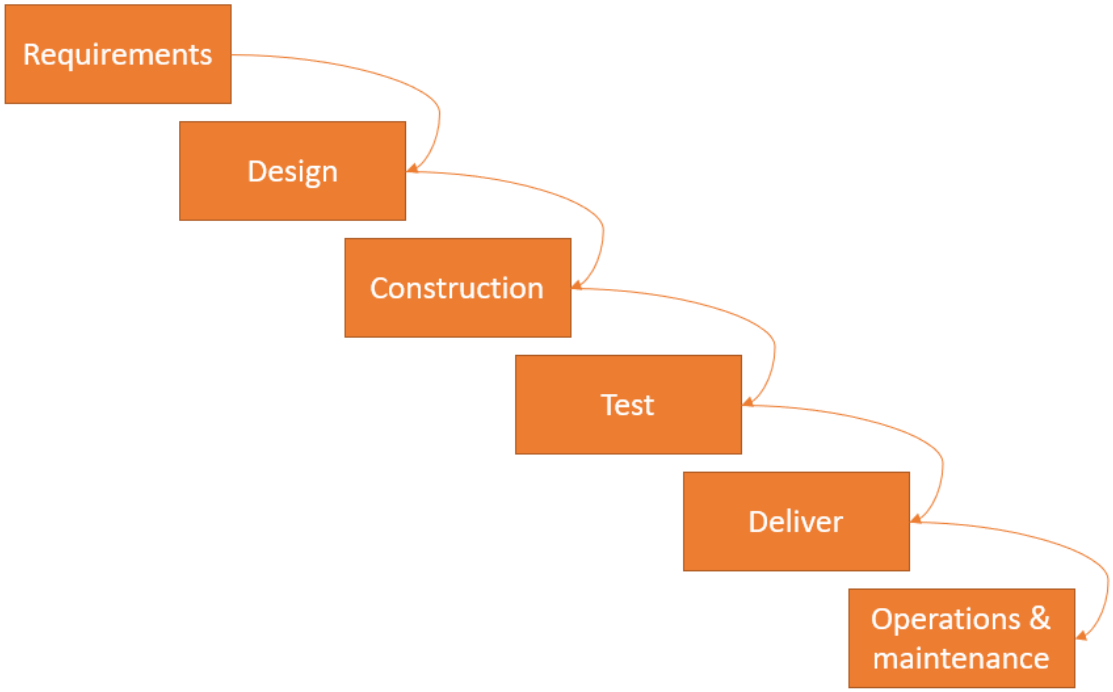


Figure 6: Traditional project management adapted from Hass (2007)

Fernandez and Fernandez (2009) have stated that the traditional approach to project management uses a linear strategy without feedback. It assumes that the project scope can be clearly defined and change is minimal; this comes from the idea that projects are linear and straightforward (Fernandez & Fernandez, 2008; Owen et al., 2006; Špundak, 2014). However, this mentality makes implementing changes difficult, and TPM methods should thus be applied to projects that have a clear goal and solution (Nicholas & Steyn, 2017). The goal of TPM is to optimise and effectively complete the detailed plan to finish the project on time and within budget and fulfil the scope that has been set (Munns & Bjeirmi, 1996; Špundak, 2014). According to Koskela and Howell (2002), TPM exists for the management of project scope. Furthermore, Verbruggen (2017) has argued that TPM assumes a project is predictable. According to Turner, (2009) TPM has five principles:

- Mange through a structured breakdown with a single point of responsibility
- Focus on results
- Balance results with the use of the breakdown structure
- Organise the project through contract negotiations
- Use simple and clear reporting

According to de Jong, (2018) the most-used project management methods in the Dutch construction sector are *projectmatig werken* and *projectmatige creëren*[5], but the use of Prince2 and PMBOK is not uncommon. These are all referred to as TPM methods (Fernandez & Fernandez, 2008).

Which means that the Dutch clients form a project management approach that follow the steps as depicted in Figure 6, to realise infrastructure projects.

[5] This roughly translates to project-based proceedings and project-based creating

3.2 Agile project management

APM is a project management approach developed by IT specialist to deliver better IT projects to customers by meeting four core values of the agile manifesto:

1. ***Individuals and interactions*** over processes and tools
2. ***Working software*** over comprehensive documentation
3. ***Customer collaboration*** over contract negotiation
4. ***Responding to change*** over following a plan (Beck et al., 2001a)

Although each of these items have worth, APM values the former ones more than the latter (Beck et al., 2001a). These four values should be achieved by fulfilling the twelve principles of the manifesto (Table 4).

Overall, APM methodologies were developed to achieve better customer satisfaction, shorten the development time of IT projects, reduce rework, and handle changing environments (Leau, Loo, Tham, & Tan, 2012). These methodologies are based on the agile manifesto or were what created the manifesto (Stoica, Mircea, & Ghilic-Micu, 2013). Therefore, they are interpretations of how to fulfil the goals set out in the manifesto. Some scholars speak of this as the agile mindset or agile thinking (Abbas, Gravell, & Wills, 2008; Denning, 2016; Highsmith, 2002; Verbruggen, 2017). According to Highsmith (2001), agile thinking is needed to see people as essential rather than as assets or means. Cockburn (2016) has stated that APM can be explained by the words 'collaborate', 'deliver', 'reflect', and 'improve'.

Table 4: Principles and ideas of the agile manifesto

APM principles according to Beck et al. (2001b)	Operationalisation (by Verbruggen, 2017)
Our highest priority is to satisfy the customer through early and continuous delivery of valuable software.	Achieve consumer satisfaction.
Welcome changing requirements, even late in development. Agile process harness change for the customer's competitive advantage.	Welcome change.
Delivering working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.	Frequently deliver.
Business people and developers must work together daily throughout the project.	Work together with the business.
Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.	Motivate and empower people.
The most efficient and effective method of conveying information to and within a development team is face-to-face communication.	Face-to-face communication.
Working software is the primary measure of progress.	Working software is the definition of getting things done.
Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.	Maintain a sustainable pace.
Continuous attention to technical excellence and good design enhances agility.	Maintain a good design.
Simplicity—the art of maximising the amount of work not done—is essential.	Keep it simple.
The best architectures, requirements, and designs emerge from self-organising teams.	Work in self-organising teams.
At regular intervals, the team reflects on how to become more effective; it then tunes and adjusts its behaviour accordingly.	Reflect to become more effective.

3.3 Comparing agile and traditional project management

There are apparent differences between APM and TPM. TPM consist of three underlying theories: management-as-planning, the dispatching model for execution, and the thermostat model for control (Fernandez & Fernandez, 2008; Koskela, L. & Howell, 2002). APM is the fulfilment of the agile manifesto to deliver better projects to the customer (Aguanno, 2004). According to Turner (2009), five TPM principles are fulfilled by identifying the project's scope and then breaking the project down so requirements can be defined (Nicholas & Steyn, 2017) often according to the SMART acronym (specific, measurable, attainable, reasonable, and timely) to make them measurable (Wasson, 2015).

In contrast, APM often utilises user stories to gather project requirements, develop the scope (Lucassen, Dalpiaz, Werf, & Rinkkemper, 2016), and understand the user's needs.

Understanding of the project's scope is used in TPM to control time and resources through fixing the scope and managing changes to it (Khan, 2010; Owen et al., 2006; Verbruggen, 2017). A work breakdown structure is used for the project's breakdown (Turner, 2009; Zandhuis & Wuttke, 2019). Contrarily, APM fixes time and resources to control the scope (Owen et al., 2006; Verbruggen, 2017). Time is managed by incremental and iterative planning through timeboxes or sprints which control the scope by defining what is and is not done in each timebox (DSDM Consortium, 2014; Sutherland, 2015). The user stories are often used to plan and estimate progress (Haugen, 2006).

Using timeboxes through an iterative design process forces the project team to keep evaluating the project (Hass, 2007). By presenting "working" software to the customer after each iteration, the project team show progress, which is used to understand if this is what the customer needed or wanted. Through this approach, changes to the project are accepted and incorporated into the next iteration. To reduce the amount of work for each timebox, prioritisation of the requirements is used to allow changes or to plan the project accordingly (Racheva, Daneva, & Herrmann, 2010).

On the other hand, TPM tries to reduce the number of changes since any change is seen as a threat to the scope of the project. Implementing change is, therefore, complicated even if it is understood that change is inevitable (Lycett, Rassau, & Danson, 2004; Sohi, 2018). Because changes are inevitable, risk management became an essential aspect of TPM. Uncertainties that might affect the project are thought of as risks, which could have either positive or negative effects on the outcome; thus, risk management is used to maintain better project control (Arkesteijn & Mooi, 2014).

In APM, communication is needed to understand stakeholder needs, and this form of management is built on collaboration often finding face-to-face communication important (Beck et al., 2001a). To fulfil this agile manifesto principle the customer and the project management team to be co-located (Beck et al., 2001b; Lindstrom & Jeffries, 2004). In addition, APM uses delivered value and visualisation to communicate and readjust the set scope of the project (Hass, 2007).

Whilst TPM also uses meetings, these are to identify scope changes and then correct them (Nicholas & Steyn, 2017). Nicholas and Steyn (2017) have recommended making a communication plan for larger projects, which includes a schedule with details on documentation and formal communication.

Moreover, visualisation is utilised by both project management styles, although TPM often uses Gantt charts to communicate progress (Karlesky & Vander Voord, 2008), whilst APM uses "working" software, often in combination with a burn-down chart[6], to report progress (Karlesky & Vander Voord, 2008). Kanban boards report and show what the project team is currently working on, what user story is finished, and what must still be done in that iteration (Hass, 2007). This project visualisation gives the team the ability to assess its progress and control over what is done next.

A user story is fulfilled when it meets the definition of done[7]. In TPM, requirements must be validated to create traceability and accountability (Hoezen et al., 2006). Therefore, TPM makes use of rigorous documentation through different management plans and breakdown. On the contrary, APM uses "working" software as a primary form of documentation. In addition, a product backlog with all the requirements is often kept along with any other documentation that is deemed necessary.

Finally, APM utilises self-organising teams to plan and manage the project, whilst TPM often uses a hierarchical structure to keep people accountable. Leadership in APM is often distributed within the teams, and managers function as facilitators (Hoda, Noble, & Marshall, 2010; Verbruggen, 2017). Members of these teams make use of informal, implicit, and spontaneous roles to satisfy their organisational needs (Hoda & Murugesan, 2016). By evaluating governing variables, the efficiency of the project team is improved (Owen et al., 2006). However, TPM often views a project as so unique that the lessons of the past are ignored (Nicholas & Steyn, 2017). Thus, evaluation of TPM projects is focussed on improving the action strategy.

[6] Burn-down charts are used the track progress by plotting the to completed tasks versus the total project time to visualise progress (Woodward, Cain, Pace, Jones, & Kupper, 2013).

[7] Abstract agile concept which uses multiple definitions, but generally it is accepted that a user story is accepted when reviewed and excepted by the product owner (the person representing the customer).

3.4 Conclusion: Project management activities of the Dutch clients

This chapter has presented information on the Dutch clients and the different management approaches in order to create the serious research game and analyse the results from the sessions. From this information, two sub-questions can be answered:

How does the project management approach of the Dutch clients look like?
&
What is the agile project management approach, and how does it differ from the current project management approach of the Dutch clients?

3.4.1 What the Dutch clients do to realise infrastructure projects

When the Dutch clients want to realise an infrastructure project, a project team within the client's organisation is set up. The team is responsible for successfully creating and identifying the scope, design, and plan of the project in the front-end development phase. The construction phase is executed by a contractor selected through a tender procedure overseen by the project team.

By using TPM methodologies, the scope of the project is managed according to what the planning and resources are based on. Multiple stakeholders are involved because the construction takes place in a living environment in which risks emerge and must be managed. This is done through communication and collaboration within the project management team and with the stakeholders.

The teams define early on the requirements of the project, which make up the scope. The scope influences the resources and planning, which, in turn, also influence the scope. Communication helps to identify issues and readjust the project so that it follows the plan, making it difficult to deal with changes.

Figure 7 depicts five interacting variables a project management team manages to control project performance for the Dutch clients. These variables influence each other. The variables times, resources and scope are classic variables from the iron triangle. Stakeholders and risk can also change these variables. Risks and stakeholders decide upon the cost of the project (resources), what can and will be realised (scope), and when it needs to delivered (time). Collaboration and communication are needed to understand and manage these interacting variables.

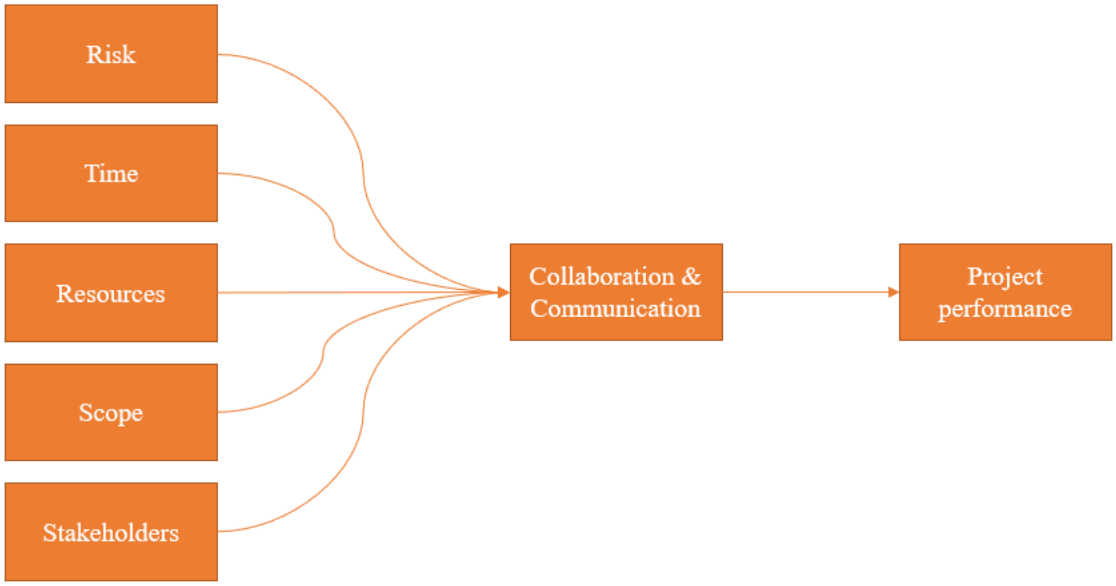


Figure 7: Causality diagram, project management (own illustration)

As seen, to realise infrastructure projects, the Dutch clients appoint a project management team responsible for managing the scope, stakeholders, resources, planning, and risks to build the infrastructure. Often, TPM methodologies are used to manage these projects.

3.4.2 Possible Alternative approach ~ agile project management

APM is an alternative approach mainly used in the IT sector and is determined by the agile manifesto. APM methodologies focus on achieving the four values and twelve principles presented in this manifesto; different techniques and tools are used to accomplish this.

The use of APM differs from TPM. APM makes use of an iterative design process with timeboxes to collaborate with and gain input from the customer and to allow changes to the product. The requirements are often defined through user stories, and working software is used as a communication and documentation tool to make sure that what has been created is what the customer wanted. Self-organising teams are used to enforce collaboration, and the project is delivered when the customer is satisfied with the product.

Figure 8 depicts the relationships between the need to deliver a satisfactory project to the customer and fulfilling the four values and twelve principles of APM. Arrows between the boxes represent these fulfilments. The figure shows that the practices are needed to fulfil APM principles that in their turn, satisfy one of the four APM values. These values are attained so that satisfactory a project can be delivered to the customer. This means, APM is the fulfilment of the four values in the agile manifesto. This is referred to as agile thinking.

In conclusion, the main difference between the APM approach and the TPM approach is the focussed on realising the four values presented in the manifesto. From this all other differences and practices originate.

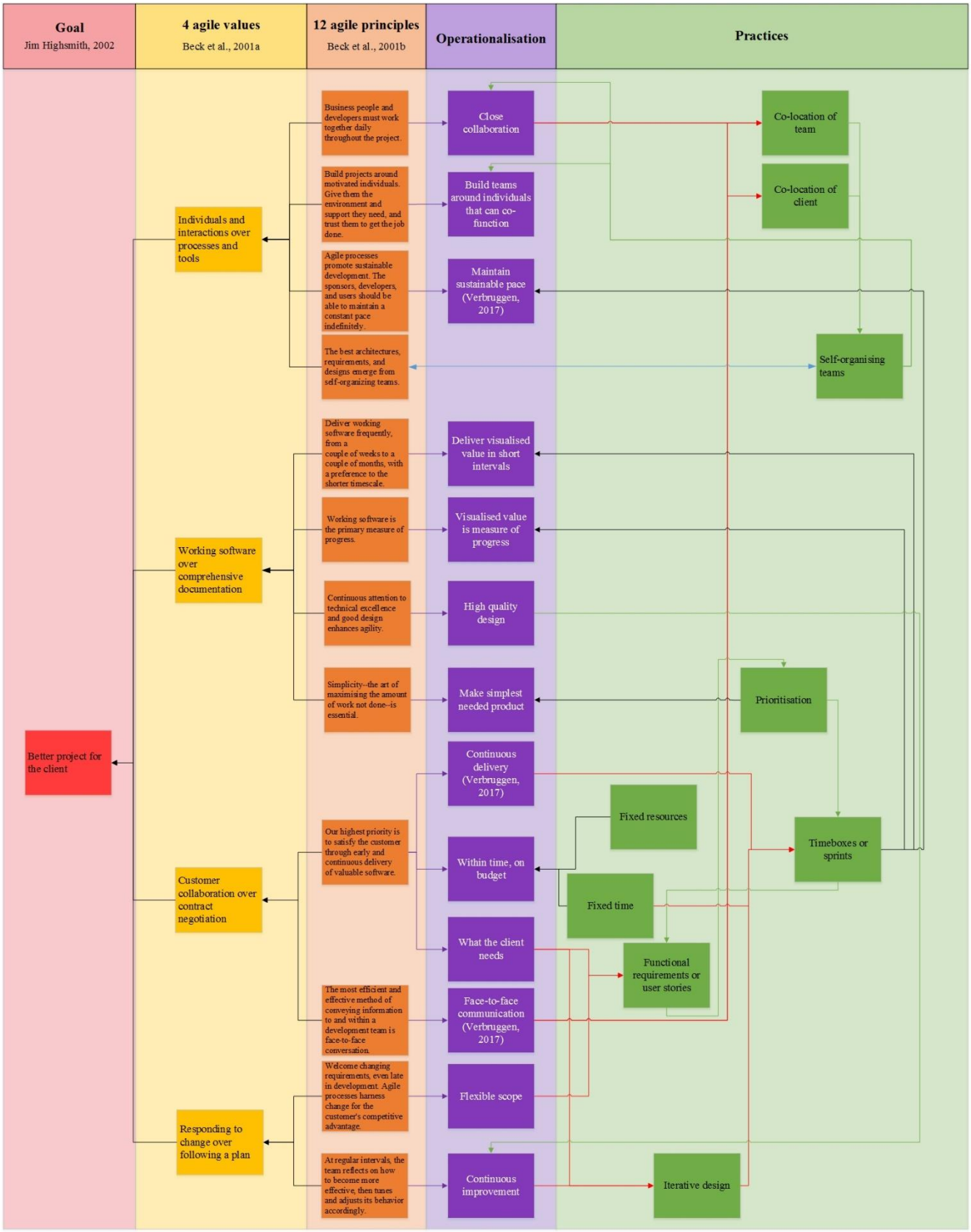


Figure 8: Summary of APM (own illustrations)

4 Literature study: Serious research game design

A serious research game (SRG) was created for this study to make a researchable project management environment. The SRG functions as a pilot test of the use of agile project management (APM) for the realisation of infrastructure projects. For the practical application of a SRG, it is essential to understand serious research gaming (section 4.1) and its design elements from a theoretical point of view (section 4.2). Section 4.3 summarises this chapter.

