TU Delft

GAMIFICATION TO ENHANCE MOTIVATION IN A REAL WORLD ORDER PICKING ENVIRONMENT OF AN ONLINE GROCER

MASTER THESIS
TIM VAN DEN BERG

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PICNIC

A CASE STUDY AT PICNIC

PUBLIC VERSION

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Gamification to enhance motivation in a real world order picking environment of an online grocer

A case study at Picnic

Public version

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By

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Preface

In the summer of 2008, I arrived in Delft as a brand new student in Life Sciences and Technology. More than 9 years later, I left the DNA helices, cell membranes and metabolic pathways far behind with a bachelor's degree and I am almost graduating at the faculty of Technology, Policy and Management. With this thesis I hope to finalize my time at the Delft University of Technology with a master's degree in Complex Systems Engineering and Management. It has been an adventure of a lifetime.

This research project was conducted in close cooperation with online supermarket Picnic, the company where I already started my first internship at the start of 2016. Challenged by the enormous ambition and growth of Picnic, I sticked with the company and finally started my thesis research in March of this year in the fulfilment center in Nijkerk. Almost 9 months and a lot of struggles later, I may proudly present the final work of my study to the audience. I hope you like reading it!

I would like to take this opportunity to thank a lot of people that have supported me during this research and before, in one way or the other. At first, I would like to say thanks to my graduation committee from the TU Delft: Alexander, Heide and Jafar. I really felt the support from of all of you during the whole project. After a bunch of disappointing talks with several others, Alexander was the first who was very enthusiastic about my ideas for a research project within Picnic. He really encouraged me to start this project and repeated this encouragements during the meetings we had. Heide introduced me in the research field of gamification and was always available to pitch my ideas to and to give elaborate feedback on my work. Even at the time I was too busy with thinking and trying to write things down, she was willing to listen to my plans and gave the confirmation I was looking for. Jafar completed the committee with detailed observations about the quality of my research, very helpful in formulating the right research problem and questions and suggesting useful improvements of the analysis of the case study and the results.

Secondly, I would like to thank all my colleagues at Picnic who really supported me through this whole project. It was amazing to be possible to ask anyone for help at any time, no one ever refused. I started this project as part of a great team and felt so during the whole year, even when I stopped as a supervisor and more and more focused on my thesis. I thank Frederik for giving me the opportunity to join Picnic in the first place, but also for showing up at a crucial moment to give me exactly the support I needed. An opportunity which was probably never be created when Frank has not shared his enthusiasm about Picnic with me, before it all started. Special thanks I want to give to Wybe-Jan, who was part of the graduation committee on behalf of Picnic. He really put a lot of trust in me in the execution of this project. I was free to do and try whatever I thought was good, but I was also always welcome to share thoughts, no matter how busy he was expanding the fulfilment operations.

Finally, I want to thank the people I love in my personal life. Those people were very important for me, not only in the last year, but in the whole period as a student and before. The ‘Vrienden van Vroeger’ and all the friends I met in Delft, roommates, fellow board members and Åsene, from who I learnt so much about life, studying and myself. It has been almost 10 years and it feels like an era. My family, mom, dad, sisters and brother who supported me in all the choices I made to do all kinds of stuff next to my study programs, and gave me a warm home. Thank you. And last, but most thanks to Lianne. She was not only my girlfriend, but my personal and mental coach during this project. She provided me with feedback for every step and helped me through the difficult moments.

Thanks!

Tim van den Berg
Rotterdam, December 2017

Executive Summary

In a highly mature and competitive grocery retail market, supermarket companies compete with prices, service levels, and lately with their home delivery services. While the online grocery market lagged far behind on those of other product categories, it is catching up real quick recently. In 2017, the online sales of groceries will exceed 1 billion euros in the Netherlands, almost 3% of the market share. In 2015 the market share was only 1.2%. For 2030, it is estimated that 15-20% of the grocery shopping will be done online.

Next to the traditional supermarkets, online-only supermarkets enter the market of e-grocery retailing. Introducing a new and shorter supply chain in comparison to the conventional supply chains for traditional grocers, the main challenge remains to get the orders at the customers home in the most (cost) efficient way. Warehouse logistics and distribution to the customers are the most important links in this new supply chain. Warehouse logistics exist mainly of the operational processes: receiving, put away, storage, order picking, accumulation and shipping. Of these processes, order picking has been identified as the most labor-intensive and costly process. Improving the order picking process is therefore often subject of research. Focus areas for this research were mainly layout design, storage assignment, zoning, batching, routing methods and order accumulation and sorting. Human factors were often ignored in research, although it has been proven that these factors affect the performance of order pickers. Recently, gamification was showed to be an effective approach to improve work competencies in an experimental order picking environment, addressing the motivation of order pickers. The objective of this study is to test whether the use of gamification in a real world order picking process affects the motivation and thereby the performance of order pickers.

Picnic is an online-only supermarket that tries to disrupt the grocery retail market with free home deliveries and a lowest price guarantee. Real life contact between the company and customer is replaced by a high customer service level: on time deliveries, completeness of the orders, quick online support, etcetera. At Picnic, customer orders are manually picked in the fulfilment centers by order pickers called Shoppers. Since the use of gamification has showed promising results in improving the motivation and performance of order pickers, the company wants to test the effects of gamification in its operations.

Based on scientific literature and the operational experiences within the Picnic fulfilment centers, a main research question is formulated. A case study at Picnic is conducted to answer this main research question:

How can a gamified intervention in the order picking process increase the motivation of the order pickers and therewith increase the average pick productivity, while maintaining the pick quality?

In order to answer this research question, first the scientific fields of order picking, motivation and gamification were explored after which the order picking processes of the case study company were analyzed. Order picking can be defined as the "process of retrieving products from storage (…) in response to a specific customer request"[1]. Within Picnic, the commonly used human employing *picker-to-parts* system is used as the *pick by order* variant. This means that the Shopper travels along storing aisles following a fixed route to pick different items for the same order in sequence. Although order picking could be automated, it appeared to be very hard to imitate the cognitive and motor skills of humans in an economically feasible way. With a large range of products with a wide variety of size, weight and fragility, item handling demands a very high level of these cognitive and motor skills. Those are examples of human characteristics, just like motivation.

Motivation is a psychological aspect which can play an important role in the performance of order pickers. It is one of the three components of behavior according to the *Fogg Behavior Model*, next to ability and triggers. Due to the monotonous and repetitive character of the work, the work can be experienced as boring and the motivation might be low. The Self Determination Theory says that every person has fundamental psychological needs to be *competent*, *autonomous* and *related to others*. If these needs are not fulfilled by certain behavior, as during order picking, the intrinsic motivation to perform this behavior is low. As a consequence, low motivation could lead to low performance.

The intrinsic motivation can be improved by addressing the needs of *competence, autonomy* and *relatedness*. Game elements could do so: achieving a challenge gives a feel of competence, sharing these achievement in a community gives a feel of relatedness and if someone could choose his/her own challenges, the need of autonomy is addressed. Gamification is defined as "the use of game elements in non-game contexts"[2]. Since 2010, the use of game elements raised rapidly in all kind of (smartphone) applications to increase user activity. In business environments game elements are used to motivate people, influence behavior and increase performance and productivity. Empirical results showed that gamification could have the same effects in an order picking environment, although empirical research in a real world order picking environment was lacking until this study.

In the case study company Picnic, 30 to 45% of the operational costs of the fulfilment operations are the costs for order picking. Picnic aims for a pleasant and productive work environment to support high productivity and quality on the one hand and satisfied customers on the other. In the current process, the variance in productivity of individual Shoppers is too high according to the company. If the lower bound of the pick productivity per Shopper can be increased, the average pick productivity will increase as well. For this research, the scope was set on the order picking process in the ambient zone of the fulfilment center in Nijkerk. To measure possible improvements, the key performance indicators of order picking are defined: *Pick productivity* is the daily average pick speed in order lines per hour and *Pick quality* is the number of non-affected orders by picking mistakes as percentage of the total number of picked orders.

[1] de Koster, R., Le-Duc, T., & Roodbergen, K. J. (2007). Design and control of warehouse order picking: A literature review. *European Journal of Operational Research*, *182*(2), 481–501. https://doi.org/10.1016/j.ejor.2006.07.009, p. 481

[2] Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness. *Proceedings of the 15th International Academic MindTrek Conference on Envisioning Future Media Environments - MindTrek '11*, 9–11. https://doi.org/10.1145/2181037.2181040, p. 4

The goal for Picnic with the implementation of a gamified intervention is to increase the lower bound of the individual variance in productivity and therewith increase the average pick productivity in the fulfilment centers. To be able to interpret the experimental results, other factors that could affect the performance of order pickers were explored. It was found that a higher number of picks per pick round has a positive correlation with the pick productivity. Furthermore, it was showed that the pick productivity was higher with a higher share of picks in the last pick aisle in comparison to other pick aisles.

For the gameful design, a set of constraints were defined by the company. The intervention should be implemented in parallel to the actual order picking process, not affecting the work itself or the responsibilities of the leadership of the fulfilment center. The pick quality should be maintained during the intervention and it must not encourage undesired behavior which could harm the process. A final constraint, is that the intervention should only give positive feedback to the participants. From a theoretical perspective, the available theoretical knowledge about gamification and game elements limits the design choices for this study, since only game elements were examined that were previously explored with promising results.

During the gameful design process, a set of game elements were selected and a coherent design was developed. This selection was based on the theoretical knowledge provided during the exploration of scientific literature and the analysis of the operational processes of the company. The design contained the following game elements: *points, badges, leaderboards, performance graphs* and *avatars*. These game elements were combined in the so-called *Pick game*, which existed of three components: a daily personal feedback report, a daily team competition and a weekly personal performance overview.

Daily feedback report: This report contains the chosen avatar, personal statistics, points, badges and the rank on the leaderboard of a Shopper. Points can be earned for completing pick tasks and pick rounds and bonus points for achieving certain productivity goals on a day. Attached to the avatars are special attributes that multiply the bonus points. Badges can be achieved by special achievements, such as walking a certain distance during order picking. The rank on the leaderboard depends on the points of a Shopper compared to others.

Weekly performance overview report: This report shows the performance of participants in graphs. The progress in pick speed is showed over time, just like the number of completed pick tasks in comparison to others is showed. Furthermore, the amount of time that a Shopper spent order picking is shown.

Team competition: During each work day, three teams compete against each other to finish the most pick tasks of the day. All Shoppers assigned to order picking in the ambient zone are part of one of the teams and can win bonus points if their team wins. Around lunch, an update of the team scores is communicated to all Shoppers. Team members are recognizable on the shop floor by colored bracelets.

During an intervention of 12 consecutive work days, the gameful design was tested. Participants got daily feedback reports on the days they were active in the order picking process and participated in the team competition. The weekly performance overview report was sent twice to all participants. All communication about the *Pick game* was through Slack, a messenger application that is used by all employees of Picnic for internal communication. The reports were sent in direct messages to the Shoppers. Leaderboards and team scores were shared in a public channel that all Shoppers could access.

Compared to the two weeks before the intervention, a test group of Shoppers showed an increase in productivity of 5-10%[3]. The lower bound of the variance in pick productivity during the intervention was 7-13%[4] higher than the lower bound in the control period. The increase in productivity can partly be explained by an increase of picks per pick round, but a statistical test showed that after controlling for this effect there was still a significant increase in pick productivity. The pick quality during the intervention was at least equal during the intervention as it was before, therewith fulfilling the constraint to maintain the pick quality.