4.1 Serious research gaming ~ an introduction

The primary goal of a serious game is to educate and learn through play (Crookall, 2010; Deterding, Dixon, Khaled, & Nacke, 2011; Susi, Johannesson, & Backlund, 2007). Serious games are multipurpose and primarily used for educational purposes (Smith, 2010) in areas which are often considered too costly or risky (Corti, 2006; Squire & Jenkins, 2003; Susi et al., 2007). Corti (2006) has defined serious gaming as learning by doing. The framework of Susi et al. (2007) argues that a serious game focusses on problem-solving, learning elements, working with assumptions to make a useable simulation, and employing communication that reflects real-life situations. A serious game mimics a real-life process, model, or situation (Keizer, 2018). However, the definition of a serious game is highly dependent on the context, actors, and initial objective of the game (Susi et al., 2007).

Moreover, this thesis argues that there must be a distinction between serious education games (SEG) and SRG. Currently, both types are referred to as serious games, and most focus on creating *flow* for an optimal player leaning experience because the primary goal of serious games is often to educate and learn through play (Crookall, 2010; Djaforova, 2017; Jansen, 2016; Pavlas, Heyne, Bedwell, Lazzara, & Salas, 2010). An optimal learning experience is created by balancing the player's abilities and the game's complexity over the duration of the game, as illustrated in Figure 9 (Michael Csikszentmihalyi, 1990), thus creating an interactive learning process (Bressers et al., 2018).

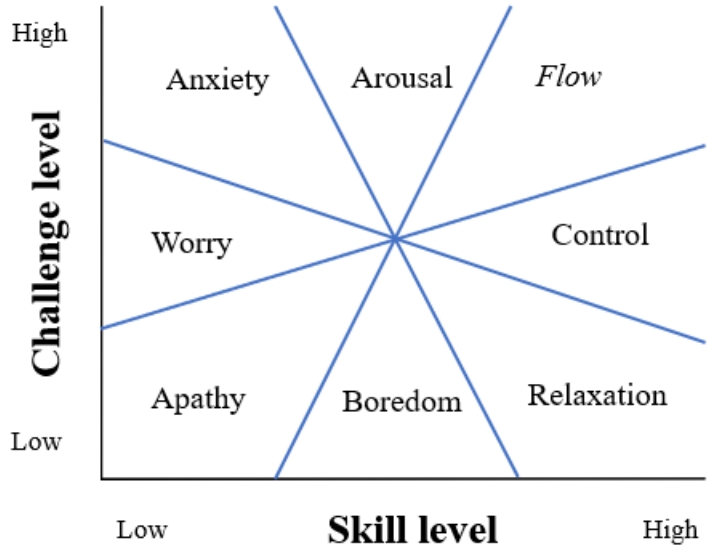


Figure 9: Illustration of the state of *flow* (Csikszentmihalyi, Abuhamdeh, & Nakamura, 2014)

This balancing means that when the player's abilities grow, the game must respond and increase in complexity by becoming more challenging (Croshaw, 2019b). This means a player faces new challenging tasks or is introduced to new game mechanics (Sicart, 2015). This approach is ideal for teaching, gradually introducing concepts to the player, increasing the complexity over time, and giving the player the ability to learn the game's mechanics and improve his or her skills; this is the player's learning curve.

However, this effect of gradually teaching and evolving the player's abilities is often unwanted in research because teaching the player affects the results: the behaviour is changed by playing the game. This is unwanted because the researcher is interested in the behaviour of the player in the created setting, not what the player learns during the game. In addition, training the player during the game makes the player more aware that he or she is playing the game because he or she is taken away from the 'action' (Atkins, 2018; Tanskanen, 2018). When this occurs, the player is more susceptible to Hawthorne effects and modifies his or her behaviour due to awareness of the research setting, reducing research integrity (Sekran, 2000).

A mitigating option is to let players become absorbed by the gameplay so that they lose themselves in it, forgetting the world outside the game. The study must have players behave as they normally would and not teach them to improve their habits. This can be achieved by creating immersion, which is defined as 'becoming completely involved in something' (Cambridge Dictionary, n.d.). Figure 10 depicts the overlapping elements between *flow* and immersion, the latter of which has an additional focus on storytelling (Qin, Patrick Rau, & Salvendy, 2009; Tanskanen, 2018).

Creating immersion reduces Hawthorne and learning effects because players forget they are playing the game and act more as they would in normal life (Tanskanen, 2018), falling back on the knowledge they already have (Tanskanen, 2018).

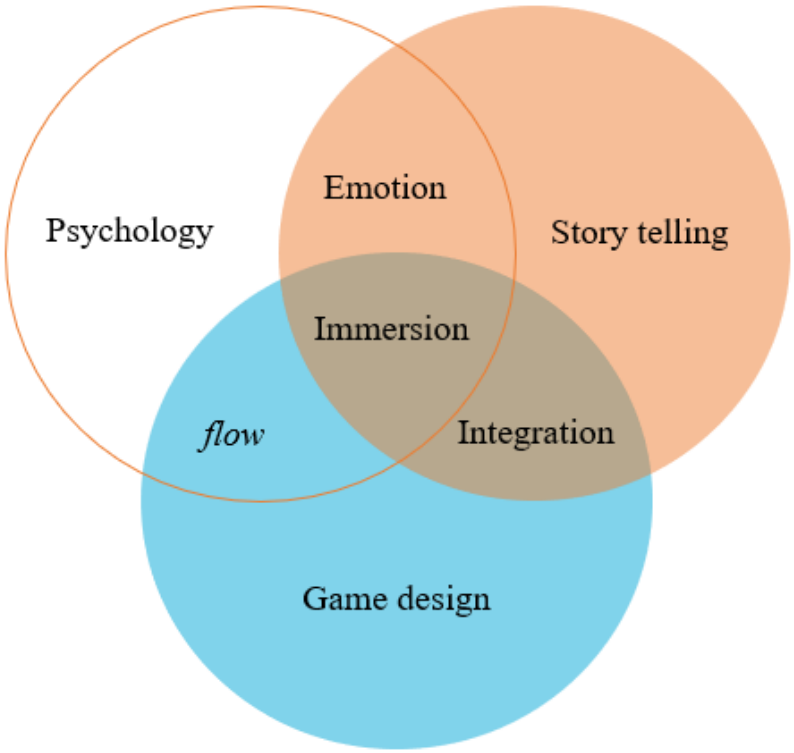


Figure 10: Game design, psychology, and storytelling Venn diagram according to Tanskanen (2018)

Thus, the researcher focusses on creating a game in which players become immersed rather than having the traditional *flow* focus, which is suited for educational purposes. This study, for instance, researches a contemporary phenomenon within a contrived setting by creating a serious game emphasising immersion over *flow*. Therefore, this research makes a distinction between serious games focussed on education (SEG) and those which focus on research (SRG). Which is needed to ensure the quality of the research conducted. This is done by limiting treats toward intern validity and increasing external validity. Causing the need for different design choices due to the focus on immersion.

4.2 Serious game design rules and elements

Designing a game is no easy task, especially when it is for educational and research purposes (Gunter, Kenny, & Vick, 2006). This section explains how to design a SRG, providing insight through entertainment games.

According to Janssen (2012), a standard game consists of components such as environments, ruleset, information, interface, theme, players, and context. These are game elements and mechanics. Game elements are the game's obstacles through which the player is kept engaged (Boller, 2013). Two types of gaming elements can be identified: playability improving and decreasing elements. Game mechanics are the rules and procedures that guide the player(s) and the game's response to the actions of the player, defining how the game is played.

Annetta (2010) has described a six-element framework for SEG, including identity and immersion, which are player-focussed, and interactivity and increasing complexity, which are gameplay-related. The elements of informed teaching and instruction are not considered relevant to this study because they are specific to teaching. According to Zhou, Bekebrede, Mayer, Warmerdam, and Knepflé (2016), there are eight rules that a serious game must fulfil:

1. Flexible and reusable: the game should be useable for, a range of similar situations and different contexts.
2. Authoritative: the game should meet analytical standards and political standards.
3. Dynamic: according to Vissers, (2016) 'the game needs to react on the actions of the participants'.
4. Transparent: the game should be clear and understandable.
5. Fast and easy to use: the time required to use the SRG should be relatively short, and non-experts should be able to use and play the SRG.
6. Integrative: the game should consider different levels of design and decision making.
7. Interactive: the game should be able to support the negotiation process among participants.
8. Communicative: the game should be able to convey meaning and insight to participants about the problem, alternatives and different perspectives.

Zhou et al. (2016) have argued the first five points are design elements which could create an immersive environment.

Annetta (2010) has argued that immersion means players have a heightened sense of presence through individual identity. Players with a sense of identity become motivated to complete the game and overcome its obstacles (Annetta, 2010). To create immersion, the game designer should consider a three-stage narrative (Zimmerman, 2004):

1. Pulling the player in through exposition,[8] with a focus on 'show, don't tell' (Croshaw, 2016; Jenkins, 2004).
2. Pacing and flow[9] of the narrative and gameplay to make the player emotionally invested (Baumann, Lürig, & Engeser, 2016).
3. Game's complexity, which is created through the primary gameplay loop to give the player(s) a purpose on a moment-to-moment basis (Croshaw, 2019b).

Additional gameplay loops increase the complexity of the game, which might help to create pleasant player frustration and more fully immerse players (Annetta, 2010; Gee, 2004). According to Annetta (2010), this can only occur when the players are met with a challenge which is exciting to them. However, challenging should not be impossible or unpleasantly frustrating as this will cause the player to become bored and disengaged from the game.

[8] Exposition is all the information available to the player; this can be texts but also visuals and are processed consciously and subconsciously. See appendix B for a more in-depth explanation through an example.
[9] This is another type of flow than that defined by Csikszentmihalyi (1990). Distinction is made through cursive lettering.

Fairness of a game is also essential in getting a player to continue to play (Iida, 2007; Uiterwijk & van den Herik, 2000). Sometimes players try to cheat, which is a problem, especially in research settings, since cheating affects the research results and fairness. The SRG designer should thus try to create a game that makes cheating nearly impossible.

Loopholes in games can also be exploited by players to get the upper hand or change the game's outcome in their favour (Brooke, Paige, Clark, & Stepney, 2004). Exploiting loopholes is considered a form of cheating. These loopholes are often but not always created by an offset game balance, which occurs when a game mechanism has a disproportionately higher impact than other choices (Baumann et al., 2016). Often, this is applicable to the in-game economy or game perks.

When a game has no end or cannot be completed (within a reasonably set time), players will get frustrated and try to break the game mechanics. They start searching for loopholes or try to affect other players for their pleasure, causing these players to control the game. The same control loss applies to game elements with a factor of chance and randomness and should only be applied within strict boundaries (Croshaw, 2019a). Thus, random game elements should not be applied in SRGs because the researcher could lose control over the variables.

4.3 Summary of serious research game design

This chapter started with the introduction of serious research games. It showed that there is a difference between serious games for educational purposes that educate and learn through play and the games for research purposes that study a contemporary phenomenon within a contrived setting through play.

The rest of the chapter has focussed on serious game design principles and choices to create the SRG used in this study and analyse the results from the sessions. Figure 11 summarises the four design values—identity, immersion, interactivity, and increasing complexity—needed to create a playable SRG. The figure shows the relationships between SRG factors and design principles.

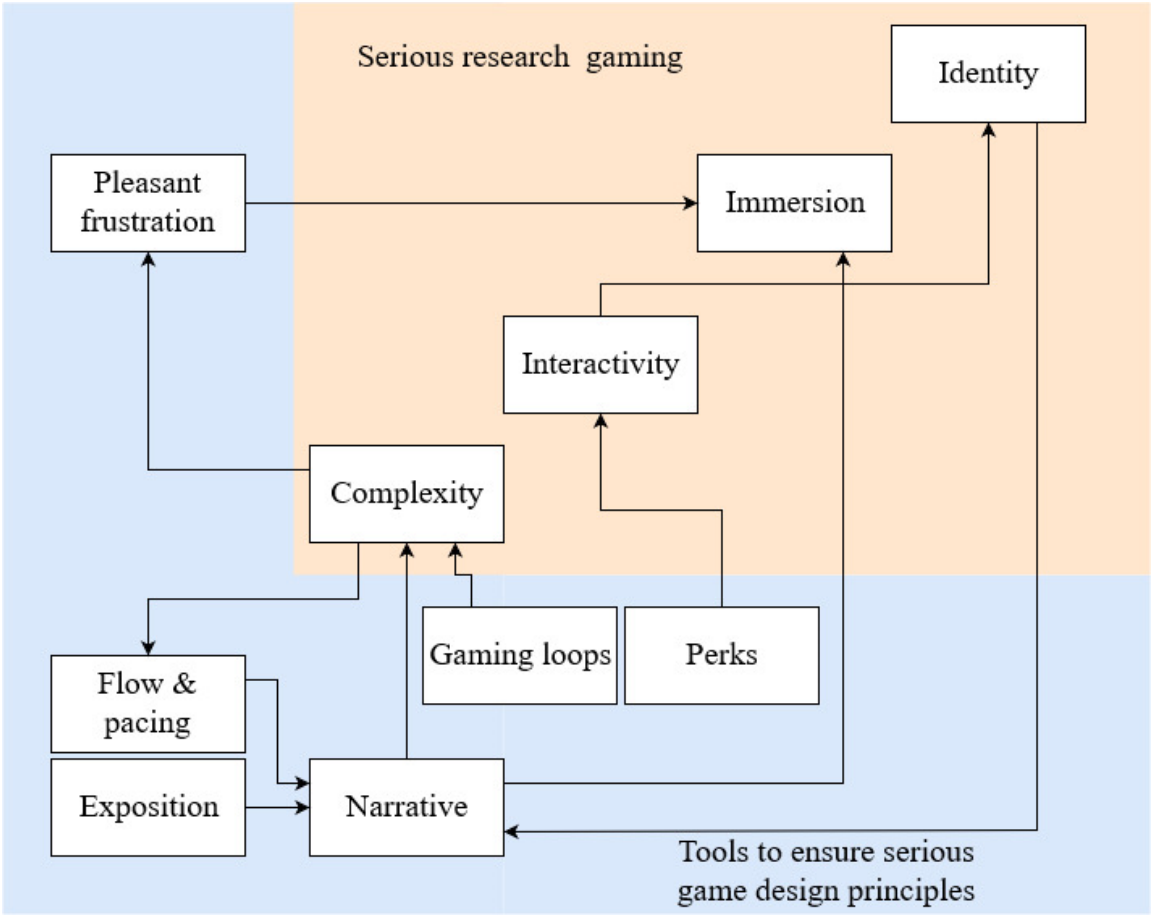


Figure 11: Flowchart values and tools to create a SRG (own illustration)

Identity is created through narrative and immersion, and interactivity helps the player understand his or her identity. Gameplay complexity is created through multiple gameplay loops, which create pleasant frustration. The game's narrative is also essential in setting up the game's complexity through exposition and limiting the player's creativity through boundaries. Immersion is also improved through flow and pacing.

The values of immersion and identity are essential in creating a SRG because they reduce scrutiny of the research by reducing Hawthorne and learning effects. Both complexity and interactivity positively affect the values of immersion and identity and improve playability of a SRG. Indeed, without interactivity and complexity, a SRG cannot be created because they ensure player feedback and challenges so that they are willing to play the game.

The player related values identity and immersion are essential value to take into account. These values affect the type of game and how the game needs to be played through the narrative the players are put it. These values determine the actions the player takes with in the game.

The game play related values complexity and interactivity are vital concepts for the playability of the created game. No feedback from the game to the player on a player's action, lets the player question the gameplay and reduces the player motivation to continue. Considering the complexity and balancing this improve player motivation to keep playing the game or even attempt to play it. Without a balanced game complexity, the game is either to easy or to hard causing players to abandon the game.

In conclusion, the SRG which was created, and is discussed in chapter 0, must fulfil the eight serious game criteria. In addition, the designer's aim was to create an immersive game with clear and fair gameplay which could be completed within a reasonable timeframe during which players could be themselves. The mechanics should be balanced, loopholes identified and closed, and complexity ensured by multiple gameplay loops. These criteria are evaluated in chapter 7.

Part C:
Serious research gaming

You can discover more about a person in an hour of play than in a year of conversation

~ Plato

5 Creating the serious research game

This chapter discusses the created serious research game (SRG): created for this study, 'Construction manager: bridge builders' (section 5.1). To create it, design choices were made (section 5.1), and the game was developed (section 5.2). Furthermore, this chapter highlights the responsibilities that are mimicked by the SRG (section 5.4). Section 5.5 explains how information is gathered from the SRG, which was developed in part to answer the sub-question:

How can an infrastructure environment be simulated to research project management approaches from the Dutch client's perspective?

5.1 Design choices

A SRG designer must make trade-offs between playability of the game and the research. A SRG is inherently limited by research considerations, so players can only play once to reduce learning effects and playtime is limited to reduce maturation effects (Sekran, 2000).

The first major consideration is to focus on *flow* or immersion; as explained in section 4.1, this research focusses on creating immersion. Players will seek to understand their role within the created game environment caused by an unfamiliar situation. To reduce this effect, the SRG resembles a real infrastructure project as much as possible to give players the ability to act as themselves.

A feeling of anxiety must be created so that players must start immediately on the tasks at hand to finish on time. This is achieved by a limited playtime and giving players most of the information at the start of the game, thus using an exposition dump.[10] The exposition dump reflects the beginning of infrastructure projects when teams are faced with an abundance of information to sort through. By doing this, players will likely act as they would in a non-contrived situation, and immersion is improved through the realistic setting and reduces negative identity effects, causing the results to be more applicable to the real world.

Often, games force the player to learn its mechanics through trial and error (Michael Csikszentmihalyi, 1990; Wang & Chen, 2010). This is unwanted in research: the players should be able to understand the gameplay immediately, or their understanding of it should grow during the SRG without the ability to fail. Otherwise, the behaviour cannot be adequately observed. Most games release exposition throughout the game which fits with the learning curve of the player. Due to the limited time and the need for realism, the SRG uses an exposition dump to mimic reality and reduce the learning curve.

This research aims to explore the possible use of APM through simulation for the realisation of infrastructure projects from the client's perspective. The game's objective is to develop and execute a construction project as the project team for the Dutch clients. To do this, a simulation is created in the form of a SRG in which APM experts can use their approach to realise an infrastructure project. This is necessary because civil project managers use TPM, and APM experts are mostly found in the software development sector.

To mimic a real-world infrastructure project, the SRG should consist of two phases: a front-end development phase and a construction phase. The development of the Sint Sebastiaans bridge in Delft is used as the base concept and is complemented with elements from the bridge *over het IJ* and the Dafne Schippers bridge. A bridge-building project has been chosen because it speaks to one's imagination and is a basic infrastructure project. Other infrastructure projects were considered, such as road development and dyke construction, but these were deemed too expert-oriented, reducing the

[10] An exposition dump is when a game provides all the information at once rather than gradually explaining it over time.

ability to research the project management approach with non-civil engineers. An area development project was also considered, but this might suit the use of APM too much.

There is a need for an open-ended solution to the game, to mitigate a possible path dependency[11]. Which would lead the players to a pre-defined set of solutions, resulting in conformation bias and neglecting possible choices that the game designer over looked but the players wanted to choose.

The SRG is played in two teams. One team consists of agile experts and the other of experts in the field. This approach was chosen due to the limited knowledge of APM within the construction sector; it also allowed the researcher to have a discussion with agile and civil experts on the project approach. Regardless of their background, participants should be able to play the SRG (which is a basic rule of serious games), but players with project management knowledge should perform better because the setting mimics a real-world situation in which project management is used to improve performance on the project.

5.2 Setting up the serious research game ~ inspiration and approach

To develop the SRG, the researcher translated the responsibilities of the Dutch clients into game mechanics and elements. Mechanics of other games were used as inspiration for this. In addition, game design inspiration and knowledge were gained from the game critic and developer Benjamin 'Yahtzee' Croshaw. The games which inspired the SRG 'Construction manager: bridge builder' are 'Dungeons and Dragons', 'Cities: skylines', and 'Settlers of Catan'.

'Dungeons and Dragons' is a popular tabletop role-playing fantasy game in which players pretend to be heroes going on an adventure. Each game is managed by a dungeon master, who has the role of storyteller. The created narrative gives goals and rewards to the players. The goal is to explore a fantasy world created by the players and the dungeon master. There is no winner and no explicit end to the game (Maza & Barton, 2018). The elements of this game that were used for the SRG are role-playing, open-ended goals, player's decisions effect on the outcome, and the game moderator.

'Cities: skylines' is a digital city management simulator in which the goal is to develop a city. The player has control over the environment, roads, buildings, and zoning plans. Citizens of the city give feedback through their moods, which affect the city the player is building. These virtual citizens are the source of income; when they are not happy, they leave the city, making it impossible for the player to further develop the city (Croshaw & Morton, 2015). The elements used in the created SRG were the influence of the citizens and the management and construction of the cities.

'Settlers of Catan' is a tabletop board game in which chance and cooperation play a role. In the game, it is essential to acquire resources, trade with each other, and gain several points to win. The mechanics include trading, cooperating, and using resources. The Catan economy is well balanced but highly dependent on chance. The in-game economy inspired that of the SRG in this research.

The design of the SRG was based on the tasks of the Dutch clients, as well as the game mechanics and elements. To test the game, the researcher used a typical iterative test approach (Godoy & Barbosa, 2010), which consisted of closed and open alpha, beta, expert, and students sessions. The closed alpha session tested individual small game elements and was done by the researcher. In the open alpha session, the game was played/tested by friends of the researcher with focus on the playability and identifying gameplay issues. Then followed the beta session, where the SRG was played for the end-users. Each test gave insight to the SRG designer, and helped to improve the game.

[11] This means that player choices are limited in such a way that they need to make certain predefined choices leading towards specific pre-defined solution.

5.3 Construction manager: bridge builders ~ Explaining the game

The SRG that was developed is called 'Construction manager: bridge builders'[12], and its objective is to let players develop, design, and build a new bridge project which solves the issues presented in the narrative. Players work together and discuss their solutions with stakeholder actors. The appendix 'Serious Research Game' contains all the materials of the game, including the player manual and the actor roles. The SRG characteristics are:

1. Multiplayer game, played in two teams of three to five people
2. Tabletop role-playing game (Team members work together to convey information on which the design and construction are based.)
3. Socially interactive (Players interact with teammates and stakeholder actors.)
4. Project management decision making (Players make typical project management decisions.)

The game mimics a construction project with two playable phases: a front-end development and construction phase. Each phase has a primary gameplay loop. The first is developing a plan for the execution phase—writing and developing plans. The second phase is the execution of this plan, making the primary loop plan execution. The secondary and tertiary gameplay loops are the same for both phases. The secondary loop is communication and information sharing, internally and externally. This entails communication within the team and between the team and actors. The tertiary loop focusses on change, which is a risk that often occurs unexpectedly. A game session consists of three parts[13]: an introduction, playing the game (2a and 2b), and evaluation.

Part 1:	Introduction	The game is explained to the participants.
Part 2a:	Game development phase	In this phase, the participants develop their plan.
Part 2b:	Game construction phase	This phase is the execution of the made plan.
Part 3:	Evaluation	The game is evaluated.

Before each session, players give their consent to play the SRG and their understanding that the results will be used for research purposes. In the first session phase, the game moderator explains the game to the participants and that the SRG is part of a research project. Teams are instructed to work as they normally would when realising a project. There is no explicit mention that a team must work using either traditional or agile project management; this is only implied through team composition. Actors receive their role description and are explicitly told that acting consistency is more important than understanding the whole motivation. Actors may improvise when information is missing, and no answer can be given to the team from the role description.

Figure 12 depicts the gameplay. Each session starts with an introductory presentation that informs the players about the research. Then players get five minutes to get to know each other through a teambuilding exercise in which K'Nex is used to familiarise players with the game resources. Players have five minutes to read the manual, and then the 60-minute game starts.

The problem the teams need to solve is a bridge building project, nothing is decided yet on the project. The city council and the citizens of the city have different demands about the bridge which the team needs to design and build. Choices need to be made on bridge type, length, width, height, and amount of bike, car and tram lanes.

The teams must develop a solution to the posed problem. To do this, they identify project requirements and make a design which must be approved by the city council actor. First, the teams select a contractor, which limits their construction abilities and design choices due to the amount and types of materials and the type of bridge that the team must build.

When a contractor is selected, a team receives a development kit as a reward; this kit contains some K'Nex parts, which the players can use for prototyping, and a ruler. A team fills in a material order form to gain the building materials. After the team's plan is approved by the game moderator and city council actor, the team receives its materials and an A1 map of the area on which the bridge to be constructed will be placed. Optionally, the teams can fill in a risk register to gain ten minutes of extra playtime. This can be done at any moment during the game.

[12] In Dutch, Constructie manager: bruggenbouwers.
[13] Parts are the steps taken in a session. Gameplay loops apply to the gameplay.

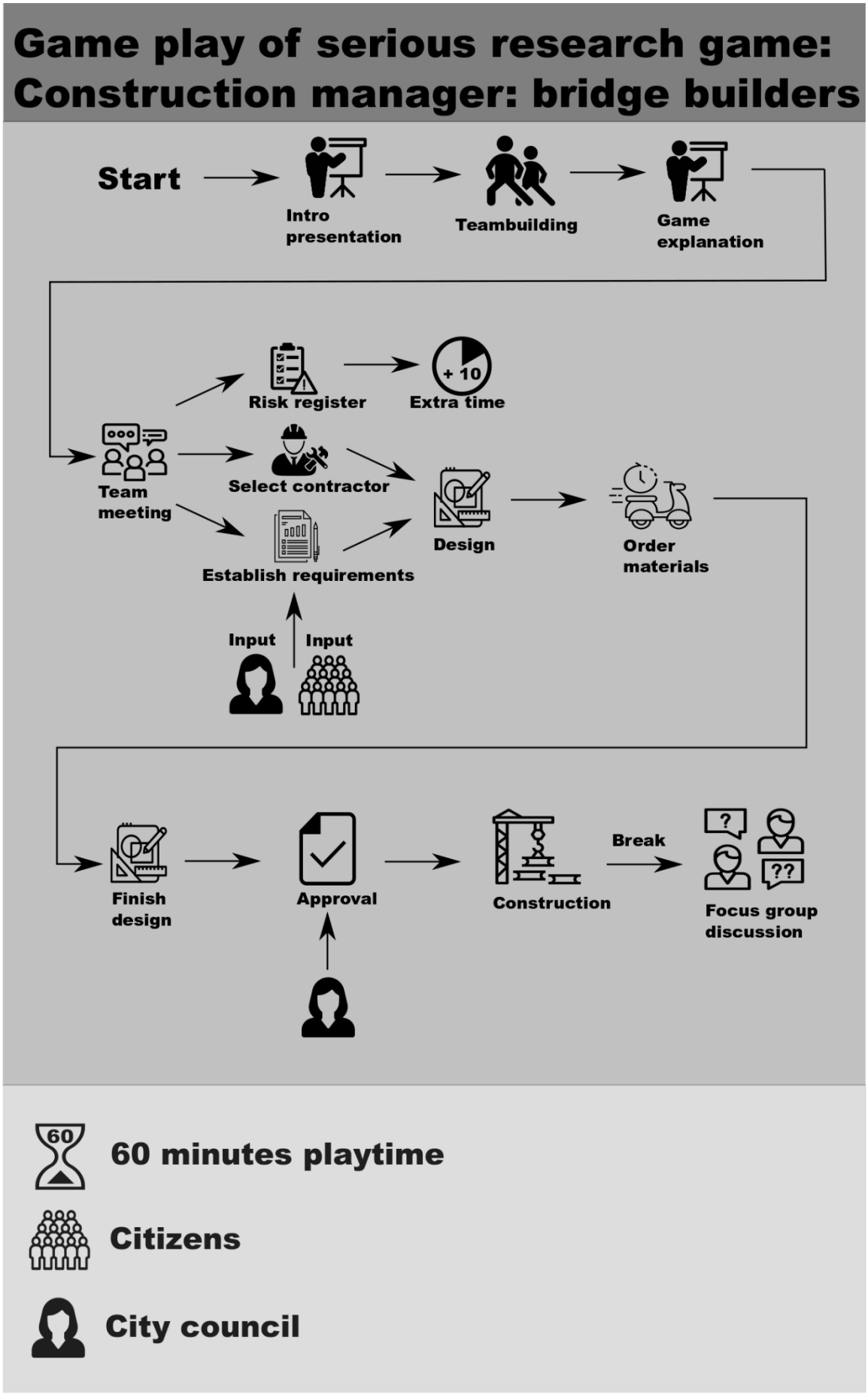


Figure 12: Gameplay flowchart for 'Construction manager: bridge builders' (own illustration)

During the game, the moderator makes a change to the setting by fictionally changing the political party composition of the city council and thus changing the motivations of the city council actor. This causes the players to, reconsider a more sustainable design which highlights construction urgency. Moreover, the moderator makes changes to the setting, monitors progression, and ensures that participants understand their tasks. This is done by observing the teams, understanding which steps they are taking during the game, and analysing if they are missing a step or possibly a task. When the moderator suspects the team is missing a critical step, the team is simply asked if they did not forget to do the identified step. If the team forgot a task and been made aware of that task, they respond in two ways. Either the task is immediately executed or the task is postponed until the task they were working on is finished.

After a 15-minute break, the results and approaches are discussed with the participants, including the actors and observers, to get multiple views on the approaches applied by the two teams. The moderator leads the discussion. Table 5 contains the summarised rules. Table 6 contains the general game mechanics.

Table 5: Rules of 'Construction manager: bridge builders'

Rule	Explanation
Time constraint	Players have 60 minutes unless a team fills in a risk register; then 10 minutes are gained.
Phase transitioning	A team needs approval from both the city council actor and the game moderator.
Resources	Resources used for the construction of the model bridge are supplied by the game moderator. No other material might be used than those supplied to the teams.
Deconstruction	K'Nex objects are prone to deconstructed; banning this can lead to players hide the fact of the deconstruction. Deconstruction is there for allowed.
Resource acquiring	Construction materials can be acquired when a shopping list of materials is handed in to the game moderator.
Resource constraint	Teams can order 80 pieces of K'Nex as building resources. Multiple orders can be placed.

Table 6: Mechanics of "Construction manager: bridge builders"

Mechanics	Explanation	Creates
Resources acquiring	To acquire resources, teams first pick a contractor and fill in an order for the materials they need. The amount of materials is restricted. Resources are ordered through a form and can be done multiple times.	Complexity
Time	Participants are under constant pressure to complete the task asked of them. The playtime is limited to 60+10 minutes; the +10 is an extension which the teams receive for filling in the risk register.	Immersion
Stakeholders	Stakeholder actors represent the opinion of the inhabitants of the city and city council. Teams interact with these actors to develop their project plan. An underlying goal of the game is to satisfy these stakeholder groups. Building consent is needed from the city council before construction can start.	Immersion, identity, complexity
Change	The game moderator introduces changes to the session based on possible emerging risks during construction projects.	Complexity, pleasant frustration
Information access	A construction project has access to a massive amount of information. Skilled project managers decide on what is and is not important. To simulate this, teams get an exposition dump at the start of the session. Additional information can be acquired by talking to the actors.	Exposition, immersion, complexity

A team consist out of people with experience in either APM or TPM to steer the decision and ensure the approach which is used. Teams play in the same room together so that the layout stimulates immersion through competition. The co-location of the teams can cause them to cheat off each other, but this argument is outweighed by the competition element and makes the game more playable. The teams' work table contains all the materials available to them. During the teambuilding phase, a bag of K'Nex is accessible but is confiscated before the second part of the presentation. This is also done with the materials in the development kit, which is confiscated when the team orders materials. A separate table is needed to accommodate other material essential to the game and is managed by the game moderator. Table 7 summarises all components of the SRG.

Table 7: Components of 'Construction manager: bridge builders'

Components	Explanation
K'NEX	This is the building material used for construction.
A1 map	This is the template on which the building is placed and functions as a playing board.
A4 map	This is a map of the town, part of the player manual.
Miscellaneous resources	Resources used to complete the bridge and to prototype; this contains paper, straws, and tape.
Contractor list	List of parties that will give the team different perks.
Actor descriptions	Explanation for the stakeholder actors.
Player manual	This is the case description with rules and other information to play the game.
Evaluation forms	This is to evaluate players' experience.
Risk register	This is a table in which risks are identified; it is part of the player manual.

Figure 13: Players designing their bridge, session 2 (own photo)

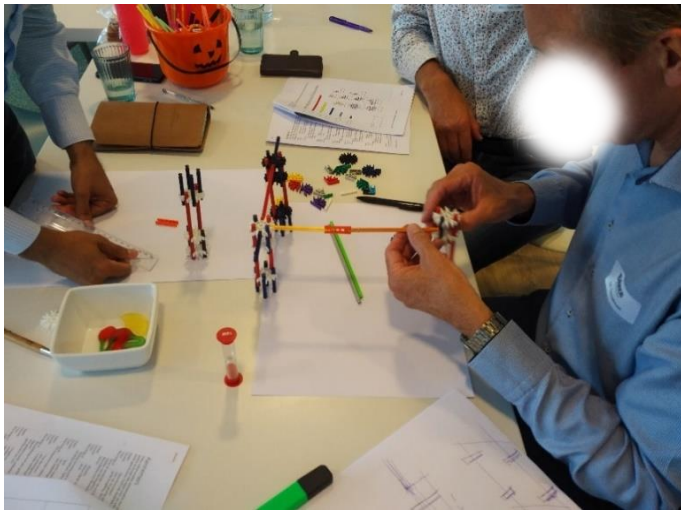


Figure 14: Players building a prototype, session 3 (own photo)

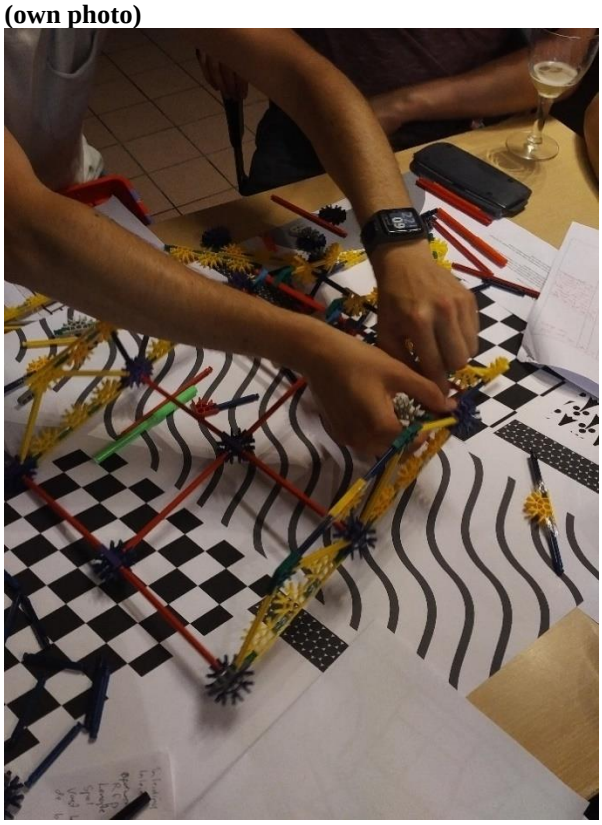


Figure 15: Players building a K'Nex bridge, session 1 (own photo)

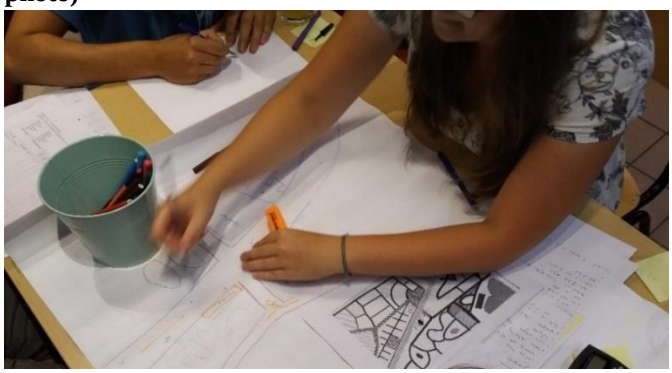


Figure 16: Player drawing the future area of the bridge, session 1 (own photo)

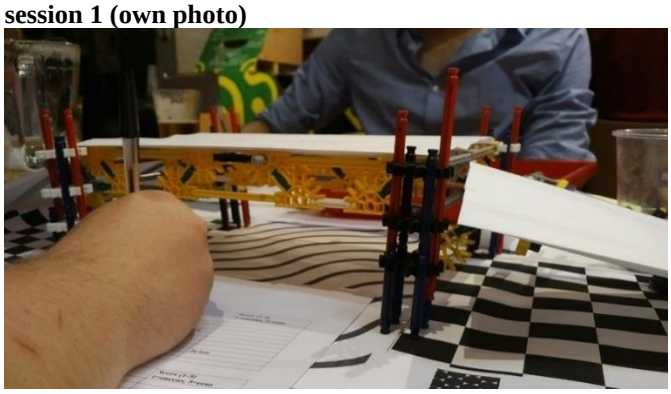


Figure 17: Finished bridge of TPM team, session 2 (own photo)

The game uses semi-fictive names; for example, the name Lely (a famous engineer and politician) was used to create the fictive Lely Canal. Fictive names are used to hide real-world cases, making the players more creative, and players feel less anxious because failure does not affect their lives (Perrotta, Featherstone, Aston, & Houghton, 2013). Figure 13, Figure 14, Figure 15, Figure 16, and Figure 17 give an impression of the SRG.