The motivation of the participants of the intervention was measured by the Intrinsic Motivation Inventory and compared to a test group of Shoppers in the fulfilment center of Picnic in Utrecht. This test showed that the intrinsic motivation of participants of the intervention was higher than the motivation of the test group. In general, the *Pick game* was experienced very positive by all involved employees of Picnic. Gathered feedback from the Shoppers and leadership of the fulfilment center showed that the different game elements were appreciated differently by Shoppers with different levels of experience. Shoppers with a high level of experience especially liked the team competition and badges, while the weekly feedback report was most appreciated by the trainees. All Shoppers that were questioned liked the daily feedback reports with the scores and ranking. The team competition was the only element of the *Pick game* that got some negative feedback; some Shoppers were not very competitive and were annoyed by the behavior of competitive colleagues.

Based on the presented results, the main research question can be answered. It was established that the intervention was experienced mainly positive. Both Shoppers and the leadership of the fulfilment center very much liked the different game elements that were used. Besides, the intrinsic motivation of Shoppers was higher for participants of the intervention than for the control group. Therefore the conclusion can be drawn that the gamified intervention, as designed in this study, increased the motivation of order pickers. Next to the increased motivation, the test results showed that the pick productivity of the test group increased while the pick quality was maintained.

After this research, the following recommendations can be given for future research:

- Future research should isolate the different game elements to determine the impact of every single game element on the motivation of order pickers.
- Future research should focus on a more elaborate empirical study in the real world with more participants and over a longer period of time to validate the results of this study.
- Further research should focus on the long-term effects of gamification in an order picking environment and could focus on how a combination of game elements could affect these long-term effects.
- Future research should focus on the other human factors than motivation to see how the performance of order picking can be further improved.

[3] This is a public version of this Master thesis. The real number lays in this range
[4] This is a public version of this Master thesis. The real number lays in this range

Finally, some recommendations can be given for Picnic, based on this research:

- In general, it is recommended for the company to implement one or multiple game elements in the operational processes of order picking.
- It is recommended for the company to implement the weekly performance overview report on the short-term for trainees during their training period.
- It is recommended for the company to improve the team competition for a more fun and fair competition.
- It is recommended for the company to research how the components of the daily feedback report could be incorporated in the own Warehouse Managing System.

Terms and abbreviations

Terms

Captain	-	Head of a department in the FC
Picking	-	Order picking; collecting articles for a customer order
Pick round circuit	-	A set of assigned pick tasks, leading through all aisles of the pick
Shopper	-	Employee in the fulfilment centers of Picnic; order picker
Shopper+	-	Foreman in a department in the FC
Supervisor	-	Operational manager of the daily FC operations
Tote	-	A container in which articles are collected during order picking
Trainee	-	New employee, in training to become a Shopper in about 4 weeks

Abbreviations

ANCOVA	-	Analysis of Covariance
ANOVA	-	Analysis of Variance
DC	-	Distribution Center
DM	-	Direct message
FBM	-	Fogg Behavior Model
FC	-	Fulfilment center
FMCG	-	Fast Moving Consumer Goods
HF	-	Human Factors
IMI	-	Intrinsic Motivation Inventory
OLS	-	Order lines
TIP	-	Technical Institutional Process
WMS	-	Warehouse Management System

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1. Introduction

In this first chapter of this thesis, the executed research will be introduced. First a brief introduction of the problem will be given in the problem description, which will lead to a research problem and objective in the second section. A set of research questions will be formulated in section 3 which will help to fulfil the objective. In the fourth and final section of this chapter, the research framework and methodologies will be described.

1.1 Problem description

The grocery retail market is highly mature in terms of growth and market saturation (Kumar, 2008). Therefore, grocery retailers have to be very competitive to grow their businesses. Supermarket companies start price wars to gain market share, but they as well compete on service level and product quality and freshness. To make a profit while competing on all these levels, retailers have to control their costs and improve their performances.

Grocery retail companies are well-known from their supermarkets that sell all kind of (non-)perishable fast moving consumer goods (FMCG). Although, these companies have more activities included than selling products to the end consumer. All grocery retailers have their own distribution centers (DC) and logistic activities nowadays. In fact, for grocery retailers, logistics is one of the core activities (G. Sternbeck & Kuhn, 2014) and come with relatively high costs in comparison to other industries (van der Vlist, 2007).

The grocery retail market is not only mature, it is also quite conservative in comparison to other markets. So far, the online grocery sales lags far behind on those of other product categories (Syndy, 2015). There is a considerable growth in the online grocery sales though, and an explosive growth is expected for the next decades. In the third quarter of 2016, 2,2% of the groceries in the Netherlands were sold online, against 1,2% in 2015. In 2017, the online grocery sales will exceed 1 billion euros, almost 3% of the market share (Rensen, 2017). For 2030, it is estimated that 15-20% of the grocery sales will be done online (Rabobank, 2016). Next to the traditional supermarkets that offer e-grocery shopping, an online-only supermarket has entered the market in the Netherlands in 2015 (NOS, 2015). Since online-only supermarkets do not have to pay for physical shops and salesman for instance (Bos, 2016), for these companies the costs of logistics are even more relevant because of the larger share of the total costs. For the so-called e-retailers, the supply chain consists mainly of warehouse logistics and distribution. The focus of this project will be on the internal warehouse logistics of Picnic.

Picnic is an online-only supermarket that disrupts the grocery market with free deliveries at home and a lowest price guarantee. While the physical contact between the company and the customer does not exist, the focus of the company is at a high customer service level: on time deliveries, completeness of the orders, quick online support, etcetera. Orders placed before 22:00, are picked the next day in one of the two fulfilment centers and delivered at home in a small electric vehicle before that day is over. Having the customer experience as unique selling point for the home deliveries, a key challenge for this company is to keep logistic costs low. Considering that order picking will stay a manual process for at least the near future (Klein, 2016), Picnic is continuously looking for ways to improve this process. In this project the focus will be on the order picking process of this company, which has been identified as the “most labor-intensive and costly activity for almost every warehouse” (René de Koster, Le-Duc, & Roodbergen, 2007b).

It is therefore that a lot research has been done already on the topic of order picking, mostly on the focus areas of layout design, storage assignment, zoning, batching, routing methods and order accumulation and sorting (René de Koster et al., 2007b). However, the human characteristics of order picking are often ignored in this kind of research projects, (wrongly) assuming that the performance indicators of order pickers are constants over time (Chackelson et al., 2013; Grosse & Glock, 2015; Grosse, et al., 2015). One way to address these human characteristics of order picking, especially the motivation of the order pickers, is by the use of game elements (Hense et al., 2014). Gamification is a relatively new research topic, rapidly gaining more attention since 2010. It can be defined as "the use of game elements in non-game contexts" (Deterding, Dixon, Khaled, & Nacke, 2011, p. 4). It is promised to increase motivation, influence behavior and by doing so increasing performance and productivity (Deterding et al., 2011; Hamari, Koivisto, & Sarsa, 2014; Landers & Landers, 2014).

1.2 Research problem and objective

In this section, the research objectives are described from both an theoretical as a practical point of view. Besides, the scope of this research is described.

1.2.1 Theoretical view

Using game elements in an order picking environment is a promising method to foster the motivation of employees, although empirical research on the application of gamification is scarce (Hamari et al., 2014). It is therefore not known for what kind of processes gamification is effective. Sailer et al. (2017) showed that gamification can help increasing the motivation during order picking, but this research was executed in an experimental environment with students as participants of the study. As far as is known, there is no empirical research done in a real work environment that could proof the concept of gamification in a real order picking process. This remains the question whether the promising results in the mentioned studies can be translated an real-world order picking environment, with actual employees.

From a theoretical point of view, the main objective of this research is to test if the use of game elements in a real order picking process affects the motivation and performance of employees. In this study, the learnings from literature will be applied by means of a gamified intervention in the order picking process of the fulfilment center of Picnic in Nijkerk.

1.2.2 Practical view

The pick productivity of Picnic employees show too much variance in the opinion of the company. This results in too many days when the productivity exceeds the lower limits of an acceptable productivity. Since the work is standardized and the work environment does not show large differences over time, it is thought that the pick productivity is dependent of the motivation of its employees. This hypothesis is supported by literature (Grosse, Glock, Jaber, & Neumann, 2015; Neumann & Dul, 2010).

The main objective of this research, from a practical point of view, is to design and test a gamified intervention. The results of this test will be used to give Picnic a set of recommendations about the possible implementation of gamification in their order picking processes.

1.2.3 Scope

This research will be conducted in the Picnic fulfilment center in Nijkerk. In this facility, order picking takes place in three temperature zones: the Ambient zone, the Chilled zone and the Frozen zone. In this study, only order picking in the Ambient zone will be considered as the experimental environment. Furthermore, this research will limit itself to the consideration of the Human Factors (HF) that influence the order picking productivity. The order pick system of Picnic will be considered as given, therefore the effects of tactical and technical design choices on pick productivity will not be taken into account. Parallel to this research, a research project was done which considered these factors (Maan, 2017).

1.3 Research questions

Based on literature and the operational experiences within the Picnic fulfilment centers, a set of research questions could be defined.

1.3.1 Main research question

How can a gamified intervention in the order picking process increase the motivation of the order pickers and therewith increase the average pick productivity, while maintaining the pick quality?

1.3.2 Sub-questions

The following sub-questions are defined in order to answer the main research question.

1. What are the KPI's to measure productivity and quality?
2. How can the motivation of employees be measured?
3. What game elements are suitable to increase the motivation of employees?
4. What are the requirements for a gamified intervention?
5. How could a tail-off of the intervention effect be prevented?
6. How does a gamified intervention for order picking activities look like?

1.4 Research framework and methodologies

In order to achieve the research objective and answer the research questions, a set of research methodologies should be selected. A research framework could help to structure this process. Given the objective to design a gamified intervention, the Technical Institutional Process design (TIP) approach by Koppenjan & Groenewegen (2005) provides a good starting point to base the research framework on. The TIP perspective considers the design of complex technological system, which exists of a combination of technological, institutional and process designs. The design of a gamified intervention could be based on the same design principles. The technological design of the game consists among others of the front- and back-end design of the game, the institutional design includes the game rules and the responsibilities of the different actors and the process design contains among others the implementation plan for the intervention.

Koppenjan & Groenewegen (2005) propose the metamodel of design by Herder & Stikkelman (2004) as a straightforward description of the design steps to be taken for a TIP design. This pragmatic tool is used to base the research framework for this project on (Figure 1). In this framework, the different steps of this project are presented. In the next paragraphs, the different steps will be discussed and the used methods will be discussed briefly. More details about the used methods for the intervention experiment will be provided in chapter 5.

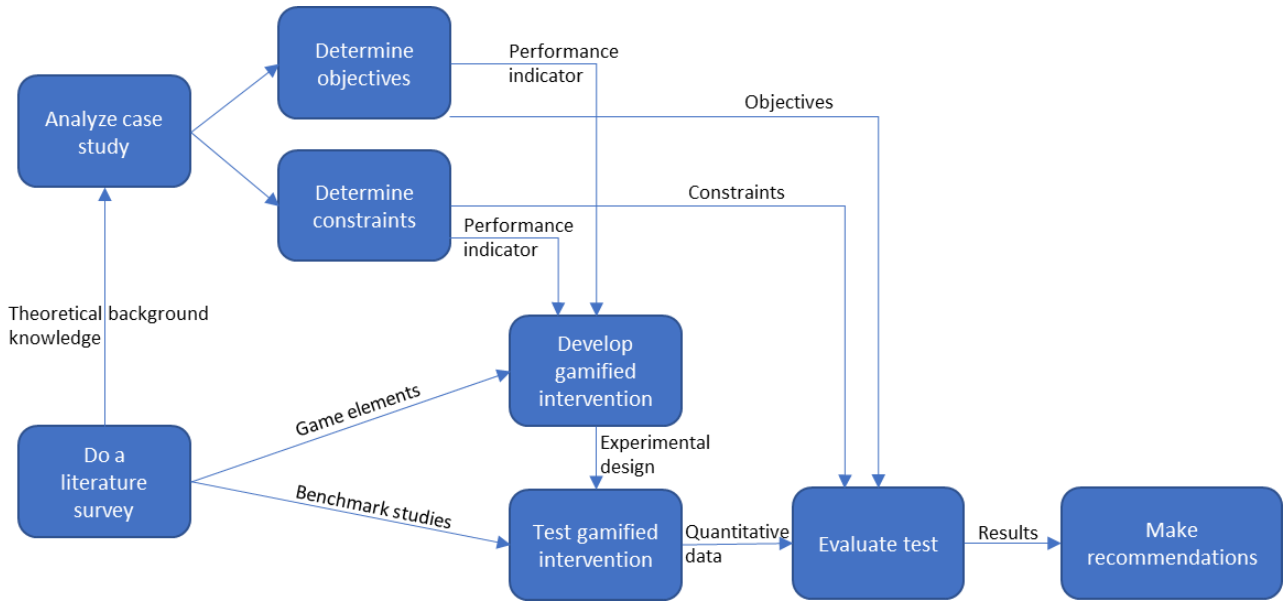

Figure 1: Research framework for this project

1.4.1 Theoretical background on research topic

The first step of this research provides in a theoretical background, as a solid base for the next steps. A literature survey will be done that explores the research fields of order picking processes, motivation and gamification to get an understanding of the possibilities to combine these topics into a promising design. In chapter 2, the results of this survey will be presented and research sub-question 2 will be answered. The gathered knowledge on the order picking topic can be used to analyze the order picking process in the case study company. The background knowledge on gamification can be used in the design process.

1.4.2 Case study exploration

As the next step in this study, an analysis of the case study will be executed. A case study can be described as a method "…in which the researcher tries to gain a profound and full insight into one or several objects or processes that are confined in time and space" (Verschuren & Doorewaard, 2010, p. 178). A case study is used to research a small domain in depth by selective and intensive data generation on site, often making use of qualitative research methods as (group) interviews. An advantage of a case study is the possibility to obtain a general overview of the research object. Other advantages are the flexibility of a case study and the less distant role of the researcher to people in the field, which makes the results of the study more acceptable for those people. A possible disadvantage of the case study is the external validity of the results. Since only one (or a few) case(s) is studies, it is difficult to apply results to a broader population (Verschuren & Doorewaard, 2010).

In this study, a case study will be done within online-only supermarket Picnic. The company Picnic will be introduced and the logistic processes will be explored, with special interest for the current situation of the order picking process. Furthermore, the objectives and constrains for a gamified intervention will be determined with the corresponding performance indicators to answer research sub-question 1. Chapter 3 shows the outcomes of this step in the research.

1.4.3 Gameful design process

With the theoretical and practical knowledge of the previous steps in mind, a designing a gameful intervention is the next step to take in this study. To do so, scientific literature will be explored to find promising gamification approaches and game elements to implement in an order picking environment. Afterwards, the 'generic roadmap for gamification of business processes' (van der Kleij, 2014) will be used as a base for the design process. Firstly, the design constraints and requirements are determined. Secondly, game elements are chosen and combined in a coherent design. Thirdly, an implementation approach will be described. Besides the obtained knowledge, observations on the shop floor will be taken into consideration in the design. In chapter 4 this design process is described and the answers on research sub question 3 and 4 are given. This project step will deliver a gameful design that can be tested in the next step of the study.

1.4.4 The intervention

The gameful design that was delivered by the design process in the previous step, was implemented as an intervention in the case study. For a period of two weeks, the intervention was live in the fulfilment center of Picnic in Nijkerk. During the intervention, data was gathered to analyze in the next step in order to measure the effects of the intervention. Chapter 5 discusses the intervention and the methodologies to gather the results from the intervention.

1.4.5 Test results

The results from the gamified intervention in the case study will be examined in the second last step of this study. To start, the performance indicators will be analyzed. Secondly, the motivation of the employees will be measured by an Intrinsic Motivation Inventory (IMI) (Intrinsic Motivation Inventory, 1994). Thirdly, a set of focus group sessions and interviews are organized to collect qualitative feedback from the company about the intervention.

1.4.6 Make recommendations

The final step of the research framework is drawing conclusions based on the results from the previous step. Before drawing these conclusions, the results will be discussed in more depth and compared with the expectations based on theoretical and practical knowledge of the previous steps in this research. Research sub questions 5 and 6 will be answered based on the discussion of the results. The research will be concluded by answering the main research question and presenting a set of recommendations for further research. Besides, some practical recommendations will be presented for the case study company.

2. Theoretical background

This chapter will provide in a theoretical base that will serve as a starting point for the experimental research into the effects of gamification on the order picking productivity. A literature research is used to get an understanding of the current state of scientific knowledge of (manual) order picking, gamification and the combination of these two fields of study. Before looking into these subjects, the field of online grocery retailing is briefly introduced.

Traditional supermarkets in the UK started to offer e-grocery at the beginning of 2000, therewith pioneering in Europe (Linder & Rennhak, 2012). Supermarkets in other European countries introduced online grocery shopping as well, but failed mostly at that time. The high logistics costs were most likely the main reason for this failure, next to slow internet connections (Saskia, Mareï, & Blanquart, 2016). High storage and picking costs and a complex delivery system for fresh products were mentioned by the fallen companies as the reason of their problems.

In 2014, more than a decade later, the online grocery retail market in the Netherlands finally transformed from underdeveloped into a maturing market with the entry of competitors for market leader Albert Heijn. In fact, the Dutch e-grocery market showed with an 55% increase in sales the fastest growth of Europe (Syndy, 2015). In 2017, the online grocery sales will exceed 1 billion euros (Rensen, 2017) and an explosive growth is estimated for the next decades (Rabobank, 2016).

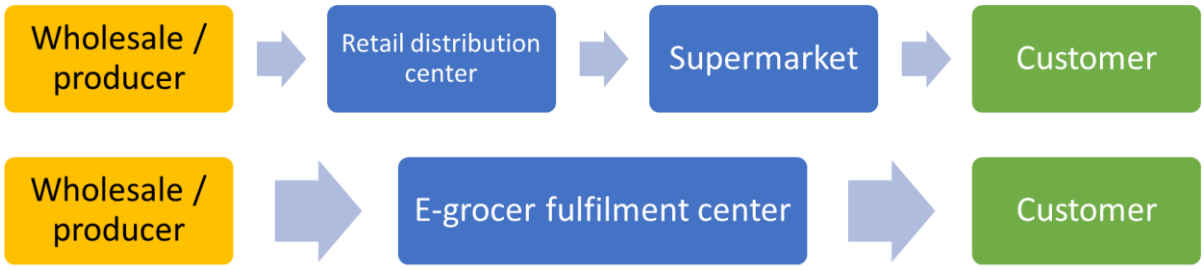

Figure 2: The shortest possible supply chains for conventional (top) and online (bottom) grocers

The direct delivery at home by supermarkets introduces a new and shorter supply chain in comparison to the conventional supply chain for groceries. This changes the relationships of involved actors, for instance suppliers, transporters and distributors, and gives the opportunity to skip intermediates (Saskia et al., 2016). The most important missing intermediate is the conventional supermarket, a physical shop with real estate and salesman as important expenses. Online-only supermarkets miss these expenses (Bos, 2016). The main challenge for e-grocery remains therefore the logistics and transport issue, to get the orders at the customers in the most efficient way (Saskia et al., 2016).

The main operation processes of a fulfilment center are: receiving, put away, storage, order picking, accumulation and shipping (Gong & de Koster, 2011). Order picking can be defined as the “process of retrieving products from storage (or buffer areas) in response to a specific customer request” (René de Koster, Le-Duc, & Roodbergen, 2007, p. 481). For almost every warehouse this activity is the most labor-intensive and costly activity (René de Koster et al., 2007; Tompkins et al., 2010).

It is therefore that the focus of this research is on the order picking process. In the next section, the order picking process as a main warehouse activity is discussed to get an understanding of the challenges to increase the order picking productivity. Afterwards, the psychological aspect motivation is explored as one of the human factors that could influence the behavior of order pickers. Finally, the concept of gamification will be introduced as a possible method to address the motivation in an order picking environment.

2.1 Order picking

Order picking systems can be divided in two main types: systems in which humans pick manually and systems in which picking is automated by machines (Figure 3) (R. de Koster, 2004). Within these two types of systems, there are many different pick strategies with their own pros and cons. Because of the scope of this study, only the *picker-to-parts* systems will be reviewed. This system is used by the case study company and other e-grocers.

In the commonly used *picker-to-parts* system, the order picker travels along storage aisles to the pick different items (René de Koster, Le-Duc, & Roodbergen, 2007b). The picker has a digital- or paper-based pick list which specifies the travel sequence, picking locations, item specifications and required number of items. After finishing all the picks on the list, the (partly) completed orders are moved to a location in the warehouse for further processing (e.g. packaging or shipping).

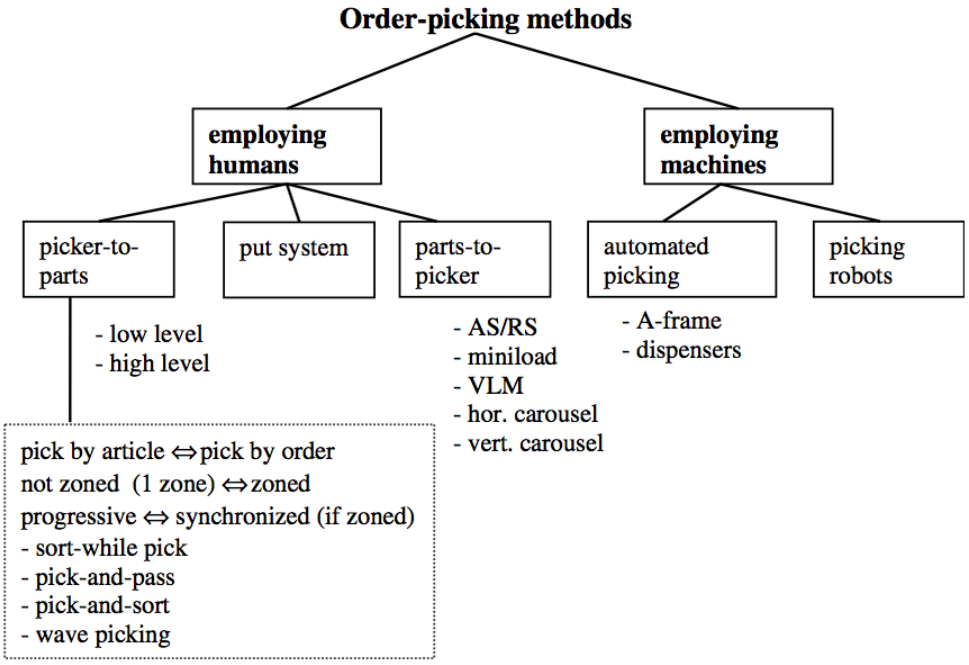

Figure 3: Classification of order-picking systems (René de Koster et al., 2007b)

In Figure 3 a set of opposite variants of a *picker-to-parts* system is shown. In the *pick by article* variant, the order picker picks the same article for multiple orders, while in the *pick by order* variant the order picker picks all different items for the same order in sequence. Furthermore, there could be different storage areas (zones) in the warehouse that may require to combine items from these different zones. Finally, there are multiple strategies to organize the sorting of items over the customer orders; sorting during picking (*sort-while-pick*) and after picking is finished (*pick-and-sort*) are for instance commonly used methods.