5.4 Fulfilling serious research game requirements

Figure 7 (chapter 3) depicts the variables the researcher manipulates in the SRG to research the effects of a project management approach on the project performance. Time, resources, and scope are traditional project management values from the iron triangle.

Collaboration and communication are also important aspects within the game; team members communicate and collaborate and also do so with stakeholders, who influence the variables of time, resources, and scope. Risks refer to possible changes to the game setting which the moderator implements during session to ensure that the game mimics reality. In addition, the SRG must meet the defined task set by Twynstra Gudde (n.d.) and should consist of a front-end development and execution phase. Table 8 shows the tasks the players fulfil in the SRG; the left side contains project characteristics and responsibilities of the project management team of the Dutch clients, as identified in chapter 3. The right side of Table 8 contains the explanation of how the responsibilities and characteristics are simulated by the SRG.

Table 8: The simulated responsibilities of the project team and project characteristics

Responsibilities and characteristics	Simulated by:
Two phases in which the design is approved by the client	Making the teams only able to start construction when consent is given by the city council player. Then the teams receive their building materials and a map of where the bridge needs to be built to simulate the change in the project environment.
Resource management	Players can order the needed resources through an order form. The amount of resources is capped.
Risk awareness	Making the team fill in a risk register.
Dealing with risk	The teams need to deal with changes to the setting implemented by the moderator.
Project information	An exposition dump is used at the start of the game, and information is gained by talking with the stakeholder actors. Players have five minutes to read the game manual, which contains conflicting information that needs to be cleared up by the stakeholders.
Collaboration and communication with stakeholders	The city council actor needs to consent to the plan. The narrative ensures that the citizens and city council have conflicting opinions, strengthening the need to communicate with both parties.
Collaboration and communication with team members	Giving the team too many things to do for one person enforces the need for collaboration. The exposition dump increases the need for communication between team members due to the limited time and the amount of information members need to convey to each other.
Tender	Teams need to select a contractor, which limits their design and building possibilities.
Attaining resources	Letting players order materials through order forms.
Describing the intended results of the project	Make the participants define requirements, the project, and its scope.
Deciding on accepting intermediate results	Make the participants build their developed plan.
Deciding on accepting project progress	Make the participants build their developed plan.
Ensuring that the project is supported by the living environment	Simulate the living environment by using actors to represent the roles of important stakeholders. Teams need to discuss their plans with these stakeholder actors.
Terminating/ending the project	Players need to finish the project within the prescribed time. Players either finish the building within the time and thus end the project or exceed the time limit and terminate the project

Not all tasks of the Dutch clients are simulated by the SRG (Table 9 shows these tasks). Some tasks are excluded for either being unfeasible to create within a SRG setting or causing strain on the playability of the SRG in such a way that it is considered game-breaking.

The SRG has no defined optimal solution. By creating conflicting wishes and demands between the stakeholder roles, the need for consensus is ensured. Options for the players were designed so that they seem reasonable; still, every decision has negative effects on one of the stakeholders.

Table 9: Tasks of the Dutch clients not represented by 'Construction manager: bridge builder'

Tasks of Dutch clients	Can or cannot be simulated as	Elaboration
Facilitating a good point of departure	*Not possible* due to the character of the statement.	-
Ensuring that the project is carried out by the parent organisation	*Not possible* due to the small-scale setting. There is no organisation to embed the project in.	-
Making agreements about when to meet about the project	*Possible* by making the players make a simple plan on how to and when to communicate.	Unnecessary complexity with no added value.
Shielding the contractor and the project from unwanted, disturbing environmental factors	*Possible,* could be simulated through risks	Unnecessary complexity with no added value.
Deciding who will use, maintain, and manage the results of the project	*Possible* by making a list of parties and their competences. Players need to assign these parties.	Specific experience is needed to understand what different parties can and cannot do. This is outside the project scope.

Chapter 4 presented SRG elements that are built into the game and these are summarised in Table 10.

Table 10: SRG design elements seen in the game

Element	Seen in the game as:
Storytelling	Narrative through presentation, player manual and actors
Anxiety	Players express feeling time pressure and created by the limited time and exposition dump
Immersion	Players lose sense of time perception
Flow and pacing	Limited playtime
Exposition	Pictures are used to show players their abilities, without telling the players that the pictures are important
Perks	Contractor selection
Complexity	Three-tiered gameplay loop
Pleasant frustration	Players enjoying the game but still finding it challenging
Game obstacles	The stakeholders have conflicting opinions
Exposition dump	Most information is given at the start of the session
Team interaction	Players need to communicate with each other, due to the exposition dump
Actor interaction	Players are not given all the right information and some is missing, can be gain through the actors
Game interaction	Players are rewarded for completing intermediate tasks

5.5 Gathering data from the serious research game

Two types of data were gathered for this research on the research phenomenon and on the quality of the created serious research game (SRG). This is done through the use of player surveys, actor feedback forms, observations, and focus group discussions.

The player survey used a Likert scale from 1 (totally disagree) to 5 (totally agree) and contained questions on player experience, game quality, realism, and the usefulness of the SRG. Statements were either conforming or contradicting. Some questions appeared multiple times to check if the questionnaire was filled out consistently.

To evaluate stakeholder satisfaction, the actors were asked to write their complaints per team and score communication, collaboration, process involvement, design, results, and an overall opinion on a scale from 1 to 10 and to elaborate on their choices. The actors were also asked to give their opinions of their role and if it was realistic.

Observation data was gathered by passive observers[14] with forms used to record the actions and decisions of the teams. By recording which team spoke to what stakeholder, why the team needed this interaction, and the discussion held by the team. With this information, a process timeline was created. After the session, the observers were asked to fill in a survey (survey questions are in section 7.1, table 25) with statements about the team using three options: agree/always, disagree/never, and not observed. A middle option between agree/always and disagree/never was excluded to force the observers to elaborate on their decisions. The observers were also asked to explain why they agree or disagree with statements about player performance.

Focus group discussions with session participants were used to understand the observed differences and to verify if results were due to an agile mentality or personal choices. This is especially

[14] Observers only observe and do not intervene.

needed for the factors of collaboration and communication. The focus group discussion was semi-structured, face-to-face, and moderated by the researcher. A recording and memo were made for the second session and transcribed for the third session. Due to the length of the gameplay, maturation effects[15] could occur. Therefore, a prioritised question list was prepared to advise the researcher during the focus group discussion. The length of the discussion depended on the concentration of the session participants and the number of questions from the researcher.

The players also produced (miscellaneous) data themselves by playing the game. This includes a requirement list, contractor choice, risk register, and other miscellaneous data from the teams. When the game session was complete, the teams were asked to prioritise the requirements; the data could then be compared to identify patterns and differences. This resulted in qualitative data as requirements, drawings and designs, identified risk, bridge type, type of construction, and end result in the form of a build bridge. The data evaluates the team's performance as well as what decisions they made.

5.5.1 Quality data on the created Serious research game

Data on the quality of the SRG was needed for improvement and also to evaluate the information gathered. For this, the player surveys, parts of the observation forms, and stakeholder feedback forms were used. Player performance was also evaluated, as suggested by Suryapranata, Gaol, Soewito, Warnars, and Kusuma, (2017). Player performance is based on their dedication to the game, end result, and player behaviour. How players performed is decided by the game moderator and aided by the gathered data.

Although little is known about assessing the quality and validity of serious games (Mohan et al., 2014), the research should assess at least internal and external validity. This is based on Sekran's (2000) validity definition for experimental research. Thus, necessary data is both player-based and game-based. Player data establishes if the players were acting as themselves, immersed, dedicated to the game, engaged by the game, and concentrating on completing the task. Game data identifies if the locations were appropriate, the game and its rules were clear, if either APM or TPM was used to complete the game, and if the game mimics a real project.

5.5.2 Processing and interpreting data

Assessment of the project management approach used was done by the researcher's observations during the session, data recorded by the observers, and the focus group discussion where players were asked if they applied a certain type of project management.

The SRG has five interacting variables over which the researcher has control. Collaboration and communication are mediating variables. Influences from this can be attributed to personality, experience, or the agile mindset. This is challenging to measure, although the decisions, actions, and steps the teams take during the SRG are of interest to the study. Player performance is decided the same way: by the researcher and aided by the gathered data.

The qualitative data is analysed through content and thematic analyses. For this, predefined codes were used to aid the researcher in finding patterns and differences. The codes were based on APM's differences with TPM.

Quantitative data was processed with the use of Excel functions and was evaluated per game session, team, and all sessions combined. Excel was used rather than SPSS and JASP due to the researcher's familiarity with the software and because the datasets were small. If the amount of survey data should become higher, it is recommended to use JASP or SPSS.

[15] Maturation effects are caused by fatigue of participants, making them less engaged with the research, lowering concentration, and reducing their reasoning abilities (Sekran, 2000).

5.6 Chapter summary

This chapter elaborated on design choices, introduced the created SRG, and explained how data is gathered from it. Figure 12 provided an understanding of the created SRG, 'Construction manager: bridge builders', and Table 8 showed how real-world characteristics and responsibilities of the Dutch clients are translated into game mechanics and elements. Data from the SRG was gathered through observations, surveys, miscellaneous data, and focus group discussions.

The SRG is evaluated in chapter 7 regarding fulfilling the criteria defined in chapter 4, and partial answers are also provided to the sub-question:

How can an infrastructure environment be simulated to research project management approaches from the Dutch client's perspective?

But, before the SRG is evaluated the results produced by playing the SRG are presented in the next chapter.

6 Interpreting the results of the research game

This chapter presents the data from playing the serious research game (SRG) and answers the sub-question:

What is the difference between using the current and agile project management approaches in the simulated infrastructure project?

The research question is answered by the data presented in sections 6.1, 6.2, 6.3, and 6.4. Only data about agile project management (APM) and traditional project management (TPM) is presented in this chapter. The SRG appendix contains all raw data gathered during the sessions. Section 6.5 interprets the data before an answer is given to the sub-question in section 6.6. First, however, introductory data is given on the four sessions.

The first session was an alpha test, and the second session was a beta test; then the expert session was played before ending with a student session (Table 11). The alpha test was completed by two teams of five people, with no observers and no stakeholder actors. The beta session was played by two teams of three. Each team had either an agile or traditional practitioner. The expert session had two three-person teams. A team was either comprised of APM or TPM experts. The last session was played with students of the project management basic course and was only used to improve the in-game economy.

Table 11: Sessions, participants, and locations summary

Session	Participants	Location
Session 1–Alpha	Mixture of MSc, BSc students, and MSc graduates with backgrounds in IT, aerospace engineering, mechanical engineering, hydraulic engineering	Delft, de Bolk
Session 2–Beta	MSc, civil engineering students/graduates and two Scrum masters	Delft, de Bolk
Session 3–Expert	Mixture of IT and infrastructure specialists who were project and programme managers with at least 11 years or more of work experience	Amsterdam, Balance
Session 4–Student	Mixture of BSc students of the TU Delft course project management basics for the project management minor	Delft, CiTg

Table 12 contains the stakeholder actors of the beta and expert sessions. In the alpha session, both roles were played by the researcher. In the student session, the actors were played by students with no relevant experience. The number in the IDs reflects the session in which the actor played. Teams could ask the actors to come to their table to discuss their plans. Both teams had access to the same stakeholders. Interactions were not limited; the teams interacted with either or both of the actors.

Table 12: Stakeholder actors

ID	Role	Relevant experience
M2	City council	Credited film actor, director, and producer
C2	Citizens	Former board member of a neighbourhood association
M3	City council	Project assistant to an airport development project
C3	Citizens	Assistant environmental manager for a railway director

Table 13 contains the observers of the beta and expert sessions. There were no observers during the alpha session other than the researcher. In the expert session, an independent observer was present to record the actions of both teams. The observers of the student session had no relevant experience.

Table 13: Observers

Observer ID	Knowledge area project management	Observed
TPM-ob2	Generic traditional	Session 2, TPM team
APM-ob2	Scrum	Session 2, APM team
TPM-ob3	Generic agile and generic traditional	Session 3, TPM team
APM-ob3	DSDM, Prince2, IPMA-D	Session 3, APM team
General-ob3	DSDM, Prince2, PMW, PMC, PMBOK	Session 3, both teams

Furthermore, this chapter uses pictograms to show the actions of the teams. Figure 18: legend of pictograms (own illustration)

Figure 18: legend of pictograms (own illustration)

6.1 Session 1 ~ alpha

Table 14 shows the participants of the first session, none of whom had experience with civil engineering or project management. The process of both teams could be considered as ad hoc. Both delivered a result based on improvisation and as needed. Both teams also tried to identify and meet the defined requirements.

Team A worked with a hierarchal model. One person took the lead and managed the team. There was limited communication between team members. The players divided the work amongst themselves, causing the players to work as individuals rather than as a collective. There was no plan/planning, requirement inventory, or detailed design made by the team. They worked with a general design and relied on improvisation during construction.

Team B collaborated to complete the assignment. Team members did multiple tasks, and a five-point plan was made to complete the game; this plan was limited and contained two milestones. Some requirements were written down which had elements of SMART formulation and were in the context of height and length. An attempt at a detailed design was made. Designs and ideas were visualised and presented to the city council.

Table 14: Participants, session 1

Id	Education level ~ team A
ID-1.A1	Computer science—WO, master
ID-1.A2	Aerospace engineering—WO, master
ID-1.A3	Aerospace engineering—WO, master
ID-1.A4	Aerospace engineering & marine technology—WO, master
ID-1.A5	Aerospace engineering—WO, master

Id	Education level ~ team B
ID-1.B1	Spatial planning and design—WO, master
ID-1.B2	Water management—HBO
ID-1.B3	Technical business administration—WO, bachelor
ID-1.B4	Aerospace engineering—WO, bachelor
ID-1.B5	Strategic product design—WO, master

6.1.1 Changes after the alpha session

After each session, the gameplay was evaluated and improved for the next session. The alpha session tested the game elements and was needed to develop the SRG. Playability was the focus of the first session. Table 15 shows the changes made to the next session, mainly reducing the time it takes to complete the game; this is done by reducing complexity and number of tasks. The tasks that the players found a nuisance or had no value to the gameplay were either excluded from the beta session or improved so that the players gain something for fulfilling the task.

Table 15: Changes after the first session

Change	Why it is changed
Included a teambuilding exercise	Improve communication and let the players get to know the members of the team better
Exclusion of the A3 temporary works map	Added complexity with no added value
Risk register delivery gives the player 10 minutes extra playtime	Had no added value, was an annoyance to the players, and therefore not considered a part of the game because there was no reason to fill it in. By giving 10 minutes, the player is rewarded.
Risk register from five to three risk reduction	Uses too much time to fill in
Moderator cannot play stakeholder anymore	This was found to be too time-consuming and decrease moderators' control over the game session. Players found it unfair that the stakeholders were also played by the moderator.
Reduction of resource from 250 to 225	Balancing the in-game economy
Map improvement	The first map was made with the idea of exposition in mind. Players therefore found the map confusing. A legend was added to the presentation as was an explanation of the map.
Contractor obligation change from the need for an arch bridge to a high bridge	No added value, only added complexity. Due to the change, the different contractors are better balanced.
Never again use the technological change with the drones	Was found to be unrealistic and dumb by the players.

6.2 Session 2 ~ beta

Table 16 shows the participants of the second play session, a majority of whom have a background in civil engineering. The two APM practitioners have an IT background. Both teams had an appointed team leader to enforce the use of either APM or TPM. This was done to test the ability to use the project management approaches in the simulated setting.

Table 16: Participants, session 2

ID	Education level	Company	Work experience	Type of project management
ID-2.T1	Civil engineering—HBO	Dura Vermeer	2	Prince2 style
ID-2.T2	Hydraulic engineering, structures & flood risk—WO, master	-	0	-
ID-2.T3	Hydraulic engineering, flood risk—WO, master	-	0	-
ID-2.A1	Computer science—WO, master	Lunatech Labs	8	Scrum, scaled Scrum - Nexus, custom - Spotify model
ID-2.A2	Software engineering—WO, master	Lunatech Labs	4	Scrum, Just-In-Time
ID-2.A3	Hydraulic engineering, structures—WO, master	Svasek Hydraulics	1	

Figure 19 depicts the steps the TPM team took during the second session. They decided first to identify the requirements, which were finished with input from the stakeholders to make a design. The detailed design was made with the restrictions of the chosen contractor. The team stressed about the limited time and finished just-in-time.