Objectives and criteria

According to a literature review by De Koster et al. (2007), the majority of warehouse picking systems worldwide are based on the human employing *picker-to-parts* (Baker & Perotti, 2008; Napolitano, 2012). However, less than 30% of the academic papers on this topic consider this kind of systems. Within the available literature, the main focus areas are: layout design, storage assignment, zoning, batching, routing methods and order accumulation and sorting (Chackelson, Errasti, Ciprés, & Lahoz, 2013; René de Koster, Le-Duc, & Roodbergen, 2007b). For all these focus areas, a general list of objectives for order picking can be defined (Chackelson et al., 2013; René de Koster et al., 2007b):

- Minimize the order throughput time
- Maximize order integrity and accuracy
- Maximize the use of space/equipment
- Maximize the use of labor
- Maximize the accessibility of items
- Minimize travel distance
- Minimize investment/operational cost

Most of the research in the order picking field focusses on a single decision problem within the listed focus areas, and do not consider a more holistic view on the order picking system, combining different focus areas to optimize the overall order picking process. Klein (2016) made a contribution to do so by assessing different design alternatives for an online grocer fulfilment center (FC) (a case study at Picnic). In this study, the realization of a semi-mechanized FC is recommended for the near future, in which picking activities remain fully manual. Despite the relatively high operational costs for manual picking in comparison to automated picking, the capital costs (and the realization time) for a manual picked FC are much lower.

Capital and operational expenditures are important criteria to consider the most suitable type of order picking within a company. As stated above, most order picking warehouses are manually operated. Imitating the cognitive and motor skills of humans turns out to be often not economically feasible (Roodbergen & Vis, 2009). These cognitive and motor skills of humans are important to process a high number of different items. For a grocer FC, with a large range of products with a wide variety of size, weight and fragility of items, item handling is demanding an high level of cognitive and motor skills (Klein, 2016). Grosse & Glock (2015) notice that these skills are human characteristics that may have high impact on the order picking performance. However, the actual effects of human characteristics on order picking processes are often neglected and therefore the performance indicators of order pickers are wrongly assumed to be constant (Chackelson et al., 2013; Grosse & Glock, 2015; Grosse, Glock, Jaber, & Neumann, 2015). Learning is another human characteristic that should be considered when the performance is modelled of tasks with cognitive and motor elements in it (Jaber & Glock, 2013). Picker performance improves over time; e.g. the picker starts to recognize storage locations, becomes practiced in the physical actions and learns where bar codes are. Since the high number of temporary workers in order picking warehouses, with a continuous labor turnover, a lot of (individual) learning takes place in this environment.

De Vries et al. (2015) present another study that explores the role of human characteristics in order picking. The focus of this research is on the individual differences in picking performance for pickers using a variety of picking tools, such as *pick by voice*, *RF-terminal picking* and *pick to light*. Exploring different picking tools is not within the scope of this study, but since there is very little known about role of individual order pickers in *picker-to-parts* systems, this research provides a first insight of a more social approach to improve picking productivity.

Grosse et al. (2015) stress the importance of considering Human Factors in order picking models since humans are the primary actors in manual order picking environments. HF elements are the interactions in a human-system relationship, existing of physical, mental and psychological aspects. According to Grosse et al. (2015), these aspects are just as important as the design characteristics layout, storage management, routing/batching and work organization. These aspects directly influence the outcomes of order picking: (throughput) time, quality and workers' health and safety (Figure 4) (Neumann & Dul, 2010). One of the HF aspects is the psychological aspect, which can be divided in motivation, stress and workload, boredom and structure of workforce and work assignment.

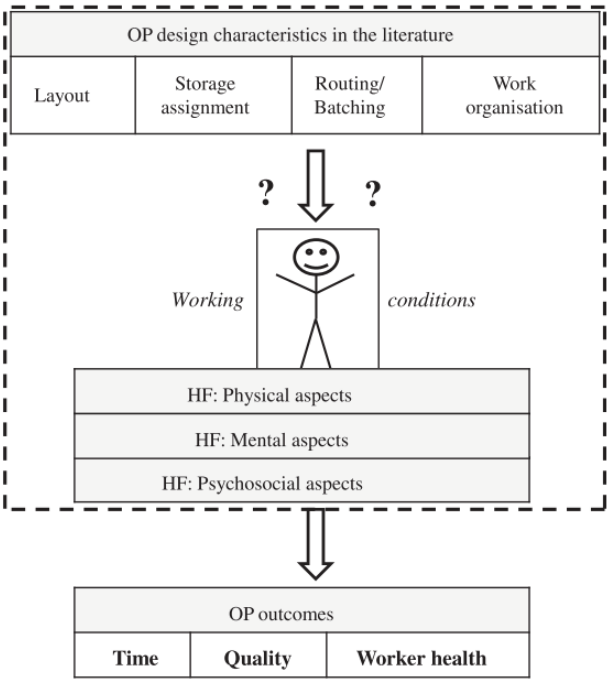

Figure 4: Human Factors (HF) should be considered in designing and planning order picking (OP) (Grosse et al., 2015)

2.2 Motivation

In the previous section is stated that the HF could influence the order picking performance. Motivation is one of the (psychological) aspects that belongs to the those HF and could be low in order picking due to the repetitive and monotonous character of the work (Hense et al., 2014; ten Hompel, Sadowsky, & Beck, 2011). In this section the motivation to show certain behavior in a work environment is explored.

If the motivation of order pickers influences the performance of these people, increasing the motivation might increase the performance. In fact, addressing the motivation of order pickers might change their behavior from less to more productive. To understand how addressing motivation could change behavior, behavior itself should be understood first.

The *Fogg Behavior Model* (*FBM*) (Fogg, 2009) presents a way to describe behavior as a product of three components: *motivation*, *ability* and *triggers*. According to Fogg (2009), these components exist of a set of elements which can be taken into account in order to change behavior. Target behavior will only be performed when a person is sufficiently motivated, has the right abilities to perform the behavior and is triggered to do so (Figure 5). For the motivation and ability components, there is a threshold that should be crossed to be able to perform the behavior. The trigger is an event that should occur to start performing the behavior.

Figure 5 is a visualization of the FBM. *Motivation* and *ability* are trade-offs according to the FBM (Fogg, 2009). This means that target behavior could be performed with low motivation, as long as the ability is high enough and vice versa. For example, a person could have a very low motivation to buy a new house, however, if this new house only costs € 1, the ability of this person is high enough to buy the house anyway.

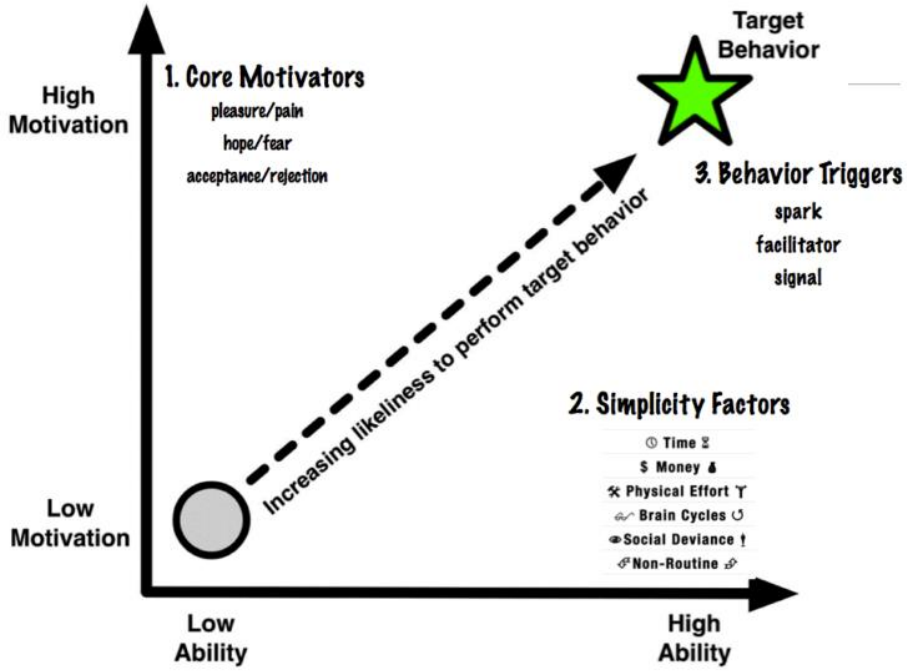

Figure 5: Fogg Behavior Model with all its (sub)components (Fogg, 2009)

Ability

Explaining his model, Fogg (2009) says that increasing ability is not about teaching and training people, but about simplifying the desired behavior. Therefore, he speaks about the six elements of simplicity: *time, money, physical effort, brain cycles, social deviance* and *non-routine*. The first three elements, *time, money* and *physical effort*, are quite straightforward. If target behavior requires *time* and *money*, this should be available to execute the behavior. Performing little *physical effort* is easier than performing a lot of *physical effort*, directly affecting the ability to perform. With the element *brain cycles* is meant that there is a difference between simple behavior, without much thinking, and more complex behavior which requires more *brain cycles. Social deviance* is about the norm that people want to behave like, to be part of society. Going against the stream costs more effort than going in 'the right' direction. With the *non-routine* element is meant that it is simpler to perform routine tasks than non-routine tasks.

Trigger

When the threshold of motivation and ability is crossed, one is ready to perform the behavior. However, only when a trigger occurs the person will really start to perform the target behavior. In a working environment, a command could be an example of a trigger (Fogg, 2009).

When there is less motivation, a spark could be used as a trigger that can leverage motivational elements. A facilitator is a trigger when the motivation is high, but there is not enough ability (yet). So this event adds ability to the user and triggers the behavior at the same time (Fogg, 2009).

Motivation

The FBM states that motivation has three core motivators: *pleasure/pain*, *hope/fear* and *acceptance/rejection*. Experiencing pleasure or pain is an immediate motivator to perform behavior (to increase pleasure and/or reduce pain), while hope and fear are motivators to behave following the anticipation of the outcome of behavior. The motivators of social acceptance and rejection are especially steering the social behavior of an individual.

Another view on motivation is provided by Deci & Ryan (2012), who developed the Self-Determination Theory. They say that every person has fundamental psychological needs to be *competent*, *autonomous* and *related to others*. Fulfilling these needs makes people intrinsically motivated to perform certain behavior, in which the behavior itself is the desired reward given these psychological needs that are met. Based on this theory, they developed a questionnaire to assess the intrinsic motivation: the Intrinsic Motivation Inventory.

The Intrinsic Motivation Inventory (IMI) is multidimensional measurement tool to assess how participants experiences of performing a given activity, testing on the following subscales: interest/enjoyment, perceived competence, effort/importance and pressure/tension. (Intrinsic Motivation Inventory, 1994; Tsigilis & Theodosiou, 2003). The subscale of interest/enjoyment is considered by the researchers as the self-report measure for intrinsic motivation. The other subscales do not measure intrinsic motivation per se. Perceived competence is a positive predictor of intrinsic motivation, while pressure/tension is a negative predictor. Effort/importance is another variable that could be related to motivation questions. This measurement tool has been proven successfully in multiple intrinsic motivation related experiments (E.L. Deci, Eghrari, Patrick, & Leone, 1994; McAuley, Duncan, & Tammen, 1989; Plant & Ryan, 1985; R.M. Ryan, 1982; R.M. Ryan, Knoester, & Deci, 1991; R.M. Ryan, Mims, & Koestner, 1983; Richard M. Ryan, Connell, & Plant, 1990), and will therefore be used to test the (intrinsic) motivation of the participants in this research as well.

According to Groh (2012), the principles of *competence, autonomy* and *relatedness* could be very well addressed by game elements. By providing in interesting challenges and structured goals, the *competence* of a user could be addressed. Implementing game elements with customizable and personal goals and a meaningful community of interest could create a sense of relatedness for the user, being part of a team. Giving people the feel of autonomy with the use of game elements is harder, since these elements are often directing users in a certain direction of behavior. Section 2.3 will elaborate further on the concept of game elements.

For extrinsic motivation, on the other hand, the goal for a person to do a certain activity is separated from the activity itself Deci & Ryan (2012). The classic extrinsic motivators are rewards (the carrot) and punishments (the stick). The disadvantage of extrinsic motivation is that the desired behavior becomes dependent of the motivators, and therefore less durable than intrinsic motivation.

The *Fogg Behavior Model* (Fogg, 2009) can be used as a base to change behavior in an order picking environment. Motivation, ability and triggers are discussed as the three components that are needed to steer behavior. Since order picking exists of a set of simple tasks to begin with, the threshold of the ability component is relatively easy to reach. This can be learnt from the six elements of simplicity for order picking: 1) there is time dedicated to perform order pick tasks; 2) there is no direct influence of money in the order picking process; 3) the physical effort to grab groceries from a shelf is limited; 4) the pick tasks are straightforward, there is no need for thinking; 5) there is no social norm that has to be exceed and 6) the pick tasks are very monotonous and repetitive.

The second component that is relatively easy to meet in an order picking environment, is the trigger. Supervisors and team captains provide this trigger for order pickers in the form of commands and designated tasks.

The third component of the FBM, motivation, is the challenging component to address in order picking. Because of the monotonous and repetitive character of order picking, the psychological needs of competence and autonomy are not fulfilled during the performance of the tasks (Hense et al., 2014; ten Hompel, Sadowsky, & Beck, 2011). Therefore, it could be assumed that the intrinsic motivation of order pickers is low. This could result in lower performances (Grosse, Glock, Jaber, & Neumann, 2015; Neumann & Dul, 2010).

A way to address the motivation of order pickers is by the use of game elements, as already stated above by Groh (2012). The use of game elements, or gamification, will be further explored in the next section.

2.3 Gamification

The starting point for this research was the hypothesis that gamification could help to increase motivation of order pickers and thereby increase the average order picking productivity of the online grocer Picnic. In the previous sections, motivation and boredom were found to be psychological aspects that have a direct influence in the performance of order pickers. In this section, the field of gamification will be explored, to get to an understanding how gamification could be used to increase the motivation of order pickers.

Gamification is a relatively new topic in scientific research, which reached a wider audience from the second half of 2010 (Deterding, Dixon, Khaled, & Nacke, 2011; Groh, 2012). In the years before, the use of game elements raised rapidly in all kind of (smartphone) applications to increase user activity, and thereby changing the behavior of this user (Lindholm & Monsen, 2016). Furthermore, the application of these elements in a business environment is used in order to motivate people, influence behavior and thereby increase the performance and productivity (Deterding et al., 2011; Hamari, Koivisto, & Sarsa, 2014; Landers & Landers, 2014)

When the academic attention started to gain, Deterding et al. (2011) was the first to propose a proper definition for gamification, as “the use of game elements in non-game contexts”. This definition contains three concepts that need more explanation to fully understand the meaning of it. In the following paragraphs, these concepts will be discussed in more detail.

Game

To explain what a game is, Deterding et al. (2011) distinguished the difference between game and play. According to the Caillois' concept, *paida* (playing) and *ludus* (gaming) are the two poles of play activities (Caillois, 2001). Free-form, expressive and improvisational behavior is categorized as playing, while more rule-based and goal-determined behavior is can be categorized as gaming. In consequence, McGonigal (2011) introduced the term *gamefulness* as the experiential and behavioral qualities of gaming, as a counterpart of *playfulness*.

Element

Deterding et al. (2011) define game elements as elements that are characteristic for games. Characteristic for games is: "elements that are found in most (but not necessarily all) games, readily associated with games, and found to play a significant role in gameplay" (Deterding et al., 2011, p. 4). This definition is not so tight, leaving room for discussion whether an element is or is not characteristic for games.

Non-game contexts

While game elements are usually characteristic for games, which are meant to entertain, by the definition of gamification these elements can be used for all applications, regardless of the intentions of these applications (Deterding et al., 2011; Groh, 2012). This definition is, explicitly stated by Deterding et al. (2011), not further limited to let gamification develop in all kind of contexts.

2.4 Conclusion on the theoretical background

In this chapter, a theoretical background on order picking, motivation and gamification was provided based on scientific literature. Thereby, research sub question 2 is answered:

2. *How can the motivation of employees be measured?*

Order picking is for almost every warehouse the most labor-intensive and costly activity and therefore subject for a lot of research. The human factor in order picking was often ignored in this research, although found very important due to the cognitive and motor skill which are still too hard to imitate by machines. Motivation plays an important role in the psychological aspect of HF, which could be low in order picking activities due to the monotonous and repetitive character of the work. The motivation could be assessed with the Intrinsic Motivation Inventory, which answers research sub question 2. Game elements could increase the motivation of order pickers, addressing the feel of competence, autonomy and relatedness as described in the Fogg Behavior Model. Chapter 4 will elaborate on different game elements and how they could be applied in the order picking environment. To create an better understanding of the order picking environment of the case study, the next chapter will first introduce the order picking process in online supermarket Picnic.

3. Case Study: Order picking in the Picnic fulfilment centers

In order to answer the research question, a case study research is done within Picnic Supermarkets. In this chapter, the fulfilment processes of this company will be discussed to get an understanding of the experimental environment. Furthermore, the current order picking process in the ambient zone will be analyzed.

3.1 Picnic – the company

Picnic is an online-only supermarket which went live on the 30th of September in 2015. Starting with the free delivery of groceries in the city of Amersfoort, the e-grocer is now operating in a more than 20 cities in and around the Randstad. In this period of time, the order volume grew from 0 to more than 25.000 weekly orders within two years. At this moment, these orders are picked in two fulfilment centers (FC) in Nijkerk and Utrecht with an equal set-up. Orders are manually picked by so-called Shoppers in these FC's, after which the completed orders are transported to transshipment hubs in the delivery areas. The orders are delivered at home from these hubs by the use of small electric vehicles.

The distinction between Picnic and other grocery retailers, is the lack of physical shops (app only) and a different distribution model for the home deliveries, resulting in efficient and short supply chain. Picnic likes to compare their distribution model with the bus-model, instead of a taxi-model (Oosterhout, 2017): delivery times are within pre-selected time slots dependent on postal codes, instead of freely selectable delivery times with dependent prices. So ordering with Picnic is like checking the bus schedule to see when you can join the ride for minimal costs, instead of calling a taxi-company which send over a private driver at a desired time for which the customer pays a lot more than a bus ticket. Other e-grocers work more like the taxi model, where you can freely select a time slot and pay in proportion of the demand for that specific time slot.

Figure 6: Screenshot of the queue for new customers to place their first order

Orders placed before 22:00 will be delivered on the next day. With the focus on customer service (free delivery, lowest price guarantee, high quality, on time deliveries, etc.) a key challenge of the company is to keep its logistic costs low. But, currently the main challenge of the company is to grow as fast as possible. The tremendous demand from new customers is higher than the company can fulfil at the promised level of quality (order completeness, on time delivery) and service level. Therefore, a queue is in place for people who download the Picnic-app and the allowance of new customers to order is dependent of the increase in the total order capacity. The capacity of order picking has turned out to be one of the main bottlenecks in order to grow the order capacity of the company over the past year. Increasing this productivity of order picking is therefore one of the main focus points of the fulfilment team of Picnic.

Picnic aims for a pleasant and productive work environment to support high productivity and quality on the one hand and satisfied employees on the other. Currently used methods to achieve this are an interactive training program, occasional additional remuneration and the use of real time dashboards with leader boards and progress charts. Even though the dashboards and leaderboards were originally meant to monitor the process, the FC leadership experienced that the presented information motivates shoppers to keep score, to compete with each other and to achieve personal high scores. It was therefore that the company became interested in the promise of (more) gamification on the work floor.

3.2 Fulfilment center Nijkerk

This is a public version of this Master thesis. Section 3.2 is non-disclosed in this version

3.3 Order picking in the Ambient zone

This is a public version of this Master thesis. Section 3.3 is non-disclosed in this version

3.4 Current productivity

This is a public version of this Master thesis. Section 3.4 is non-disclosed in this version

3.5 Current quality

This is a public version of this Master thesis. Section 3.5 is non-disclosed in this version

3.6 The Picnic employees

This is a public version of this Master thesis. Section 3.6 is non-disclosed in this version

3.7 Productivity targets and target behavior

This is a public version of this Master thesis. Section 3.7 is non-disclosed in this version

3.8 Design constraints

This is a public version of this Master thesis. Section 3.8 is non-disclosed in this version

3.9 Conclusion of the case study exploration

In this chapter the company Picnic was introduced with the FC in Nijkerk as the environment for the case study research for this project and research sub question 1 is answered:

1. *What are the KPI's to measure productivity and quality?*

Picnic is an online supermarket with no physical shops, resulting in a short supply chain with the FC operations, the transport to the transshipment hubs and the distribution to customers as main components. 30 to 45% of the operational costs of the fulfilment operations are the costs for order picking, which makes this process an important subject for improvement. For this research, the scope was set on the order picking process in the ambient zone of the FC. To measure possible improvements and answer research sub question 1, the key performance indicators for order picking are introduced. Pick productivity is defined as the daily average pick speed in order lines per hour and pick quality as the number of non-affected orders by picking mistakes as percentage of the total number of picked orders.

In the Picnic FC's, order picking is done by the *pick by order* variant of a *picker-to-parts* system. Shoppers walk fixed routes through the pick aisles with a pick cart that carries 12 or 18 order totes, defined as pick rounds. The number of picks per pick round has been proven as a factor that has a positive correlation with the pick productivity, which should be considered when the pick productivity is measured when an intervention is introduced in this research. The goal of Picnic for this intervention is to increase the lower bound of the individual variance in productivity and therewith increase the average pick productivity in the FC. Next to the performance goal, an intervention should contribute to the enjoyment of work.

Besides the objective, a set of constraints is defined for the intervention. The intervention should be implemented in parallel to the actual picking process, not affecting the work itself or the responsibilities of the FC leadership. The pick quality should be maintained during the intervention and it may not encourage undesired behavior which could harm the process. Finally, the intervention may only give positive feedback to the participants.

Now the experimental environment is known and the objectives and constraints for the intervention are defined, the next chapter will use this learnings to design a gamified intervention for the order picking in the Picnic FC in Nijkerk.

4. A gameful design in order picking

In this chapter, a gamified intervention will be designed for the order picking process in the Picnic FC in Nijkerk. In the first section, a set of suitable game elements for order picking activities will be selected based on scientific literature. The second section will describe the design process of the intervention, concluding with the complete set of elements that will be tested during the experimental phase of this research. The whole design process will be summarized in a proposed design framework in the third section of this chapter.

4.1 Game elements

Chapter 2 has provided in the valuable insights in (changing) human behavior and the promise of gamification. This section will elaborate on the possibilities to implement game elements in an order picking environment. Hense et al. (2014) stated that order picking is intensive and manual labor performed by low-paid workers. It is therefore not surprising that order picking could cause low staff motivation and fatigue in the long-term (ten Hompel, Sadowsky, & Beck, 2011) and high turnover rates. This is in line with the observations of Picnic on its workforce, as stated in section 3.6. However, few companies concentrate on motivation-enhancing tools other than extrinsic monetary intensives, only effective for the short-term (Hense et al., 2014).

In the search for useful gamification applications to enhance staff motivation, Hense et al. (2014) use *five principal perspectives* of motivation research to analyze how game elements can address staff motivation for order picking (Table 1), providing in a list of game elements that can be used in the game design of this research.