Figure 19: Process of TPM team during session 2 (own illustration)

Figure 20 depicts the steps the APM team took during the second session. They first talked to the citizens and then the city council to identify the boundaries in which the project could be created. A contractor was selected based on the design that fits within the identified boundaries. An intermediate design was discussed with both stakeholders before finalising the design and starting construction. The team delivered a minimal viable product. Members expressed that they would have liked more time to prototype and discuss with the stakeholders to create a more developed product.

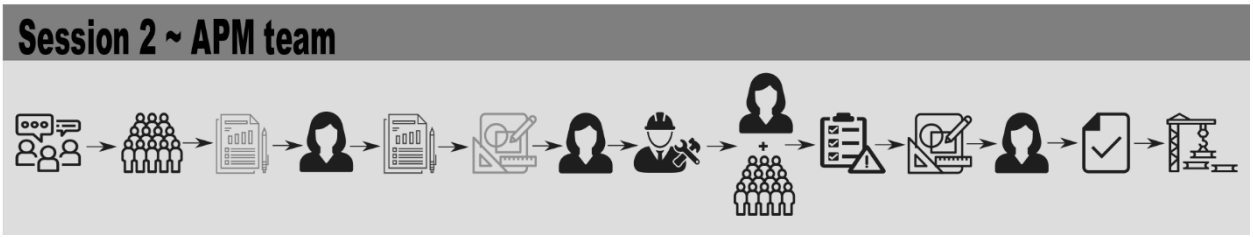


Figure 20: Process of APM team during session 2 (own illustration)

6.2.1 Focus group discussion, session 2

The session used unstructured questions, which were based on observations made during the session. This means that the researcher asked the participants to explain the choices they made during the game to understand their reasoning. C2 was unavailable during the discussion.

ID-2.A1 explained that they first met with the citizen and then the city council to identify the boundaries of the project; this was needed to understand what could and could not be made and also to find a creative solution. ID-2.A2 stated that from these boundaries, they could make a minimal viable product. Both ID-2.A1 and ID-2.A2 expressed that it was interesting to use APM for something other than an IT project. ID-2.A1 stated, ‘There are possibilities for using APM but mainly when it is focussed on the agile mindset, especially for the “people over process” aspect. However, the use would be limited because it is impossible to place an extra foundation when there are already two stories built’. Both ID-2.A1 and ID-2.A2 argued that due to the setting, it was hard to fulfil all agile principles, especially when a team member is unaware of APM. Establishing a self-organising team was found to be impossible in this setting. ID-2.A1 argued that the result is different when the whole team understands and practices APM or when a team is forced to use APM through an agile practitioner, which reduces their effectiveness.

The TPM team started with identifying the requirements and project scoping. According to ID-2.T1, they pursued a narrow project scope because he was taught to have a well-defined and clear scope. ID-2.T1 argued that this might be because the project scope is too broad, and a tunnel could be built rather than a bridge. When the team was asked if it would be a problem if a tunnel was built rather than a bridge, ID-2.T2 answered, ‘The task was to build a bridge, so we built a bridge. For a tendered project, this is the same: you build what is stated in the tender, so we did’. M2 stated, ‘If you asked and convinced me that a tunnel would be better, you could have built a tunnel’. ID-2.T1 argued that the current manner of project management is not ideal and that a different approach is needed that could improve the current process, but APM might not be the solution.

According to M2, he felt more involved with the project the APM team was realising because of the ability to give more feedback. M2 stated that both teams should have asked better questions to identify the root of the problem.

6.2.2 Actor data

The data from the stakeholders in this session is qualitative. According to both actors, the teams delivered satisfactory results. However, the result of the APM team felt better because this team communicated more. The citizen actor felt neglected by the TPM team because they only engaged with the citizen to reassure her that her opinion was taken into account without asking for her opinion. The city council actor complained about this to a lesser extent.

6.2.3 Miscellaneous data

Miscellaneous data is information like drawings and notes. The APM team chose the contractor that would allow the team to realise a simple bridge with separated traffic streams and has experience with laying track. The TPM team chose a contractor that restricted them to making a fixed bridge. This contractor was chosen because it could be constructed faster and eliminate the need for opening and closing the bridge, which was identified as a risk by the team (Table 17). The team proposed to build parts of this bridge elsewhere and transport them to the location to minimise nuisance.

Table 17: Risk analysis of the TPM team, session 2

Risk or opportunity	Consequence	Mitigation measure
Bridge does not open	Economic losses due to waiting ships	Backup mechanism and frequent maintenance
Bridge does not close	Traffic jam	Backup mechanism and frequent maintenance
Ship crashes into bridge	Bridge is damaged	Extra safety measures

6.2.4 Changes after the beta session

After each session, the gameplay was evaluated and improved for the next session. The beta session tested the ability to use the project management approach to the game. Table 18 shows the changes made to the next (expert) session, mainly to improve the clarity of the game and playability.

Table 18: Changes after the second session

Change	Why it is changed
Exclusion of temporary work	No added value, unnecessary complexity
Only one change instead of three	To better control the variable, reduce time pressure
No time reduction	Was found to be unrealistic
Stricter building rule: construction can start when a design is approved	Give more weight to the approval of the city council actor
Development kit has double amount of materials	Requested by players to make prototypes
Added extra general independent observer	Requested by graduation committee
Reduction of resources from 225 to 200	Better balance the in-game economy
Players got five minutes to read the manual	Variable reduction; this was first used as added complexity but found to be an unpleasant annoyance
Player received the manual nine days beforehand by e-mail	Variable reduction, same as above. It was proposed by players of the second game session as a sort of realism. In real life, people can research a project before it starts
Stakeholder actors got their description nine days before play session via e-mail	Requested by the actors of the second session to be better prepared on the day the game is played
No team leader appointed	Was only added to the second session to force the players to work either with APM or TPM; because not all participant had experience with project management

6.3 Session 3 ~ experts

Table 19 shows the players who are experts in either civil engineering projects or software engineering projects. The experts from software engineering are well acquainted with APM and formed the APM team in this session. The TPM team consisted of civil project and programme managers who use TPM in their daily lives.

Table 19: Participants, session 3

ID	Education level	Company	Work experience	Project management type
ID-3.T1	Spatial planning and design—WO, master	Balance	31	PMC, IPM
ID-3.T2	Civil engineering, hydraulic structures—WO, master	Balance	32	Twynstra Gudde
ID-3.T3	Technical business administration—WO, bachelor	Balance	27	Prince2
ID-3.A1	Computer science—PhD	P2 managers, agile business consortium, freelance company, ministry of economic affairs & climate	30	DSDM
ID-3.A2	Information science—WO, master	IN10	14	Scrum, Lean
ID-3.A3	Computer science, information architecture—WO, master	Tradecloud, freelance company	11	Scrum, Kanban

Figure 21 depicts the process of the TPM team during the expert session. They started with identifying the requirements from the manual and their experience and identifying project risks (Figure 22). A product requirement document was needed to present to the city council. Based on these requirements, a design was made without input from the stakeholders. This design was used to 'help' stakeholders to make decisions. The team tried to convince the stakeholders that this design was the right solution. The definitive design focussed on the fixed defined requirements; almost no input of the stakeholders was represented by the design. The team needed to reassure and convince the city council that this design was the right solution and that changes could not be implemented due to time restrictions. They got reluctant approval from the city council actor because she could not identify problems with the plan. After finishing construction, the team celebrated their achievement (Figure 23).

The team missed a requirement verification and wanted a contractor that could accommodate their needs. Extra time was not needed, and the team let both stakeholders give their opinions but had almost no questions for them.

Figure 21: Process of TPM team during session 3 (own illustration)

Figure 22: Players filling in risk register, session 3 (own photo)

Figure 23: Finished bridge of TPM team, session 3 (own photo)

Figure 24 depicts the steps the APM team took during the expert session. This team started with a meeting with both stakeholders to identify the boundaries of the project by letting the stakeholders draw their vision (Figure 25) of the project and then let each other comment on the designs created (Figure 26). These designs formed the intermediated design, which was presented to the stakeholders to gain feedback on it. The team chose a contractor who could make this design. Due to the time constraint, approval was sought on the design; otherwise, the team would have continued to improve the design with the stakeholders. The stakeholders were promised that in a later iteration, more parts would be added. The team created a minimal viable product by continuously assessing the requirements and dropping those that were deemed out of scope for that iteration. The team wanted to have the ability to make prototypes to show the stakeholders and gain feedback from them.

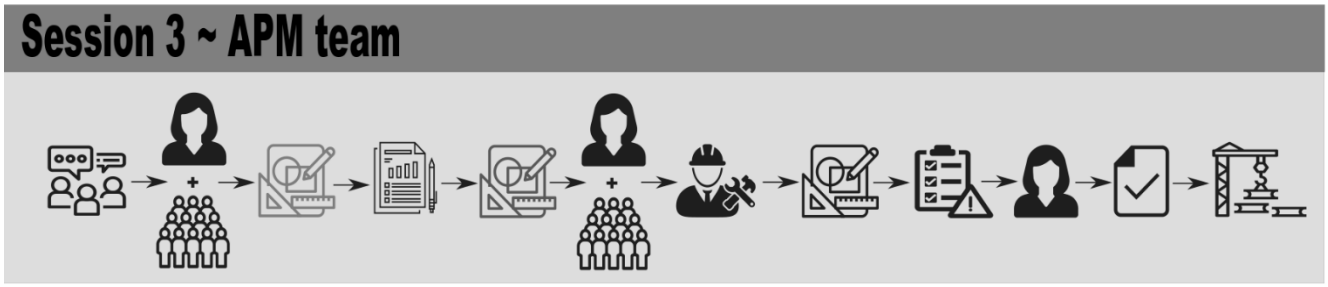


Figure 24: Process of APM team during session 3 (own illustration)

Figure 25: Stakeholders designing during session 3 (own photo)

Figure 26: Stakeholders commenting on each other's designs during session 3 (own photo)

6.3.1 Focus group discussion, session 3

After a break, a focus group discussion was held with the observers, actors, and players to answer eight questions about the actions and motivations of both teams during the game. The transcript can be found in the "serious research game" appendix (p. 18–21).

What is the reason that the APM team's first action was to talk to both stakeholders at the same time?
To facilitate discussion between the two stakeholders, identify common ground, and demarcate the project. According to ID-3.A1, they were trying to identify the project boundaries.

Why did the TPM team first define requirements and a design which was then proposed to the stakeholders?
The team wanted to steer the stakeholders by showing examples. ID-3.T3 stated, '*We wanted to help them'*. M3 argued that the TPM team thought they were finished with the requirements when they were identified. However, in reality, the demands of the stakeholders change over time. ID-3T.2 believed that makes the project less flexible and they needed the design to have persuasive power so the communication between the two stakeholders could be managed.

Why did the APM team create a minimal viable product (MVP)?
The APM team argued this was caused by identifying common ground and reducing the number of requirements. ID-3.A2 agreed that they made an MVP and first wanted to identify the absolute acceptable minimum and add to that design in later iterations.

Did the civil experts identify problems with the created MVP?
The TPM team felt it was important to prepare for future needs since infrastructure is made to exist for decades. According to them, by using APM, the whole product is not considered, only the minimum needed for that moment. ID-3.T2 argued they had the correct solution because they identified all the requirements from the narrative and their solution was made for current and future situations. ID-3.T3 thought creating an MVP was risky, but with the help of the project team, it could evolve into a suitable solution.

Is there a difference in communication with the stakeholder between the APM and TPM teams?
According to M3, she is more pleased with the MVP result of the APM team than the 'exuberant' bridge the TPM team made. She felt more engaged with the APM team due to her involvement in creating the design and stated that the main difference was that the TPM team needs to sell their vision, but the APM team collaborated to create the client's vision. According to C3, she was more involved with the APM team's process: 'The TPM team only wanted my requirements, and then I could leave'. APM-Ob3 argued that the team worked as a mediator between the stakeholders, and ID3.A1 stated, 'There is always one party that signs, but that does not mean you need to handle the other stakeholders differently'. According to ID-3.A1, they needed to have all important stakeholders at a table to agree on a solution.

Is APM applied, or are there personal interventions used?
All three APM players nodded approvingly when asked if they applied APM. ID-3.A3 stated that he applied APM to his project and always applied it this way. ID-3.A1 added that they used APM by trying to define the requirements through multiple iterations and continuing evaluation. According to ID-3.A1, it is agile to use prototyping and visualisation to show the client what product might be made, which he wanted to do more of during the game to make sure the clients got what they needed. According to ID-3.T1, this difference in approach is caused by a different way of thinking caused by sectoral variations, meaning that the way software is developed caused the way of thinking by the APM team.

Do the experts identify problems with this project approach?
ID-3.T1 argued that a project should consider all requirements because infrastructure is built for a more extended period. Moreover, agile thinking should be possible by using visualisation of the project through models and tools before going to the construction phase. ID-3.A1 stated that from an APM way of thinking, nothing is built for more than 30 years, and so the project team needs to keep a degree of freedom in mind. According to the TPM team, this might be a problem due to the nature of infrastructure projects which need to exist for decades.

How do the civil experts see the importance of and reliance on front-end development?
ID-3T.1 said he had experience with an "agile" approach recently wherein a contractor used visualisation to determine the stakeholder's vision rather than defining all requirements and then making a visualisation from that requirement list. According to him, this approach felt better and the realisation speed was faster than the requirement route, which encounters resistance from the stakeholders because they cannot envision lists of requirements.

6.3.2 Actor data

According to both stakeholder actors, the APM team took too long to complete the game, but they complained about the lower process involvement with the TPM team, though they felt both teams completed the game sufficiently. The city council actor felt the APM team performed better, but the citizen actor favoured the TPM team slightly more. The collaboration score of the citizen player was excluded because the actor interpreted the classification differently than intended; this decision was based on the elaboration of the actor, who stated 'the team worked well together', but the classification was intended to reflect the collaboration between the team and the stakeholder, not the team members. M3 felt better about the result of the APM team. Table 20 contains the scores the actors gave to both teams.

Table 20: Stakeholder evaluation

	City council		Citizens	
Team	APM	TPM	APM	TPM
Communication	9	6	7	6
Collaboration	9	7	-	-
Process involvement	9	6	7	7
Design	9	6	6	8
End result	9	7	7	7
Overall feeling	9	7	7	7.5
Average	9	6.7	6.8	7.1

6.3.3 Miscellaneous data

Miscellaneous data is all other data gathered during a session, like drawings and registries. Such data includes that the TPM team made a bridge that would be open 28 minutes of each hour; the APM team's bridge would be open 12 minutes each hour. Both teams used an elimination process to pick a contractor; the one chosen by the APM team was based on a shared vision between the stakeholders, and the TPM choice was based on identifying risk with each stakeholder and choosing the one with the lowest risk profile. The TPM team also chose a contractor with the ability to keep the shipping lane open, while APM chose based on the contractor's experience and the shared vision of both stakeholders.

In reality, the TPM team bridge would probably be unacceptable because 46% of the time, it could not be used by the citizens. However, the team sold the city council on the idea that these problems could be managed. The minimal viable design for the bridge contained a tram track and one two-way lane for cars, bikes, and pedestrians. The TPM team made a requirement list, which they prioritised after completing the game.

The APM team's requirements were compiled by a process and included three types: ones there is consensus over (C), requirements which are postponed (P), and ones the stakeholder did not want (N). The requirements made by the teams are presented in Table 21.

Table 21: Requirements identified by teams during session 3

TPM requirements

1. Simultaneous use of cars, trams, bikes, and pedestrians. Limited room for sound and vibrations
2. Eye-catching bridge
3. Stay within budget
4. Room for cars and work-related traffic

- View over the channel
- Traffic hindered by the bridge's timetable
- Use prefab building materials to reduce construction time

APM requirements

C1. Fast construction time by starting small and expanding later
C2. Two car and bike lanes
C3. Bridge open and closing times minimised
P1. Tramline construction; there are buses currently
P2. More traffic lanes
P3. Playground
N1. Not a high bridge
N2. High bridge
N3. Building an eye-catching bridge

6.4 Session 4 ~ students

The opportunity was presented to play a fourth session with project management students to change the in-game economy by limiting the amount of resources to 80, which is considered an improvement, but economy issues remained. Table 22 shows the session changes.

Table 22: Changes for session four

Change	Why it changed
Four teams	The game was played for students participating in the course of project management basics, which limited possibilities.
Reduced time to 50 + 10	
Exclusion of teambuilding exercises	
Improve presentation with flowchart	
Played with non-Dutch players	
Reduced resources to 80	
No information beforehand, only in session	
No changes during gameplay	

The session was played with four teams containing around six or seven people and three actors during a lecture, which limited the available playtime considerable to a maximum of 60 minutes. The participants had no project management experience other than the recently taught project management course. Moreover, the session was conducted in English whilst the written material was still in Dutch.

The session revealed that the in-game economy is improved but the playability of the game is strained due to the time reduction. The used lecture room was not an ideal place to play the game and the openness of game caused problems for the teams because they badly understood what to do. This was caused by the larger teams, location and the reading material being in Dutch.

The session did show the students the importance of stakeholder collaboration and that any project management knowledge and experience help the players to better preform during the game.

In the end the session exposed the need for actors that want to play the role of one of the stakeholders, because it improves playability. As is the need for observers that are willing to observer and note the actions of the teams else the research value is limited.

6.5 Interpretations of the beta and expert sessions

From the second and third sessions, it was found that a traditionally managed project creates a project vision from expertise and information. Due to this, the city council must be convinced that this vision is the best solution to the problem. When APM is used, the requirements and vision are defined with the stakeholder to create a shared vision, letting the team function as a communication facilitator, whereas the TPM team functions as a messenger between stakeholders. This difference in approach to the start of the project dictated the rest of the process.

Both methods need visualisation; TPM uses it to convince the stakeholders that the solution created by the project management team is the right one, and APM uses it to determine requirements and as a communication tool to improve collaboration. This means that the visualisation acts as a form of documentation. In APM, the stakeholders are the experts of the design, or, as Brus (2018) has stated, the design experts. When using TPM, the team is the design expert.

The TPM approach needs requirement validity to understand if the project is finished; it therefore uses requirements that fulfil the SMART criteria to measure if the requirement is satisfied. This forces the use of fixed defined requirements. However, APM uses a definition of done before the client accepts the completed project. This causes the need for evolving requirements.

In addition, APM's need for early collaboration and allowing change causes the scope to change; this is managed through prioritisation and the identified project boundaries. A MVP is created, to which value is added by the stakeholders. In contrast, TPM avoids scope change because changes to the plan are difficult to implement. An APM team works in an evolving environment, but TPM follows a plan.

Both methods are iterative in the design phase: APM evolves the design they are making due to the need for constant input from the stakeholders, and TPM is iterative because it needs design verification. Due to the importance of collaboration in the APM approach, stakeholders feel more involved. The clients are also more pleased with the results because they helped to evolve and create the product themselves, even if it is less elaborate than the TPM result.

With this information, the simplest possible approach to the SRG is created by giving a fictional team an unlimited amount of time to complete the SRG. Figure 27 depicts the process of the traditional approach, where the team starts with identifying the requirements before a design is made; this design is then shared with the stakeholders. Ideally, the stakeholders have no comments or minor ones on the design. If there are comments on the design, the project management team will try to convince them that their issues are already being taken into account or are non-issues, or that there is no time to implement the changes. When the city council approves the designed project, construction can start.

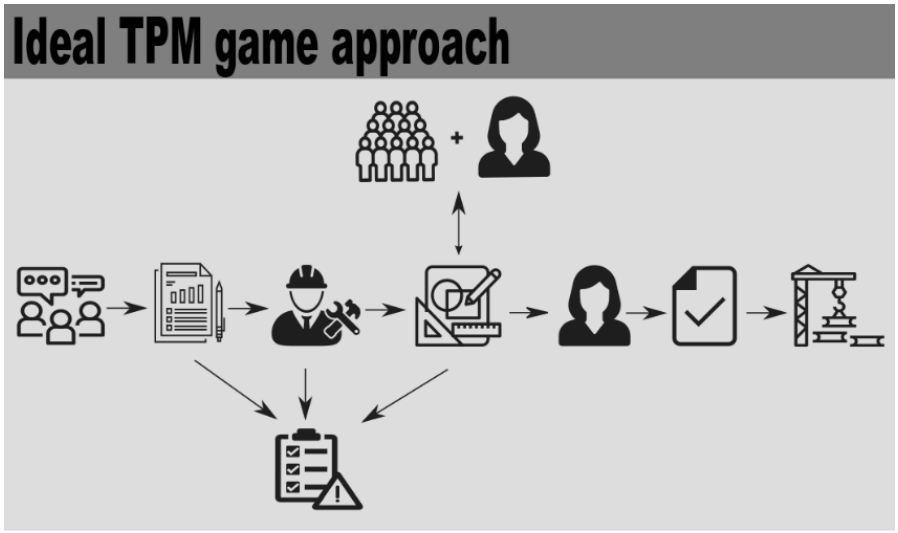


Figure 27: Possible abductive ideal TPM gameplay approach (own illustration)

The ideal APM approach to the game differs from TPM, as Figure 28 illustrates. With this approach, the team will start with combined talks with the stakeholders before a design, requirements, and prototype are simultaneously made. This is done because the design and prototype embody the requirements, though sometimes the requirements are created through the design or prototype and vice versa. This visualised result is then shared with the stakeholders so they can give feedback and complement the visualisation. To do this, a minimal viable visualisation is created and expanded upon until time runs out or all stakeholders agree upon the visualised result. Only then does construction start.

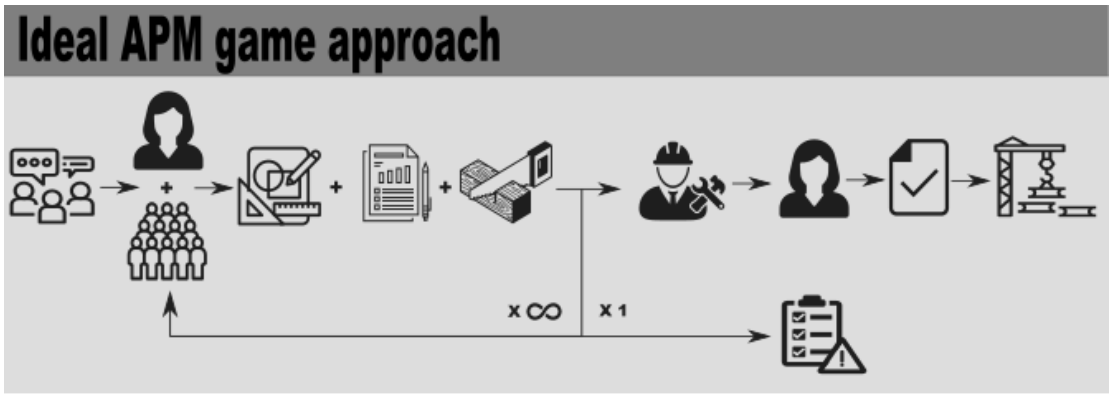


Figure 28: Possible abductive ideal APM gameplay approach (own illustration)

6.6 Conclusion

The results show that the APM and TPM teams played differently due to the variations in approach. With a TPM approach, the project team needs to convince the client that their solution is the right one. This causes polarisation because stakeholders can only agree or disagree on the design. This is in contrast with the APM approach, in which the stakeholders are taken on a journey to create their vision together. The project team facilitates this by making visualised products that aid communication. A minimal viable visualisation is created and evolved with the stakeholders until the construction starts. The MVP is created with evolving requirements that set the project boundaries. This project boundary is narrowed over time. The scope is controlled through prioritisation; in this way, the support of all stakeholders is sought. The visualised intermediate results are evaluated as much as possible by and with the stakeholders to improve them. This means the project changes time after time but is also flexible and adaptive because the boundaries are understood.

Table 23: Differences in APM and TPM in an infrastructure project

Agile project management	Traditional project management
Demarcates project through collaboration with stakeholders	Dictates project boundaries through project proposal
Communication to collaborate with the client	Communication to convince the client
Evolving requirements	fixed requirements
Project environment is seen as evolving	Project environment is seen as static
Needs to be flexible to collaborate	Needs to be static to minimise changes
Needs prioritisation to control the scope	Needs fixed scope to control project
Needs a demarcated project to create in	Needs project vision to create with
Checks small elements of design with the client	Checks full design with the client
Focus on stakeholder collaboration	Focus on establishing the plan, design, and realisation of the project
Creates minimal viable product as a starting point	Creates full product as a starting point
Focus on client satisfaction	Focus on requirement fulfilment
Creates project support through collaboration	Creates polarisation by lack of stakeholder input
Client establishes requirements	Client confirms requirements
Time needed for front-end development	Time needed to convince the stakeholders
Collaboration focussed	Expert focussed
Needs feedback to develop design	Needs feedback on requirements
All stakeholders are included in the development process	Stakeholders' opinion is reassured
Needs prototyping to develop design	Reluctant to change the design
Stakeholders essential to design	Project team essential to design
Stakeholders part of the development process	Stakeholder needed for feedback on the development process
Evolving requirements	Static requirements

In contrast, in the TPM approach, a project proposal dictates the line of reasoning, and only this proposal is evolved, though as little as possible. Changes to the plan are hard to implement because the project management team focus on creating a full design that needs to be approved by the client; they therefore emphasise fulfilling requirements and fixing scope to do so. Changes to the project are seen as risks to be mitigated; however, in APM, changes are seen as inevitable, and risks are identified as early as possible to handle them accordingly. This difference in approach creates the rest of the variations summarised in Table 23, which also answers the sub-question:

What is the difference between using the current and agile project management approaches in the simulated infrastructure project?

7 Evaluation of the serious research game

This chapter evaluates the serious research game (SRG) (described in chapter 5) according to the criteria in chapter 0 to answer the sub-question:

How can an infrastructure environment be simulated to research project management approaches from the client's perspective?

This was answered by creating the SRG 'Construction manager: bridge builders', which is evaluated in this chapter. The chapter first summarises the evaluation data (section 7.1). Section 7.2 interprets this data before the sub-question is answered, and a conclusion is presented in section 7.3.

7.1 Evaluation data

All players filled in a survey to evaluate different game elements. The summary of this data is presented in Table 24. The evaluation form was improved after the first session due to changes in gameplay and missing information. The surveys for the second and third sessions were the same.

Table 24: Summary of player evaluation data

Statement	AVG	STD	S1 AVG	S2 AVG	S3 AVG	Δ s1-s2	Δ s1-s3	Δ s2-s3
General								
I enjoyed the game.	4,68	0,57	4,80	4,50	4,67	0,30	0,13	0,17
The location was good.	4,11	0,70	3,65	4,33	4,67	0,68	1,02	0,33
The game took too long to complete.	1,36	0,51	1,50	1,17	1,33	0,33	0,17	0,17
I understood what was expected of me.	3,59	0,55	3,50	3,33	4,00	0,17	0,50	0,67
The introduction presentation was unclear.	1,82	0,52		1,50	1,83			0,33
The rules were clear.	3,64	0,56	3,67	3,50	4,00	0,17	0,33	0,50
The context of the game was clear.	4,24	0,71	3,70	4,50	4,83	0,80	1,13	0,33
The context of the game was interesting.	4,14	0,59	4,10	4,33	4,67	0,23	0,57	0,33
The location was a distraction.	No		No	No	No			
The rules were unclear.	No		No	No	No			
Teambuilding								
The teambuilding exercise was useful.	4,09	0,59		3,83	3,67	3,83		0,17
The teambuilding exercise was clear.	4,64	0,42		4,50	4,00	4,50		0,50
The teambuilding exercise is a valuable addition.	4,09	0,58		4,00	3,50	4,00		0,50
The teambuilding exercise did not help me learn to play with K'Nex.	1,64	0,92		1,33	1,67	1,33		0,33
The teambuilding exercise helped me to better know my teammates.	3,36	1,01		3,00	3,17	3,00		0,17
Reality								
The game reflects reality.	3,10	0,56	3,00	3,33	3,00	0,33	0,00	0,33
The game is practical.	3,90	0,80	3,44	4,33	4,17	0,89	0,72	0,17
It can be played again with the current knowledge.	3,91	0,82	3,80	4,17	3,83	0,37	0,03	0,33
I had to communicate with my team.	4,50	0,56	4,20	4,67	4,83	0,47	0,63	0,17
I had to communicate with the stakeholders.	4,20	0,64	4,05	4,17	4,50	0,12	0,45	0,33
Experience								
I felt part of a team.	4,18	0,93	4,00	4,50	4,17	0,50	0,17	0,33
Realising the goal was important to me.	4,64	0,56	4,50	5,00	4,50	0,50	0,00	0,50
The game was clear.	4,27	0,75	3,90	4,67	4,50	0,77	0,60	0,17
The game was fair.	3,75	0,99	3,50	3,17	4,67	0,33	1,17	1,50
The changes were frustrating.	2,09	0,89	2,20	3,00	1,00	0,80	1,20	2,00
I lost my perception of time.	3,14	1,09	3,56	3,67	2,00	0,11	1,56	1,67
The random changes were annoying.	2,33	0,88		3,00	1,67			1,33
The random changes were unrealistic.	2,08	0,88		2,50	1,67			0,83
The random changes were a valuable addition to the gameplay.	4,42	0,44		4,67	4,17			0,50

Reflection								
Playing the game had value for me.	3,82	0,74	3,80	3,33	4,33	0,47	0,53	1,00
The game gave me new insights.	3,14	1,03	3,10	3,33	3,00	0,23	0,10	0,33
The project management method used is applicable to this project.	3,83	0,45		4,17	3,50			0,67
The project management method used is suitable for this project.	3,58	0,40		3,33	3,83			0,50

The observation forms were filled in by the observers and gathered data on clarity, game-breaking elements, immersion, and identity. Table 25 shows the averages of the statements given by the observers of both sessions. The second and third sessions made use of stakeholder actors to represent either the city council or citizens. Actor M2 helped to improve the story and script for the actors.

Table 25: Summary of observation data for game quality

Statement	Game aspect	Average S2&s3
Players were distracted.	Immersion	Never
Players understood what they had to do.	Immersion	Not always
Players work with dedication to complete the assignment.	Immersion	Always
Players found the changes frustrating.	Immersion	Disagree
Players found the changes distracting.	Immersion	Disagree
Players understood the rules.	Clarity	Almost always
Player understood what was expected of them.	Clarity	Almost always
Players were themselves.	Identity	Always
Players used their phones.	Immersion	Never
The team communicated well with the stakeholder players.	Interactivity	Agree
The team communicated well with each other.	Interactivity	Sometimes

7.2 Interpreting the evaluation data

This section evaluates the improvements made after each session was played by analysing the differences between sessions. The data from the first three sessions is evaluated according to serious game design criteria (Table 26), additional design criteria (Table 27), and gameplay criteria (Table 28). The evaluation is done through a series of tables that use arrow symbols to illustrate improvement (up) or decline (down) of that factor. The tables also include the source of data and aspects on which the evaluation is based. This evaluation is done to understand the quality of the SRG and identify factors which the developed game might be lacking.

Table 26: Design criteria improvement

Interactive				
Session 1	↑	Session 2	↑	Session 3
Source: Player evaluation forms, stakeholder feedback form, observation				
Aspect: Communication between team and actor, need to communicate with the actor				
Players found it necessary to communicate with the stakeholder actors and each other. Improving clarity of the gameplay probably improved the participants' understanding of what to do, combined with the use of project management techniques and the work experience of the players.				
Communicative				
Session 1	↑	Session 2	↑	Session 3
Source: Player evaluation forms, stakeholder feedback form, observation				
Aspect: Communication of player and stakeholders				
Same as interactive				

Identity				
Session 1		Session 2		Session 3
Source: Observation, game moderator observations				
Aspect: Players do not take on another identity to play the game				
No changes made that would have affected this factor; players were found to act as themselves.				

Table 27: Additional design criteria improvements

Immersion				
Session 1		Session 2		Session 3
Source: Player evaluation, observation				
Aspect: Loss of time, frustration, phone use, enjoyment, distractions, dedication to the game, interest in the game, location				
Immersion was improved from the first session due to the reduction of game mechanics and better pacing of the SRG. The inclusion of a clock in the third session reduced the level of immersion. Nevertheless, players were still considered well immersed in playing the SRG.				
Realism				
Session 1		Session 2		Session 3
Source: Player evaluation forms, stakeholder evaluation				
Aspect: Players' realism experience, actor role realism experience				
The reduction in elements and the exclusion of the drone change improved realism from the first session.				

Table 28: Gameplay criteria

Game clarity				
Session 1		Session 2		Session 3
Source: Player evaluation forms, observations, game moderator observations				
Aspects: Understanding rules and context, interest in the game, understanding presentation, understanding gameplay				
Improving and reducing the game mechanics improved the players' understanding of how to play the SRG. Having an explicit introduction is needed to create this.				
Clarity of stakeholder roles				
Session 1	N/A	Session 2		Session 3
Source: Stakeholder evaluation				
Aspect: Role understanding, explanation, and definition				
In the first session, the stakeholder roles were played by the researcher. No relevant changes were made to the role descriptions for any session.				
Player experience				
Session 1		Session 2		Session 3
Source: Player evaluation forms				
Aspect: Fairness, enjoyment, interest, value to the player, new insights				
Fairness was improved because actors were present for the second and third sessions.				

Team collaboration				
Session 1		Session 2		Session 3
Source: Player evaluation forms, observation				
Aspect: Feeling of a team member, communication within the team				
Team collaboration was probably improved by the inclusion of the teambuilding exercise in combination with the smaller team for the second and third sessions.				
Pacing and flow				
Session 1		Session 2		Session 3
Source: Player evaluation, game moderator observations				
Aspect: Loss of time perception, completion within a time limit, player stress, playtime				
Players mostly found that the game was not too short and experienced time pressure, as was intended. The number of changes to the setting, the exclusion of temporary works, and the work experience made the expert session easier regarding completing the SRG within the playtime.				

According to the player evaluation data, the game improved over time, locations were considered to cause no nuisance to the players, and players were focussed on playing the game. The gameplay was considered fair, and the teambuilding exercise was deemed useful for participants to become familiar with K'Nex. Improvements to the teambuilding exercise could be made to increase its effectiveness. Data on game realism in the third session was skewed due to one of the TPM players scoring a 1; the other TPM players scored a 4. This was caused by the player's view that the SRG could not embody a real-world infrastructure project because it was 'just' a game. The other two traditional players found that using TPM was a correct approach to the game. The TPM players were also sceptical about the use of APM. This is probably because APM was created for the development of software.

The researcher did not notice any signs of cheating or the occurrence of game-breaking elements. The information dump was found to cause confusion and decrease game clarity. This information managing was designed into the game to reflect reality. In the third session, the APM team interpreted the rules of the game wrongly, and the researcher needed to re-inform the team. In all four sessions, the researcher reminded one of the teams of one of the rules of the game.

For a player without any experience with the material K'Nex, a learning curve emerged, which was not considered a problem. The learning curve was reduced by the teambuilding session and the simplicity of the building materials available to the players. Still, players with prior experience with K'Nex had an advantage.

Three of the actors (from the beta and expert sessions) found the role description complex, but consistent acting was key. Not knowing all the details of the provided role definition was not a problem. Actors were instructed to focus on being consistent towards both teams and using their own experiences. This was done to let the actors be more comfortable in their role and provide the teams with clear information. All actors found the role realistic.

7.3 Conclusions: created game evaluation

There are no significant issues found with the created SRG; it fulfils the eight criteria: flexible and reusable, authoritative, dynamic, transparent, fast and easy to use, integrative, interactive, and communicative (see Table 29). The SRG was found to be realistic, but improvements could be made; players found the game fair and were immersed in the gameplay. Although immersion can be improved, it is considered already well established. No major gameplay problems were identified; however, stakeholders' backstory could be less complicated.