Table 1: Game elements that address to the different perspectives of motivation

Principal perspective	View on motivation	Game elements
Trait perspective	Individual characteristics as source of motivation: Achievement motive, need for recognition. Stable over time and context	Epic meaning (McGonigal, 2011) by virtual status symbols like badges and avatars.
Behaviorist learning perspective	Motivation is result of previous experiences	Reinforcement/punishment: levelling up or losing a virtual life
Cognitive perspective	Motivation depending on means and ends	Clear goals: quests/challenges with clear objectives and rewards (Hense Jan & Heinz Mandl, 2012); badges to show performance to other users (Antin & Churchill, 2011)
Self-determination theory	Psychological needs: competence, autonomy and social relatedness	Autonomy by different opportunities and choices; meet challenges to feel competence; sharing achievements for relatedness
Perspective of interest	Motivation results from individual preferences and content aspects	Players should have the opportunity to choose a quest of preference

Another source of possibly effective game elements is provided by Hamari et al. (2014), presenting a literature review of empirical studies on gamification. It is notable that most of the reviewed literature is written in a context other than work. Only four studies were done in a work environment, of which only 2 showed quantitative results. In these studies, the following game elements were found effective to motivate workers: points, leaderboards, challenges, stories, rewards and the visualization of progress (Eickhoff, Harris, de Vries, & Srinivasan, 2012; Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011). Multiple reviewed studies confirming the positive results of these game elements in another context, such as education and learning.

A very useful insight in the promising game elements for order picking is provided by Sailer et al. (2017). In an empirical study, a gamified intervention is implemented in an order picking process. He recognized the lack of empirical research on the effects of gamification on competence development and motivation in a work environment. The results of this experiment were promising, both qualitative and quantitative performances were significantly higher for the gamification group of participants in comparison to the control group. The picking speed and accuracy (less picking mistakes) were significantly higher for this group and a significant higher experience of psychological needs as the feel of competence, meaningfulness and autonomy was perceived.

In the game design of Sailer et al. (2017), the following game elements were used: *points, badges, leaderboards, performance graphs, meaningful story, profile development* and *avatars*. Other sources in literature confirm the positive effects on motivation of these elements (Antin & Churchill, 2011; Eickhoff, Harris, de Vries, & Srinivasan, 2012; Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011; Hamari, Koivisto, & Sarsa, 2014; Hense et al., 2014; McGonigal, 2011).

The first three elements (*points, badges, leaderboards*) provided feedback to the order pickers and were found relevant for development of work competencies and motivation by the satisfaction of competence needs as described by Deci & Ryan (2012). The *performance graphs* provided more elaborated feedback that was useful in the learning process for the order picking. The *meaningful story* and the use of *avatars* were addressing the feel of autonomy (Edward L Deci & Ryan, 2012), beside that the decision for an *avatar* and the opportunity of profile development addressed the psychological needs for relatedness (Edward L Deci & Ryan, 2012).

A limitation of the study (Sailer et al., 2017) is that most of the participants (85%) were students and none of the participants had prior experience in order picking. Therefore, it is not to say that the effects of the game design are similar in a real working context. This study will provide in more insights regarding this research gap.

4.2 Design process

For a structured design process of a gameful design, the 'generic roadmap for gamification of business processes' by Van der Kleij (2014) can be used as inspiration (Appendix). This roadmap gives a clear overview of all the process steps a designer has to take from the idea of using gamification to the implementation of an operational tool. In this stage of this research, steps 1 and 2 of the roadmap are already taken in fact. Chapter 3 provides in an extensive description of the context and identifies the target behavior as goal of the application of gamification. In chapter 2 is discussed how motivation in order picking might be low and how a spark can be used to overcome the threshold of showing the target behavior (Fogg, 2009). Step 3 to 5 will be taken in this part of the research, to develop a gameful design for the order picking process in the Picnic FC.

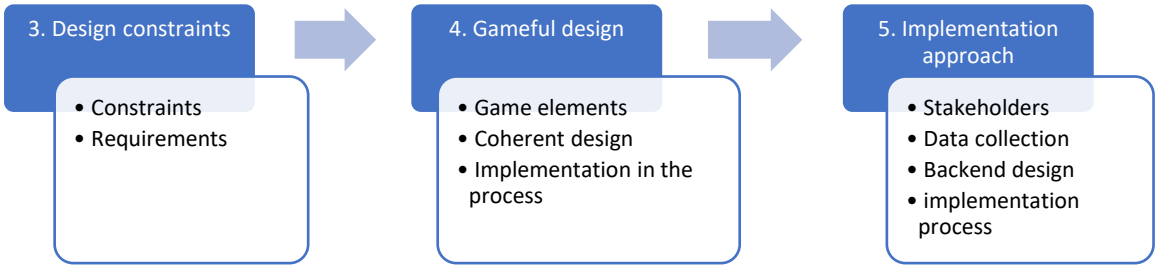

Figure 7: Developing a gameful design, based on the generic roadmap op gamification for business processes (van der Kleij, 2014)

4.2.1 Developing a gameful design: design constraints and requirements

The design constraints according to the company are already mentioned in chapter 3. The main constraint for an intervention is that it may not affect the actual order picking process. A constraint in resources is defined for the labor that is needed to maintain and operate a gamified intervention. Furthermore, the intervention may not encourage "cheating" and blaming and shaming is not allowed.

Next to the these design constraints on behave of the company, there is also a theoretical design constraint. There is only a limited amount of theoretical proof based on empirical research for game elements. The available theoretical knowledge about gamification and game elements limits the design choices for this study, since only game elements will be examined that are previously explored with promising results.

The goal of the intervention is to increase the motivation and enjoyment of Shoppers during order picking. Besides this goal, Picnic has indicated that it desires that the design contains an element that focusses on the team effort of order picking. For Picnic there are, next to the constraints, no further specific requirements for the structure and shape of the gameful design. Since Picnic is an innovative and data-driven company, it is desired to keep in mind the interfaces of the data structures and systems within Picnic. The Warehouse Management System (WMS) that manages the order picking process generates lots of data operating the process, which can be used to operate possible game elements. Furthermore, Picnic is developing its own, brand-new WMS which is already in use for some of the other processes in the FC besides the order picking process. In the near future this own WMS will be used for order picking as well, which offers great opportunities for the implementation of game elements since the user interface of the required software tools will be built from scratch. The knowledge and resources to include game elements in the own WMS are available, provided that the positive effects of these elements are proven.

4.2.2 Gameful design

In the gameful design phase of the roadmap (van der Kleij, 2014), game elements should be selected that can motivate the employees. Another needed condition for the game elements is the possibility to implement them in the business processes.

In the first section of this chapter, a list of game elements is discussed that could be feasible for a successful design in the order picking process. Multiple perspectives of motivation are discussed as well, with different game elements that could address the motivation from these different perspectives. Although these insights provided in a large list of possibilities for a promising gamified intervention, there is not a clear consensus about the best practices. Sailer et al. (2017) selected a set of seven elements that are used in many games and supported by various scientific sources and theories. In their study, Sailer et al. (2017) showed with this set of game elements that gamification could increase both motivation and productivity in an experimental order picking process. Therefore, this intervention will be used as a starting point for the gameful design of this study, adapted for the specific order picking process within Picnic. The following game elements are considered:

Points: A simple game element that could be linked to almost every activity. Accomplishing (desired) activities gains points, whereby the number of points display the success of a participant. Points are a kind of feedback and could satisfy the need of competence (Edward L Deci & Ryan, 2012). (Eickhoff, Harris, de Vries, & Srinivasan, 2012; Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011; Hamari, Koivisto, & Sarsa, 2014). Can be used to assign points for pick tasks for instance, based on the available pick task data from the WMS.

Badges: Virtual status symbols (McGonigal, 2011) linked to specific achievements which provide feedback and can be used to show performance to others (Antin & Churchill, 2011), satisfying the need of relatedness (Edward L Deci & Ryan, 2012; Groh, 2012). Badges could be earned by accomplishing special achievements, such as picking a certain number of a specific item, based on the available pick task data.

Leaderboards: displaying the rank of participants by score, for instance for the gained points. Often used to encourage competition (Eickhoff et al., 2012; Flatla et al., 2011) and satisfying the need of relatedness showing achievements to others (Groh, 2012). Leaderboards are already used in the daily operation of Picnic, displaying the number of picks per person per day.

Performance graphs: provide in feedback by displaying the performance of participants over time, satisfying the need of competence (Edward L Deci & Ryan, 2012). The number of picks per person per day can be showed in these graphs, as a visualization of progress (Eickhoff, Harris, de Vries, & Srinivasan, 2012; Flatla, Gutwin, Nacke, Bateman, & Mandryk, 2011).

Meaningful stories: a story can be linked to the work environment to as an dimension, next to the actual work. A meaningful story can address to the feel of autonomy (Edward L Deci & Ryan, 2012). To create a meaningful story, a story line should be made and a user interface should be designed. Because of the available time for this research, a meaningful story is not used as a game element in this project.

Avatars: a visual presentation of a participant, often free to choose by the participant, addressing the feel of autonomy (Deci & Ryan, 2012). An avatar can also be used as a status symbol, if the avatar allows for upgrades after certain achievements (McGonigal, 2011).

Profile development: a participant has the possibility to customize his/her own profile, addressing to the psychological need for relatedness (Deci & Ryan, 2012). Since a user interface for an intervention will not be created because of the time constraints for this research, profile development will not be used in this project.

From the discussed game elements above, *points, badges, leaderboards, performance graphs* and *avatars* are selected for a gameful design in the order picking process within Picnic. The reasons to choose these elements are given below per game element.

Points: Observations on the shop floor showed that most of the Shoppers are very interested in their "score" on the FC dashboards; the pick speed. The competitive behavior stimulates Shoppers to work hard, but has also led to undesired behavior (see section 3.8). Introducing points could fulfil the need for competition in a more balanced way than only on the pick speed.

Badges: It can be assumed that not all Shoppers are competitive or could compete with the most experienced Shoppers, for those Shoppers badges could add value. Badges are available for everyone, also for the somewhat slower order pickers or trainees. Besides, it could add an element of surprise to the very predictable job of order picking and gives something to talk about the work with colleagues.

Leaderboards: Picnic has very positive experiences with the leaderboards that are already used in the FCs. Shoppers come often by to check the leaderboards and talk about it and compete with each other. The existing leaderboards will stay available during the game. Besides, a leaderboard gives value to the earned points by showing the rank of Shoppers based on these points and thereby enhancing the competition between Shoppers.

Performance graphs: These graphs are easy to make based on the available data and give Shoppers feedback over multiple days, information that was missing in the current operation. Leaderboards reset every day, by introducing performance graphs Shoppers can be shown how they perform over multiple days.

Avatars: The avatars can be used to immediately engage Shoppers with the intervention, since they can actively choose their own avatar at the start of the intervention. Furthermore, the avatars can be used to add some personalization, in order give everyone the feel of involvement.

For the chosen elements, there are multiple indications in literature that they have a positive effect on the feel of motivation and enjoyment for employees and the elements meet the requirements and constraints that were set in the previous section. This combination of elements addresses motivation from 3 out of 5 perspectives of motivation by Hense et al. (2014): the trait perspective, the cognitive perspective and the self-determination theory.

With this selection of game elements, now a coherent gameful design can be thought of to implement in the order picking process. As mentioned before, the normal process shouldn't be affected by the intervention. In the next paragraphs is explained how the intervention, communicated to the employees as the 'Pick game', is structured.

The Pick Game

The gamified intervention will focus on the group of order pickers in the Ambient pick zone in the fulfilment center in Nijkerk. For the participants, the game exists of three main components: a personal (daily) feedback report with scores and badges, a daily team competition and a weekly performance overview. Communication between the "Game master" and the Shoppers takes place through Slack. Slack is a messenger application for businesses that is used within Picnic, which has also a social-media-like character. There is the possibility to send direct messages (DM) to each other and to share messages in topic-related #channels. Shoppers can access Slack via an application on their smartphones during their breaks or at home. The Shoppers-channel of Slack is used by Picnic to communicate general information to the Shoppers, while the channel has also the function of a forum or message board. Slack is therefore a very accustomed way to communicate with the Shoppers for the "Game master". Shoppers do not have to use a new communication tool, which makes it easy for them to access the information.

The personal feedback reports and week performance overviews will be send to Shoppers by DM, while the information about the team competition is shared publicly in the Shoppers-channel. Next to these messages, every day a leaderboard will be shared in the Shoppers-channel with the Shoppers Top 5 (the 5 Shoppers with the highest score).

The daily feedback report

At the end of every workday, a personal feedback report (Figure 8) is distributed to the all the active order pickers in a DM through Slack. This report contains the following information:

- Name
- Character
    - Name
    - Visualization
- Score
    - Daily specification
    - Total score
- Rank
- Team
    - In which team the Shopper was a member on the specific day
    - Did his/her team win?
- Daily Stats
    - Number of picks
    - Walked distance
    - Number of customers served
    - Total items picked
    - Average Pick speed of the day
    - Number of pick rounds
    - Number of items per pick
- Personal high scores
- Earned badges
    - Name
    - Visualization
    - Explanation

Figure 8: The personal feedback report for Shopper X, sent after the workday of 16-09-2017. Scores and statistics are non-disclosed in this public version.

Earn points

One of the main elements of the feedback report is the score of the Shopper. During a day of order picking, there are multiple ways to earn points:

1) 0.1 points for every pick
2) 2.5 points for starting a new pick round
3) Bonus points for achieving a certain average pick speed during the whole day (Appendix)
4) Bonus points for finishing a certain number of picking hours (Appendix)
5) Bonus points for finishing a certain number or pick rounds (Appendix)
6) Bonus points for winning the daily team competition (Appendix)

For the assignment of points to certain tasks, the behavior of the Shoppers during picking is extensively examined. As already mentioned, Picnic already shows some daily stats of the order picking process on the FC dashboards. As a consequence, the average pick speed (displayed on the dashboard) is a measure which is always kept in mind by the Shoppers. Some Shoppers even show undesired behavior to increase his/her personal pick speed. In section 3.8 a few ways of "cheating" were already mentioned. It is also observed that some Shoppers were very quick in comparison to others, but they did in the end relatively few pick tasks because of a high idle time. It is therefore that points are at first assigned for picks, not for a certain pick speed. To prevent Shoppers to be selective for "large" pick rounds (see section Design constraints), points are assigned for every pick round as well. The number of points for picks and pick rounds is set in this proportion to exclude the size of the pick round as a factor on the score of a certain Shopper.

Bonus points are assigned for excessively good behavior, for the Shoppers who perform above a certain threshold. These thresholds are per bonus category based on the 15% highest performances, based on historical data (Appendix), and in consultation of the Picnic leadership.

Earn badges

Besides the points that can be earned, pickers can earn badges for special achievements. While the number of earned points will only increase by a higher (team) productivity, the earning of some badges is based on “luck” and therefore the hypothesis is that badges stimulate a feel of curiosity and surprise. Order pickers do not have any influence on the kind of products they have to pick, so they will earn specific product badges randomly. However, finishing more pick tasks increased the change of getting a certain badge.

All the badges below are earned by cumulative achievements. Daily badges or achievements could have been added, but will not be part of the intervention in the experimental phase. Badges are presented as a visual presentation accompanied with a short explanation in the daily feedback report.

- Walked distance badges
    - McDonalds-badge: 10 pick rounds finished
    - Hub Amersfoort-badge: 63 pick rounds finished
- Product badges
    - Bananas
        - 10 times bananas: Abu-badge
        - 20 times bananas: Donkey Kong-badge
        - 50 times bananas: Elephant-badge
    - Cat litter
        - 5 times cat litter: Popeye-badge
    - Coca-Cola
        - 50 times a Coca Cola product: Santa Claus-badge
- Customer groups
    - Picnic Soccer Team-badge: 11 customers served
    - 1-tegen-100-badge: 100 customers served
    - Shoppers Nijkerk-badge = 160 customers served
    - Picnic Employees-badge = 1150 customers served

Game character

Every shopper that participated in the pick game will be personally asked to choose one of the seven available characters as their avatar (Appendix). These characters all have a special attribute which can be used to gain more points on a specific performance indicator. These three performance indicators are strongly connected, although in practice is observed that some shoppers show undesired behavior when only one of the performance indicators is monitored. With this choice of character, order pickers can predict on which performance indicator they'll score the best and thereby gain a bonus.

- "Speed"
    - For the fast pickers
    - Performance indicator: picking speed (picks/hour)
    - Bonus: multiplier for the speed bonus (Appendix)
- "Time"
    - For the pickers with a door perseverance
    - Performance indicator: total picking time
    - Bonus: multiplier for the time bonus (Appendix)
- "Endurance"
    - For the pickers that walk a lot
    - Performance indicator: # pick rounds.
    - Bonus: multiplier for the pick round bonus (Appendix)

Team competition

Next to the personal feedback report, the team competition is the second main component of the pick game. Every day, before the morning standup, pickers are randomly divided in 3 teams for that specific work day: Team Bananas, Team Blueberry and Team Oranges. Shoppers can recognize fellow team members by a colored bracelet, which will be handed over during the team standup in the morning. Colored bracelets are chosen because of the low purchase costs and the ease of wearing these items for the Shoppers.

The team that finishes the most picks that day, wins and every team member of that team earns bonus points and will be honored in the Shoppers-channel of Slack. When 50% of all picks are done, an update on the team scores so far will be shared in this channel as well. The end score of the day will be shared when the day shifts are over.

Performance overview report

At the end of the week, Shoppers will receive a performance overview report next to the daily feedback report. This performance overview (Figure 9) contains the following information:

- Performance graphs
    - Pick speed per day
    - Total picks per day
    - Time picked per day
    - Average number of picks per order picker per day

This is a public version of this Master thesis. The figure with the performance overview report is non-disclosed in this version

Figure 9: The performance overview report for Shopper Y, sent at the end of week 37

4.2.3 Implementation approach

The fifth step of the roadmap describes the needed steps for a successful intervention of the gameful design in the business processes. For this case, the intervention is designed in such a way that it does not interfere with the actual order picking process. The team competition is the only component of the design which is physically visible in de FC during the day, because of the colored bracelets that should be handed over. So, to implement the team competition on the work floor, the bracelets should be available and there should be procedure to hand them over to the Shoppers.

The Ambient team captain, who is responsible for the order picking process in the Ambient zone, starts his/her day with a short standup in which the tasks and responsibilities of the day are divided. Since this team captain has direct contact with all order pickers before the start of the actual process, he will be asked to include the team compositions in his/her talk and hand over the matching bracelets.

Besides the announcement of the team compositions and the distribution of bracelets, there is no need for other involvement of the leadership during the intervention. However, in the background the scores of Shoppers should be tracked and the reports should be prepared. In the next few sections, these procedures will be explained. In Appendix a set of screenshot is presented to illustrate these procedures.

Data collection

To keep track of all the finished pick tasks by the Shoppers and assign scores according to the game design, the data should be collected which is generated during the order picking process. In the database of the WMS, Corax, every completed pick tasks generates a data point with a unique task id and associated variables. This Corax data is used as the source to base the scores on for the gameful design. The next variables are used to calculate scores and statistics for the different components of the design.

Item: This variable contains the item ID and name of the picked product. This information is needed to keep track of the progress of Shoppers to earn the product badges.

User: The 'User' variable is used to link pick tasks to Shoppers

Changed date time: This variable is used to filter the data per date. All scores are assigned daily and reports conclude feedback per day.

Order: This field gives the unique order id per customer, which can be used to count the number of customers that is served by a certain Shopper. This information is used for the daily statistics (served customers) and the progress of Shoppers to earn the customer groups badges.

Qty completed: This field gives the quantity of the product that is picked within one pick task. This field is used to keep track of the progress of Shoppers to earn the product badges and for the daily statistics (Total items picked).

Document: This field presents the document id of the pick task. The document id is unique for every pick round, so all pick tasks within the same pick round has the same document id. This variable is therefore used to count the number of pick rounds per Shopper, for the walked distance badges (every pick round is 220 meters) and the daily statistics (Number of pick rounds).

Next to the dataset from Corax, one other data source is needed to keep score. In order to present the real time dashboards in the FC, the WMS sends interface messages to the Picnic systems to calculate the statistics that are shown on these dashboards. These dashboard statistics are saved per day and used as input variables for the daily statistics in the daily feedback reports and the (weekly) performance overview reports:

Avg: This variable on the dashboard gives the average Pick speed of that day per Shopper. The value of this variable at the end of the day is used for the statistics in the daily feedback and performance overview reports and for the calculation of scores.

Lines: This variable on the dashboard gives the number of completed order lines of that day per Shopper. This value is equal to the number of completed pick tasks and used as the input variable for the daily feedback and performance overview reports and for the calculation of scores. This value is furthermore used to calculate the scores of the different teams in the Team competition.

Time: This variable on the dashboard gives the total time that a Shopper spent order picking on that day. This value at the end of the day is used for the statistics in the daily feedback and performance overview reports an for the calculation of scores.

Score calculations and report preparations

In order to calculate all scores, the progress in earning badges and to prepare the daily feedback reports, two software applications are used. The daily feedback report is created in Microsoft Excel. The data with the dashboard statistics is directly imported into Excel for this purpose. However, the computing power of this application appeared to be not sufficient to process the dataset with pick tasks from Corax to determine statistics per Shoppers and calculate score. Therefore, an intermediate step is needed to process this data. The application Tableau is used for this intermediate step. The raw data from Corax is therefore imported in Tableau on a daily base. In Tableau, per Shopper the following variables were calculated per day:

- The number of pick rounds
- The number of served customers
- The number of picked items
- The number of picked items that count for the product badges

The output data from Tableau is imported in Excel to create the daily feedback reports. This daily feedback reports are exported as PDF-files and send to the specific Shoppers over Slack.

The performance overview reports are created at the end of every week by the use of Tableau. The dashboard data is used as the only data source for these reports, which are exported as PDF-files and send to the specific Shoppers over Slack.

4.3 Design process framework

Based on the research steps and the design process of this research, a new framework could be proposed that can be used to develop a gameful design in a real world working environment (Figure 10). In chapter 2 was showed that the human factors of a system could influence the performance of the system. These human factors could be divided in physical, mental and psychological aspects. Motivation is one of the psychological aspects and could be low if the work itself does not address the psychological needs of people to feel competent, autonomous and related to others. In that case, gamification might be an interesting tool to improve the system, since game elements could enhance the motivation of employees by addressing these psychological needs.

In chapter 3 was showed that an analysis of the system provides in a list of requirements and constraints for a gameful design, which defines the design space for the design process. Before a real design could be created, a set of game elements should be chosen that addresses the psychological needs that define motivation. These game elements could be selected based on empirical findings of previous research. In Figure 10, the game elements are shown that were selected during the gameful design process in this research. Based on these elements, a coherent design was created that can be implemented in the case study environment.