Table 29: Serious game criteria and fulfilment

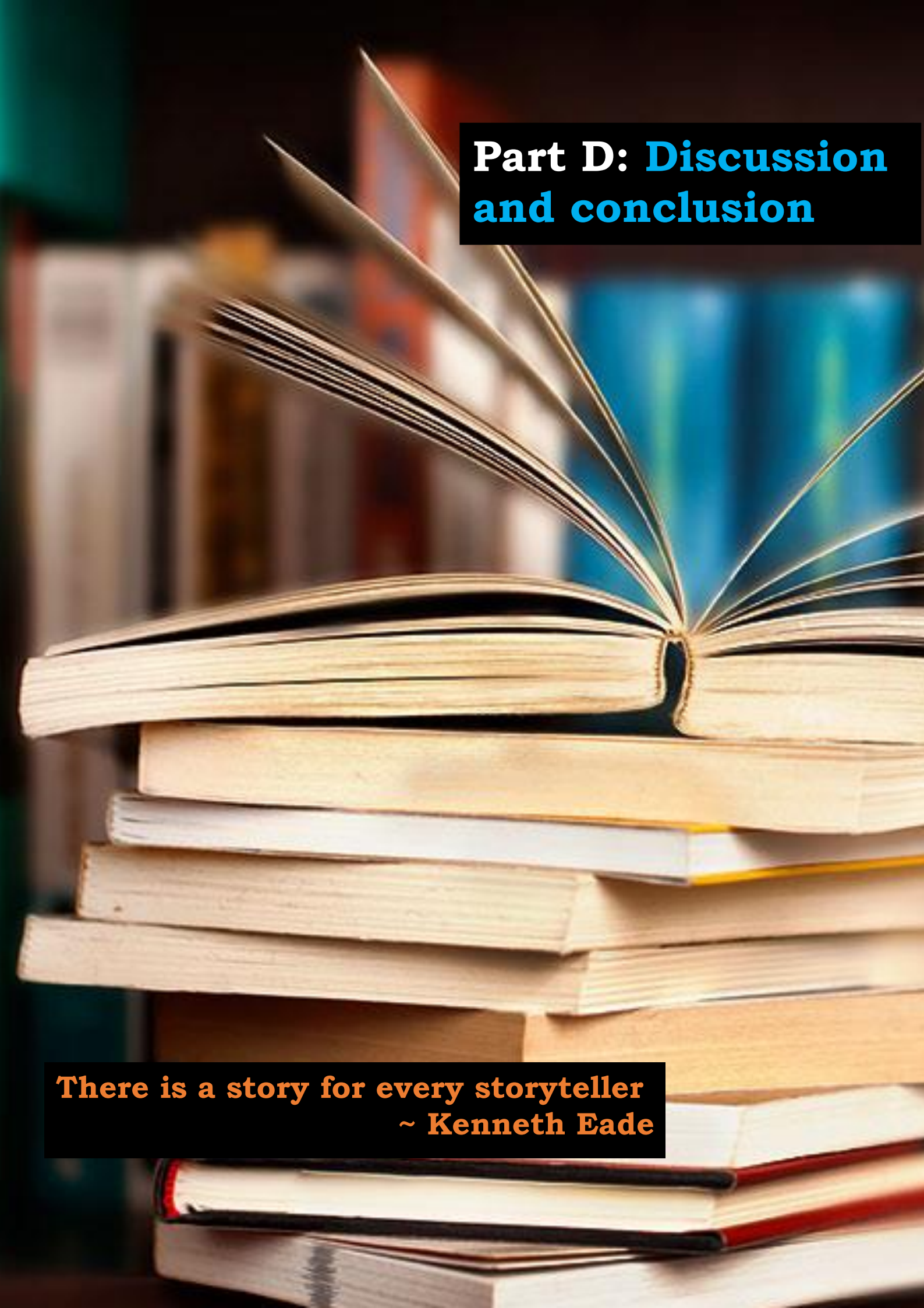
Criteria	Defence
Flexible and reusable	Game setup is broad and can be used to test project management aspects. The game can be modified to research or teach other variables. The game is useable to anybody who can read and understand the Dutch language. Due to the use of actors, their interpretation, and the questioning of the players, the SRG is played differently each time, making it replayable.
Authoritative	All players were informed that this SRG was part of research and gave consent. Data is anonymised for the public version and evaluated with a commonly used tool. This is done to meet analytical and political standards.
Dynamic	The game reacts to the players' action. Game elements are designed to be needed to reach the end goal of the game. Talking to the actors gives the players information.
Transparent	Results should be clear and understandable.
Fast and easy to use	The SRG is designed to be used by others. All necessary documentation can be found in the serious research appendix and contains the player manual, role descriptions, plan of action, and empty evaluation forms.
Integrative	Levels of decision making are guaranteed by the built-in three-tier gameplay loop.
Interactive	The game has built-in negotiation processes between the team and the actors and between players.
Communicative	The SRG uses two teams with different expertise and a focus group discussion with all participants.

Players were dedicated to playing the game, although the in-game economy could be better so that they could experience a strained budget and a limited amount of resources. The balancing should be done through trial and error. No other balance issues were identified.

The factors of usability, attention, relevance, confidence, and satisfaction were met. A narrative with a focus on exposition was created in the player manual and during the introduction presentation. Flow and pacing were created by limiting playtime.

The SRG fulfilled its function and satisfied the set criteria despite room for improvement. This means that 'Construction manager: bridge builders' can simulate a researchable project management environment, which answers the sub-question:

How can an infrastructure environment be simulated to research project management approaches from the Dutch client's perspective?



Part D: Discussion and conclusion

There is a story for every storyteller
~ Kenneth Eade

8 Discussion

This chapter discusses the research and gives an understanding of the results. Limitations and interpretations of the research are discussed in in four parts: discussion of the study (section 8.1), the developed serious research game (SRG) (section 8.2), findings from the SRG (section 8.3), and the research limitations (section 8.4). Section 8.5 contains the contributions of this study.

8.1 Discussing the study

This thesis contributes to two scientific subjects, serious research gaming, and agile project management (APM) for the construction sector.

This thesis made a distinction between serious games for educational purposes and research purposes which focus on creating immersion over *flow*. A SRG was developed which can be reused and adapted for research into the use of project management in the construction sector or research into a specific variable of project management. However, changes must be made if the game is used for educational purposes (how is explained later in this chapter).

This research explores the field of APM in construction projects. which is in its infancy. This study shows that there is a possibility to use APM for infrastructure projects, but a cultural change is needed. Implementing APM practices will not make a project agile, nor will it necessarily deliver the desired results. Using APM only works if, from the start of the project, agile thinking is applied and all stakeholders involved are convinced that this approach works.

The agile manifesto makes APM people-centric: people, not the process, realise the project and make the design – the process does not. Kotteman et al. (2017) has argued that Prince2, when applied differently, is agile. The researcher argues that this is only true when the method's main focus is to fulfil the values of the manifesto and not just by using agile practices. Often, the focus is on elements and tools of APM (which can be and are already used for traditional practices). However, the primary focus should be on fulfilling the values of the manifesto; this is difficult to grasp due to it is abstractness.

Joslin and Müller (2015) have argued that researching project management methodologies should be done for individual project management elements and tools. However, the researcher would argue that this is probably only true for traditional project management (TPM), which lacks the manifesto focus of APM. The tools in TPM are used to realise the project, not fulfil a way of thinking.

In addition, TPM acknowledges that change is inevitable (Lycett et al., 2004; Sohi, 2018) but focusses on avoiding changes, which can be contradictory. The researcher believes this is caused by the stage-gate mindset; thinking in sequential steps and not revisiting earlier stages makes it difficult to accept change.

There seems to be a difference in type of requirements. APM often evolves the requirements: TPM often fixes the requirements. This distinction is essential because in APM, evolving requirements define the boundaries of the project. In TPM, they limit the scope. This difference is not well reflected by the literature.

In a broader sense, APM is often researched through its methodologies of Scrum and extreme programming, but not all papers state which (combination of) methodology is used. Sometimes the terms APM and agile practitioner are presented, but these can be misnomers referencing the methodology DSDM (dynamic systems development method). Lean methodology can also be regarded as APM (VersionOne Inc., 2007), but others state it as inspiration (Sutherland, 2015). Because Lean is included in the state-of-agile reports, it is often considered an agile methodology. There is also an ongoing debate about whether Scrum is agile (Jeffries, 2018; Nijland, 2019; Weyland, 2019). Because Sutherland is one of the contributors to the manifesto (Beedle et al., 2001) and the developer of Scrum (Sutherland, 2015), Scrum is considered an APM methodology in this thesis .

Moreover, the terminology for both approaches is uncomfortable. The word 'traditional' has a slightly negative connotation but is used because it is the most common phrasing. The word 'agile'

gives the impression that APM is flexible and nimble, but in a way, it is stricter than the traditional approach due to the focus on realising the four values. Enforcing the fulfilment of these factors makes APM less flexible.

8.2 Discussing the serious research game

The main research tool used in this research is the uncommonly used, low-cost, low-risk SRG. This study made a distinction between educational games and SRG, utilising different design choices, a focus on immersion, and an interactive story and causing the emergence of the genre interactive storytelling for SRG. Breuer and Bente (2010) and Jansen (2016) have argued that classification of serious games is controversial and researchers should refrain from doing so because the classification could be incomplete or redundant. This researcher argues that one should try to classify one's game; this gives the designer an explicit purpose and helps to create understanding.

To develop the SRG, the researcher used a combination of serious game (SG) design rules and entertainment game design rules. Research on both fields is limited, and different schools of game design exist, making it challenging to find appropriate studies.

This research often used ideas and design principles, as stated by video-game developer and critic Benjamin "Yahtzee" Croshaw. His design ideas and rules are amended with the appropriate research. Video games differ in that they are computer-controlled with an object displayed on an electronic screen (sciencedaily.com, n.d.).

The aspect of fun is usually not considered a factor in SG. However, the researcher argues that creating fun is important in that it helps to create a better immersive environment and motivate participants to play the game, improving the research quality.

The developed SRG meets the eight design criteria and is thus considered a SG. Internal validity is high, and external validity is low; this is similar to an experiment (Sekran, 2000). The researcher argues that a SRG should also asses the players' identity, the creation of immersion, the need for communication and collaboration, and the occurrence of game-breaking elements to determine its validity and quality. This practice is uncommon but is needed to assess the quality of the results. However, these factors can only be evaluated by playing the SRG.

Threats to the game's internal validity include history effects, maturation effects, testing effects, instrumentation effects, statistical regression, selection bias, and mortality effects (Sekran, 2000). Maturation effects occurred during the focus group discussion of the first and second sessions; this was caused by playing in the evening. History and morality effects did not occur, and statistical regression does not apply. Testing effects might have occurred since participants knew this was an experiment. The study was done in a contrived setting which participants had limited time to get used to. Instrumentation effects were present because each team was observed. However, these effects were minimised by using standardisation, an extra independent observer for both teams, and the researcher's own observations. Unclear data was edited after consultation with the observer and was only done when a consensus was reached. Selection bias did occur, but this research required experts, not a randomised population. The participants were sourced from either the researcher's network or that of the company Balance. Players were found to act as themselves, and immersion was considered well established. The need for communication and collaboration was designed into the SRG, and players found this necessary. No game-breaking elements were observed.

External validity for this type of research is low; however, through realism, external validity is improved. Players, on average, found the project realistic, but improvements are possible. This is probably caused by game design choices which limited realism since a game can only mimic real-world situations. All actors found their roles to be realistic.

The developed SRG, 'Construction manager: bridge builders', does not fulfil all tasks required by Dutch clients (see Table 9). For instance, the SRG used two stakeholder groups. In reality, more stakeholder groups are involved. Two actors were used, to which both teams had access; if a team needed an actor, they asked him or her to come to them, but sometimes the actor was preoccupied with the other team. This reduces the fairness of the SRG.

K’Nex was also used for the SGR, and the colour of the material was often referred to in communication amongst team members, which can be a disadvantage to colourblind players. K’Nex is also prone to improvisation since materials can be used for different purposes. Improvisation occurred during the sessions, which means the design was altered on the spot. Similarly, in construction, project rework is not uncommon.

Realising a balanced economy within the SRG was almost accomplished in the fourth session, but the required materials were still highly dependent on a player’s experiences and team size. More time is thus needed to develop the in-game economy. A well-balanced economy improves realism because construction projects work with a strained budget. For most sessions, players had an abundance of materials at their disposal. Instead of the idea of limiting the amount of resources, an experiment in which different materials have different values and the players are given a budget might work better.

Time is limited to an hour plus a maximum of 15 minutes to reduce maturation effects. Due to the time limitation, players do not have to make a plan. However, one would be needed when more tasks must be completed over a more extended period of time. Moreover, the agile principle of self-organising teams is not considered in the SRG and is almost impossible to enforce. There is no management layer simulated that steers the teams because this it would also alter the results.

Furthermore, the SRG could be transformed into a SEG since multiple options are possible. An expert agile user can gradually introduce the steps of APM. The other possibility is to teach the mechanics and the steps the team must take, as outlined by a project management methodology. This way, the players are taught to use a specific project management methodology, and the game is focussed on creating *flow*.

8.3 Implication for infrastructure projects

From the results and differences presented in sections 6.5 and 6.6, Figure 29 has been hypothesised. This figure describes the possible approach of APM for real-world projects of the Dutch clients.

The approach seeks constant feedback and collaboration with involved stakeholders, and communication is done through the visualised results: designs, models, or prototypes created with evolving requirements. Timeboxes constrain the scope and ensure the execution of the project. They are needed in the front-end development phase to create feedback loops to evolve a minimal viable design until construction starts. In this process, the stakeholders should be viewed as the design experts who are aided by the project management team to realise their vision.

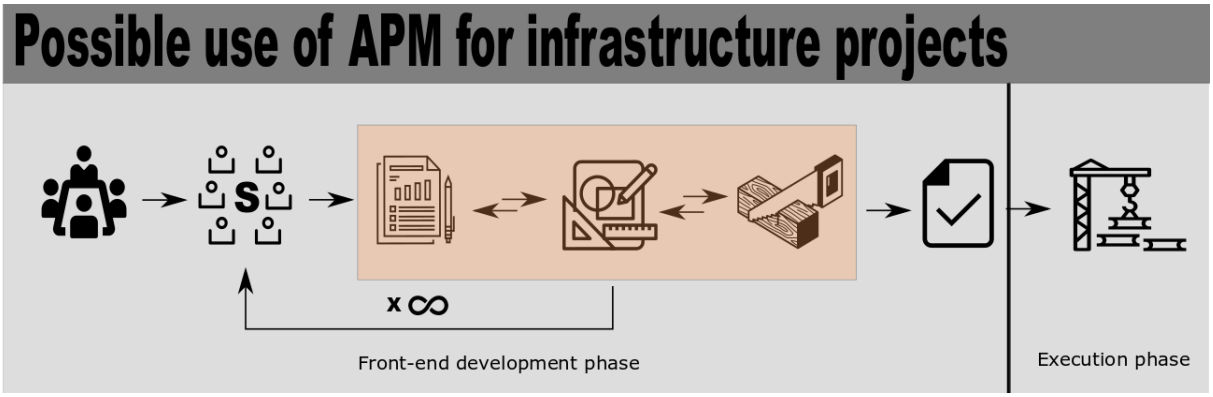


Figure 29: Hypothesised APM approach to infrastructure projects (own illustration)

However, there are issues with this hypothesised approach to using APM for the Dutch clients to realise infrastructure projects. For instance, the early project phases might cause problems with tender procedures and contracting. The Smakkelaarsveld project used a bilateral development agreement[16] and a tender approach focussed on collaboration, which is uncommon. This project might also provide solutions to a different tender procedure and contracts, but their effects are not yet understood.

[16] In Dutch, this is *bilaterale ontwikkel overeenkomst* (BOO).

This approach also differs from the hypothesised use by Owen et al. (2006), which theorises that in the pre-design, design, and construction phases of the project, APM is useful. This research shows that using APM in the earliest stages—or, as Owen et al. (2006) have termed it, the pre-design phase—can be done. However, starting to use APM in the design phase without first using it in the pre-design phase will probably not work; the dimension of the project will by then already be too narrow, causing the team to fall back on convincing the stakeholders that the created design is the right solution. In the construction phase, Owen et al. (2006) have proposed that APM could be used for the planning of the project, but the researcher thinks this neglects the values of APM and that this phase should focus on frequent collaboration and communication with the stakeholders on the construction site to fulfil the values of the agile manifesto, thus creating a better understanding between the involved parties and positively improving the opinion of the stakeholders (Hoezen et al., 2006).

Furthermore, Aangeenbrug et al. (2019) have reasoned that APM might manage infrastructure projects better because it deals with change, improves communication, and delivers results which are more comprehensible. The results of this research do not disprove or confirm their claims. Instead, this study shows that communication has a different application and is more frequent when APM is used. This is caused by the need to involve the stakeholders early and often in the process because they are creating the project; the project management team only facilitates them in this. According to Brus (2018), this is letting the stakeholders become the design experts.

In addition, Owen et al. (2006) have mentioned the need for a cultural change when APM is used for the infrastructure project. Adut (2016) has also stated that the use of APM for the construction industry was limited by the stage-gate mindset and that a cultural change in the industry was necessary to implement agile thinking. This research agrees that this cultural divide exists and that it might be hard to change to the agile mindset since changing a culture is difficult and causes resistance (Inglehart & Welzel, 2005).

However, infrastructure projects do have a change in environment; going to an outside project location changes the dynamic of the project. Design and materials must be decided before construction can start. Adding changes to the built structure is hard and can be unsafe. This could be mitigated by accepting that construction can only begin when the front-end development phase is completed. This phase could then utilise the practices of APM.

Another mitigation option is having an evolving design that first creates a framework on which the project could be built and evolve, continuously fixing design aspects that could later be built. Although creating an MVP might cause issues later in the use phase, there should be no reason that first developing an MVP in the front-end development phase and evolving it into a future proof product is not feasible.

Of course, safety should always be the primary project driver; accidents where people are hurt or even die are unacceptable. In IT projects, this is a minor issue. However, in construction, the risk analysis made by the teams shows a difference between APM identifying risks as early as possible and TPM's approach to risk mitigation. This research cannot identify if this difference in risk analysis is caused by the project management approach or is due to the lack of education on making risk registers.

Finally, APM methods often make use of a product owner who is responsible for all stakeholders in the process, this is often just one stakeholder. This is a problem for infrastructure projects where multiple stakeholders are usually involved. Using a product owner streamlines the process and might resemble an area manager,[17] but this is not researched in this study.

Overall, according to State-of-Agile, (2019), APM projects deliver on time and within budget. However, software development's main cost is programming hours, whilst in construction projects, man hours are secondary to the materials and equipment. In addition, APM is often applied for smaller IT projects with smaller teams, whereas infrastructure project teams are large. An agile movement to deal with larger projects and teams is emerging, but whilst its effects are not yet fully understood, this might offer solutions for the organisation of infrastructure projects that aim to use APM.

[17] In Dutch: Omgevingsmanager

In addition, APM seems to overlap with process management because it is goal-seeking and works with an open context, which are typical process management elements (De Bruijn, Heuvelhof, & Veld, 2010). Understanding where agile project management fits between process and project management could offer some solutions.

Furthermore, APM seems to overlap with modern TPM practices. Like early contractor involvement. In some cases, some agile practices are already present in the realisation of infrastructure projects but there is a difference in terminology. The daily stand-up for example is common in the exaction phase of infrastructure projects but is usually called something like work consultation. But these overlapping concepts, ideas and elements are not researched in this thesis.

8.4 Limitations of the study

This research explores the new field of APM for the construction sector with an unconventional research method, causing the study to have a high risk of criticism.

Moreover, most Dutch clients use the collaboration model *intergraal projectmanagement* (IPM), but the effects of this model, along with self-organising teams, are not considered in this study.

Communication and collaboration worked as mediating variables, but manipulation of these variables was not done since their effects are not well understood and are difficult to measure. Additionally, the researcher became aware that not everybody sees a difference in communication and collaboration; for some, communication is collaboration.

Extracting data from a SRG is done in multiple ways through the operationalisation of variables. For this, the researcher attempted to measure the agility of both teams using an altered version of the measurement tool made by Verbruggen (2017). Because, this tool is abstract and could only be used by APM experts. An attempt was made to reduce the abstractness, but the data from the new agility survey was unable to distinguish between APM and TPM. Because it neglected agile thinking, which is found to be more important than the tools used. To mitigate this, the focus group discussion was prioritised, and observations were used to highlight the differences in approach. Another solution might be the use of a comparative agility tool (Comparative Agility, n.d.). Which was not used because the researcher found the existence of this method when the data was already gathered. The tool was found in the thesis by Hendriks, (2019).

Because the created measurement tool failed, the researcher decided whether the team worked with a TPM or an APM approach, making the researcher a measurement tool. The decision was aided by players' answers to whether they worked with TPM or APM and the composition of the teams.

Another limitation is that the literature reviewed might in some cases be considered old, although the researcher tried to use the most current and relevant literature possible. As of 1 October 2019, no new information was sought, with the exception of the thesis by Hendriks (2019), which was recommended by the daily supervisor. All literature as of 1 October is verified.

In addition, the researcher has dyslexia and wrote this thesis in a second language, which might affect readers' understanding or interpretations. All reasonable measures to mitigate these effects have been taken, but issues might remain.

8.5 Scientific and practical contributions

This research broadened the current state of knowledge on APM for infrastructure projects and SRG. The developed SRG could be used to test their developed approaches, as a teambuilding exercise, or as an illustration of what project managers do and how this can differ.

The answer to the research question is abstract and is considered the next step (as described in section 2.4) from the philosophical use of APM in the construction sector because just implementing its use is considered too risky for an industry with low profit margins (Hoezen et al., 2006).

The use of APM can improve the realisation of infrastructure projects because it improves collaboration and communication with the stakeholders. This will probably improve public perception of the project because stakeholders are part of the project. The role of the project management teams of the Dutch clients changes by becoming project facilitators.

9 Conclusion

The objective of this research was to explore the possible use of agile project management for infrastructure projects. This chapter answers the sub-questions in section 9.1. Section 9.2 concludes the research with an answer to the main research question:

How might the Dutch clients use agile project management for the realisation of infrastructure projects?

9.1 Answering the sub-questions

This section answers the four sub-questions, which leads to an answer of the main research question.

SQ1: How does the project management approach of the Dutch clients look like?
To realise an infrastructure project, the Dutch clients tasks an in-house project team with realising an infrastructure project. This team is responsible for describing the intended results and selecting a contractor through a tender procedure which the team must set up. The team is then tasked with monitoring the progress of the project and results whilst ensuring that the project is supported by the affected stakeholders. This is done through managing five interacting variables: scope, cost, time, stakeholders, and risks. These factors are managed through collaboration and communication and ultimately affect the project's performance, which is managed through the use of traditional project management approaches.

Traditional project management is a sequential approach in which steps are taken; when a step is finished, it is assumed that it is not revisited again. This process is depicted in Figure 6. The traditional project management method assumes that projects are predictable and focusses on controlling the scope to manage the cost and planning of the project. Communication is managed through plans and is used to identify changes to the scope so that the appropriate actions can be taken to get back to the original plan. Risks are identified to minimise changes to the scope. Traditional project management is used by the project management teams of the Dutch clients to realise infrastructure projects.

SQ2: What is the agile project management approach, and how does it differ from the current project management approach of the Dutch clients?
Agile project management is the fulfilment of the four values presented in the agile manifesto to deliver a better project to the customer. To fulfil these four values, twelve principles are presented and adhered to. From this, a set of practices emerges to help uphold the twelve principles; these relationships are depicted in Figure 8.

Agile project management uses frequent collaboration and communication with the customer to readjust the project. For this, visualisation is used to communicate the progress of the project. Because the project can be readjusted after each iteration, the scope is considered to be flexible. This means that the scope must be managed, which is done through prioritisation and timeboxes. Project requirements are fulfilled by self-organising teams that prefer to use face-to-face communication with each other and the customer.

Traditional project management does not have the same focus as agile project management. Due to this fundamental difference in philosophy, additional differences appear in agile principles and practices regarding project organisation and the people involved, project development, and project realisation, all of which are caused by the pursuit of the four agile values.

SQ3: How can an infrastructure environment be simulated to research project management approaches from the Dutch client's perspective?

One way to simulate an infrastructure environment is through the created serious research game 'Construction manager: bridge builders'. This serious research game mimics a project environment in which teams realise and manage a bridge-building project in a contrived setting. The game tasks a project management team with fulfilling the front-end development phase and construction phase of a bridge-building project. Its game mechanics are based on the tasks a project management team must do to realise an infrastructure project for the Dutch clients.

The game consists of three gameplay loops to ensure complexity. The primary gameplay loop is different for the two-game phases. The game reacts to the players' actions by either rewarding them or giving them additional information, thus making the game reactive.

The designed serious research game also focusses on creating an immersive environment. This is done by creating a realistic fictive setting and using an exposition dump at the start of the game. Playtime is limited to reduce maturation effects and to create an anxious feeling so that the players immediately start to work on the tasks at hand. This is done to get players to behave as they normally would when they realise a project.

The project management approach used by the team affects the performance of a project. This has been researched through the use of a focus group discussion to understand the choices made by the players of the game, observations which record the teams' discussions and choices made during the game, feedback from actors playing the stakeholders, and miscellaneous data created by the participants.

The serious research game created is considered a serious game because it fulfils the essential criteria (Table 29). Additionally, the game establishes immersive players, rules are clear, the game is fair, and no game-breaking elements are observed. Internal validity is high and external validity low. The game's realism, clarity, and in-game economy could be improved, all other criteria are satisfactorily fulfilled.

SQ4: What is the difference between using the current and agile project management approaches in the simulated infrastructure project?

Because agile project management has the need to fulfil the four values of the agile manifesto, the approach to realising the project differs to that of the traditional approach; this is the main reason for the differences that emerge between the applied agile and traditional project management applied to the game. The agile project management approach is people-centric and thrives on communication and collaboration. To realise this project, teams start with understanding the boundaries of the environment they are working in. Through the use of visualisation of the intermediate results, the progress of the project is communicated so that stakeholders can give feedback and readjust when necessary. This way, the stakeholders are taken on a journey to develop the requirements and the project through frequent evaluation rounds. By doing so, they become the design experts of the project; the project team is there to aid them in developing the project and considering technical implications. This differs from the traditional approach, in which the stakeholders must be convinced that the created project plan is the right solution. Table 23 shows the differences of the two approaches during the game.

9.2 Answering the main research question

This research explored the hypothetical use of agile project management for the construction sector through a serious research game, which answered the main research question.

How might the Dutch clients use agile project management for the realisation of infrastructure projects?

For the Dutch clients, there is a possibility to fulfil the four values of the agile manifesto whilst realising infrastructure projects. The serious research game showed that the four values can be met, and, thus, agile project management can be used. However, this means that the project management teams of the Dutch clients must work differently.

When agile project management is applied to the realisation of infrastructure projects, project stakeholders should be involved early in the project realisation process, and from the start of the project, agile project management must be used to understand the stakeholder demands and wishes. In this way, the boundaries of the project are identified. Thus, frequent feedback from the stakeholders is vital. The intermediate results should be presented and visualised to aid communication and collaboration so that the project management team can become the facilitators helping the stakeholders to create the project.

The use of agile project management by the project management team of the Dutch clients (as illustrated in Figure 29) means that they should let go of the current stage-gate mindset and start to accept the stakeholders as design experts. In return, the project management team will not have to convince the stakeholders that the solution they created is the right one.

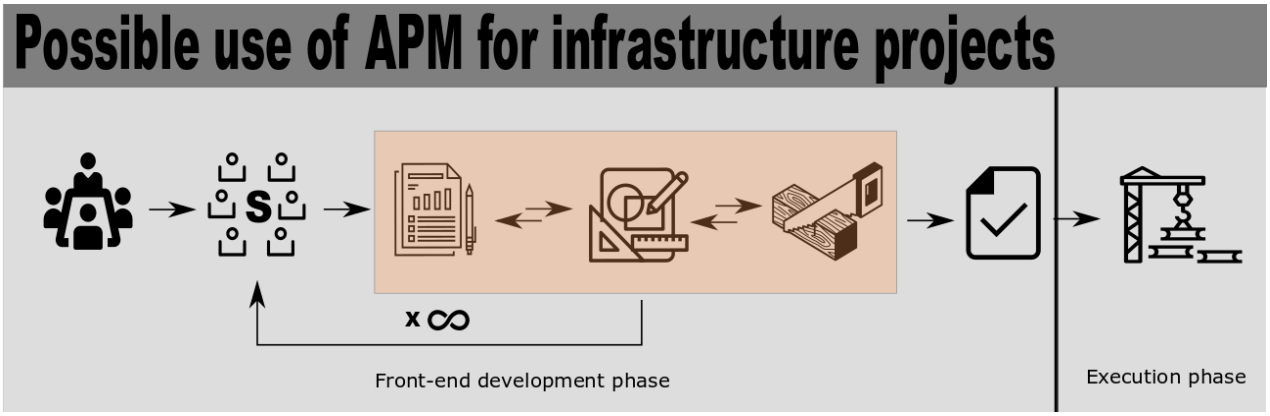


Figure 29: Hypothesised APM approach to infrastructure projects (own illustration)

Figure 29 depicts the proposed, agile project management approach to realising infrastructure projects. It shows an iterative design process, requirements, design, and prototype influence each other to create a visualised result (orange block). This intermediate result is shared with the stakeholders to gain their feedback (arrow back). This is done until the stakeholders are satisfied with the result or until a set deadline is reached. Then the execution phase starts. The first pictogram represents the project management team of Dutch clients.

Stakeholder involvement is the main benefit to the Dutch clients due to the focus on collaboration and communication, a better understanding of the project, and the constraints created, possibly increasing the client's satisfaction. However, it is questionable whether the approach reduces issues such as going over budget or not completing the project within the set timeframe, more research is needed.

Through the use of the serious research game, it has been shown that the Dutch clients could use agile project management in projects where the stakeholders can become the design experts. This can be done early in the realisation process of the infrastructure project by facilitating the stakeholders' ability to create their project through frequent communication and collaboration, which is aided by visualised results. However, this approach can only work in projects where the stakeholders can become the design experts. And seems to already have similarities with modern traditional project management.

10 Recommendations

This thesis researched a new field of study: the use of agile project management for infrastructure projects. This was done using an uncommon research tool, the serious research game. Due to this combination, a new field and research method have been explored, providing innovative insights but also raising questions.

The conclusion showed that using agile project management might be a viable option in realising infrastructure projects, and the discussion presented a testable hypothesis. Thus, this research reduced the scope for the use of agile project management for the construction sector, but much is still unknown. Testing the presented hypothesis can be done in multiple ways, and a viable option is using the created serious research game. However, the hypothesis scope is probably too large for a master's thesis, so a PhD might be a better option.

Solutions and ideas of how to apply agile project management might be sought in methodologies such as the Spotify model, scaled agile framework (SAFe) built for large projects, or the Smakkelaarsveld project in Utrecht, which seems to use a rudimentary form of agile project management.

The researcher also recommends that Balance continue their efforts in using agile project management and testing the proposed hypothesis. This thesis gives Balance a tool to research agile project management in the form of a serious research game, as well as a starting point on how to use agile thinking for the realisation of infrastructure projects. However, the current strategy of teaching employees agile project management through DSDM might not succeed because it might not give practitioners the needed agile mindset.

A better solution is redeveloping the create serious research game into a serious educational game to teach the project managers of Balance this focus on the agile values and to show the importance of early collaboration. This is especially useful for the future, when the new '*omgevingswet'* becomes law. In this law citizen participation will probably be obligated. The game could improve the benefit awareness of early project collaboration with the stakeholders among the project managers of Balance. Changing the mindset of the project managers could help Balance to better prepared for the law change.

Finally, Balance could benefit from developing this project management approach and understanding that different approaches are needed for various projects. This will help them to better facilitate and aid their clients by advising the right methods and delivering project managers to the appropriate projects. Thus, giving Balance a head start on their competition.

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11 Reflection

The past six á seven months, I dedicated my life to writing this thesis. To reach my ultimate goal of graduating from the TU Delft after 7.5 years of hard work. Writing this thesis reminded me of the lyrics by Green Day '*I walk a lonely road'.* Luckily when going into this project I was aware of this. To successfully complete this thesis, I needed all the help I could get. And use all my skills and determination I gather over the years attending this university and my high school.

As a person, I grew and now better understand my limitations. I have always struggled with my dyslexia but writing this thesis made this limitation even clearer. But it also gave me the determination I needed to complete the task at hand.

My high school taught me the importance of collaboration and communication. This also gave me the opinion that the use of APM for the construction industry might be THE solution to the problems this industry is facing.

However, during this research, two things became evident. Firstly, APM could be used for bettering the sector, but its effect and usefulness are limited, although it does provide some guidelines on where to look for solutions.

The other major factor that emerged were the rooted convictions of the practitioners. They were often adverse to change, which is probably caused by the focus on minimising any changes to their projects but could also be due to the mentality of the practitioners since good managers need strong convictions and the ability to make decisions. They only see the problems a change might cause, not the solutions it might bring. Alternatively, some are of the opinion that they should continue with traditional methods because it is the evil that they know. No project management methodology—traditional, agile, or a future one—can be perfect; there is always room for improvement. Admitting this is the first step. Only then might one be able to change one's culturally coloured opinion and start changing the culture of the industry itself.

A future where there are multiple project management approaches is not unthinkable but should start with the idea that using TPM for all infrastructure projects will deliver satisfactory results is madness. Different types of infrastructure projects exist and should be handled in individual ways. Trying to generalise a perfect project management method is ironic for a field that considers all projects as unique.

Moreover, if I would to do this all over again, I would start earlier with the idea to use a SRG. To allow for more play sessions. Additionally, I would sooner realise that I already have a huge amount of knowledge rather than trying to reinvent the wheel.

Lastly, I think that the current manifesto is not suited for the construction sector. Alterations to the manifesto are needed, without software references. Therefore, I propose Table 30. When using APM for the realisation of infrastructure, the fulfilment of the agile manifesto values should be the main focus.

Table 30: Proposed changes for the agile manifesto that are applicable to the construction sector

Agile manifesto	Changes
Working software over comprehensive documentation	Visualised value over comprehensive documentation
Delivering working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale	Deliver visualised value as often as possible
Working software is the primary measure of progress	Delivery of visualised value is the primary measure of progress

~ Boedi

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Appendix A: Information on the appendices

There are two additional appendixes that are part of this thesis, one contains all information of the serious research game the other the information on project management:

- Serious research game
  - Game manual
  - Role descriptions
  - Raw data
  - Memo session 2
  - Transcript session 3
  - Session specific notes
- Project management
  - Additional information agile- and traditional project management
  - Analysis agile methodologies 2006-2019
  - Original comparison table by Verbruggen, (2017)
  - New comparison table

All other appendices are presented in this document. The public versions contain all the same data, but this data is anonymized. The memo of the interview with Heleen Wijtmans is available on requested in the public version. The same applies to the transcript, photos and any audio recordings of the sessions.

Appendix B: Game Definitions & the Mario example

This chapter contains game definitions and explanations that might not be common knowledge. Through the video-game super Mario Bros, an example of some of the definition is given. In this game, a player is controlling the avatar Mario his goal is to save the princess.

Game mechanics
Game mechanics are rules and procedures that guide the player and the game response to the actions of the player. Game mechanics define how the game is played. Elements are the game's obstacles and are what keeps people engaged with the game (Boller, 2013).

Perks
Perks are exclusive bonuses that the player can pick or add to their character to relate or build a character they want or need to play the game their way. Sometimes perks influence the starting point of the game, or different in-game advantages can be chosen (Croshaw & Morton, 2016; Shamoon, 2007).

Video-games
Video game differs from other touchable games due to their use of a computer through either a personal computer (PC), console or arcade machine. A video-game is nothing more than a game that is computer-controlled with object displayed on an electronic screen (sciencedaily.com, n.d.).

Gameplay loops
The primary gameplay loop is what the player does from second to second, in Mario that is to move to the right and survive. The Secondary loop is what the player has to do from minute to minute, in Mario, this means you have to beat the level before the time runs out. The Tertiary loop is what the player has to do from moment to moment or in Mario beat all the levels to save the princess.

Exposition
On playing Mario, a player is faced with the avatar Mario the rest of the screen is empty apart from some information on the number of points the player got, which level is played and the amount of time there is to complete the task. The rest is empty, there is no text telling the player what to do, but because Mario is placed on the left of the screen and the rest is empty the player is invited to move to the right as is depicted in Figure 30. This is exposition, letting the player explore by intrigue and in the meantime also teaching the player that the character needs to move to the right and not to the left.

Alpha- & Beta-test
Alpha is an acceptance test to identify if the game is playable. A Beta-test is a performance test by the possible end-users of the game and is performed as the game is intended to be played as much as possible. And is considered the final test before the game is ready. Both Alpha and Beta test often consist of an open and closed phase.

Figure 30: super Mario Bros level one start screen (own screenshot, owned by Nintendo)

Appendix C: Dutch information

The task of the client in Dutch by Twynstra Gudde, (n.d.).

Taken van de opdrachtgever zijn:

- Voor een goed begin zorgen;
- De doelen en het resultaat van de unieke opgave (laten) omschrijven;
- Ervoor zorgen dat de unieke opgave in de permanente organisatie(s) wordt ingebed en rugdekking krijgt;
- De opdrachtnemer selecteren en ondersteunen;
- Afspraken maken over tussentijdse en fase- of stadiumrapportages;
- De tussentijdse resultaten goedkeuren;
- Tussentijdse beslissen over de voortgang;
- Regelmatig toetsen of alle betrokken nog hetzelfde beeld van de opgave hebben;
- Beslissen over onverwachte, noodzakelijke tussentijdse wijzigingen, binnen en buiten de marges;
- Zorgen voor draagvlak van de relevante omgeving;
- De werkers en de opgave zelf afschermen van ongewenste, verstorende invloeden uit de omgeving;
- Bepalen wie de uitkomsten zullen gebruiken, begeren dan wel onderhouden;
- De opgave beëindigen (Twynstra Gudde, n.d.).

Appendix D: Smakkelaarsveld

Appendix available upon request