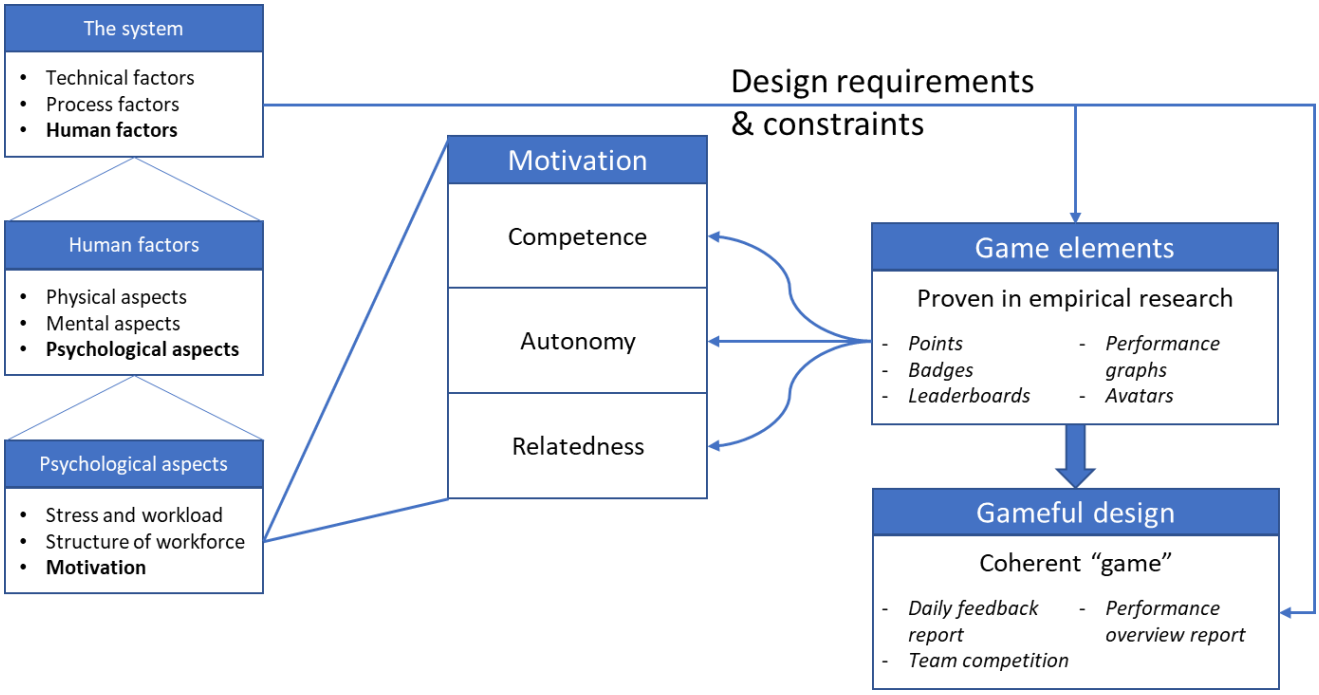

Figure 10: Framework to develop a gameful design in a real world working environment. In italics the elements can be found that were used in the design of this research, but could differ in different circumstances and systems

4.4 Conclusion of the design process

In this chapter, a gamified intervention is designed for the order picking process in the Picnic FC in Nijkerk. During the design process, research sub question 3 and 4 are answered:

3. What game elements are suitable to increase the motivation of employees?
4. What are the requirements for a gamified intervention?

Based on scientific literature, a list of suitable game elements was discussed in the first section. These elements were found using five different perspectives on motivation and in empirical studies in similar work environments as the order picking environment. In the next section, the actual design process was described, starting with the design constraints and requirements in section 4.2.1. Herewith, the answer on research sub question 4 was provided. Based on these constraints and requirements, and with the list of suitable game elements, a gameful design was created. The design contains the following game elements, known from literature: points, badges, leaderboards, performance graphs and avatars. These elements are combined in the so-called Pick game, which exists of three main components: a daily personal feedback report, a daily team competition and a weekly performance overview report. Data to set up these components is provided by the WMS which is used in the FC and the dashboard statistics from the company. The reports are produced using Tableau and Microsoft Excel and distributed to the Shoppers through messenger application Slack. In section 4.3 a framework is proposed that summarizes the design process in this study.

5. The intervention: research methodology

In the previous chapter a gameful design is proposed that could be used as an intervention in the order picking process of Picnic. This section will elaborate on the execution of the intervention and used methods to analyze the results of the intervention.

In the case study intervention, a mixed methods research approach is used to combine both qualitative and quantitative research. A mixed method research "…recognizes the importance of traditional quantitative and qualitative research but also offers a powerful third paradigm choice that often will provide the most informative, complete, balanced, and useful research results." (Burke Johnson, Onwuegbuzie, & Turner, 2007, p. 129). In a mixed method research the 'triangulation metaphor' is used in which quantitative and qualitative empirical findings are related to theoretical concepts in order to integrate quantitative and qualitative data (Erzberger & Kelle, 2003). In this way, a better understanding can be obtained between theory and the empirical findings (Östlund, Kidd, Wengström, & Rowa-Dewar, 2011). Given the research question of this study, the mixed method approach is very appropriate because of the combination of motivation and productivity. Productivity can be very well measured quantitively and motivation can be assessed with qualitative findings.

5.1 The intervention

The gameful design, as presented in section 4.2, will be tested for two weeks in the ambient zone of the FC in Nijkerk (Figure 11). The test includes 12 consecutive working days. All Shoppers who participated in the order picking process in the ambient zone during the intervention, participated in the intervention. These Shoppers get at least one daily feedback report on the day(s) they are active in the order picking process. There will be no control group during the experiment, because of two reasons. Firstly, the sample size of participants would be too low to draw conclusions from the generated results if half of the Shoppers would not experience the intervention. Secondly, it would not be possible to organize equal circumstances for a gamification and a control group. It is not desired that the leadership of the FC is dependent of the experimental setting to make the work schedule, as stated in the third design constraint in section 3.8. If the experimental setting is not taken into account in the scheduling, the ratio between the gamification group and the control group on picking activities is not secured. It might be that after the experimental phase the control group worked twice as much time on order picking than the gamification group or vice versa. Besides these two main reasons, it would not be possible to implement all game elements as described in this chapter. Messages in the Shoppers-channel in Slack would for instance reach all Shoppers, also those in the control group. Besides, all Shoppers would be aware of the team competition due to the colored bracelets and the public pick speeds of the team members on the public dashboards in the FC.

Before the intervention starts, all employees of the FC in Nijkerk will be informed. The Captains and Supervisors will be briefed with a presentation during the weekly Captains-meeting. To inform the Shoppers, a Pick game explanation PDF-file will be shared in the Shoppers-channel on Slack (Appendix).

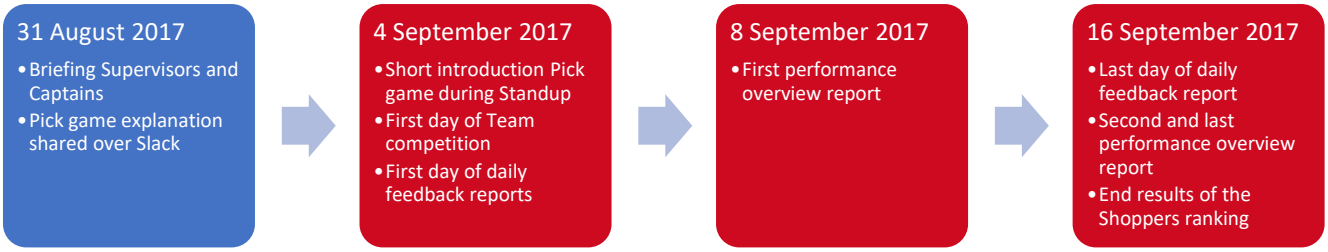

Figure 11: Important moments during the execution of the intervention. The Game was introduced by Shoppers and Leadership at the 31st of August 2017, while the actual intervention started at the 4th of September 2017.

The intervention starts at the 4th of September 2017 with a very short introduction by the "Game master" during the morning Standup and the distribution of colored bracelets as explained in the section 4.2.3. From that day on, the (team) scores are tracked and reports are distributed as described in section 4.2. The intervention ends at the 16th of September 2017, after which the test results will be examined. This examination of results will be discussed in the next chapter.

5.2 Quantitative analysis

The quantitative analysis exists of the two measured KPI's: the pick productivity and the pick quality.

5.2.1 Pick productivity

To find the influence of gamification on the order pick productivity, the productivity of the Shoppers will be examined during the two weeks of intervention. The two weeks before the intervention will be used for comparison. The reason to use only two weeks as comparison, is based on the always changing circumstances in a real working environment, especially in a company that is still improving its operational processes.

Not all participants can be used for an analysis of the pick productivity during the intervention in comparison with the two weeks before. The composition of the group of order pickers is affecting the productivity because of an variety of individual performances. Therefore, for the analysis the composition of the group of order pickers during the intervention should be similar to the composition of the group during the two weeks before.

The data quality would be highest if only Shoppers will be included in the analysis that work every day of the intervention and the control period, resulting in a complete similar composition of order pickers during both periods. However, with Shoppers working a maximum of 5 days per week, this is not possible in the real world. A trade-off has to be made between the data quality and the sample size of the test group; including Shoppers with less active days increases the sample size but decreases the data quality.

Furthermore, trainees should be excluded from the analysis since they show a learning curve in productivity during the first few weeks of order picking. Only experienced Shoppers should be included in the productivity measurements.

Taking these remarks into account, the productivity analyses will be based on a set of Shoppers that meet the following requirements, in which 'X' will be defined based on the available data after the experiment and the trade-off discussed above:

- At least X days active in the order picking process during the intervention
- At least X days active in the order picking process during the two weeks before the intervention
- Start date as order picker before the 1st of August 2017

Based on the productivity data of the 'Test group', the average pick productivity during the intervention can be calculated and compared with the productivity during the control period before the intervention took place. An independent t-test can be used to test whether there is a significant difference in productivity before and after the intervention. A t-test is a statistical test that can be used to test whether two group means are different (Field, 2000). In this case, the two groups are the intervention and the control period. Since the Shopper composition is different on daily base and the days before and during the intervention are not paired, the independent variant of the t-test will be used.

Because of the small sample size, the productivity data might not meet the assumption of normality, which can bias the t-test. The non-parametric counterpart of the independent t-test, the Mann-Whitney test, does not have the assumption of normality (Field, 2000). This test can therefore be done to validate the outcomes of the t-test, in case that the assumption of normality is being questioned.

In chapter 3 was showed that the pick productivity is positively correlated with the number of picks per pick round and with the number of picks in path F. Therefore, the results on pick productivity should be controlled for the effect of these factors. An analysis of covariance (ANCOVA) can be used to compare means, adjusting the effect of one or more covariates (Field, 2000); in this case the number of picks per pick round and the relative number of picks in path F.

5.2.2 Pick quality

The second performance indicator to examine is the pick quality. As explained before, the pick quality is defined as the number of non-affected orders by picking mistakes as percentage of the total number of orders. In order to determine the effect of the intervention on the pick quality, the picks of the Test group will be analyzed. This means that the given pick quality will consider the non-affected orders by picking mistakes by the Test group as percentage of the total number of orders that are picked by the Test group. The pick quality data is provided by the Customer Success department of Picnic, based on feedback from the customers. For the test group of Shoppers, the pick quality before and during the intervention will be compared to see whether the constraint on quality will be met.

5.3 Qualitative results

The qualitative analysis of the intervention will be based on the Intrensic Motivation Inventory and the experiences of Shoppers and the FC leadership, examined in two focus group sessions and an interview.

5.3.1 The Intrinsic Motivation Inventory

In chapter 2 is reasoned how gamification might affect the motivation of order pickers. To test the intrinsic motivation of order pickers while they perform picking activities, the IMI-test is introduced in that chapter. In the week after the gamified intervention, the participants of the intervention will be asked to fill in this test to measure their intrinsic motivation. The more days Shoppers have worked during the intervention, the better the effect of the game on motivation can be tested by the IMI test. To get an sample size that is large enough to draw conclusions afterwards, all Shoppers will be approached who performed order picking activities for at least 3 full days during the intervention. For these Shoppers can be assumed that they fully experience the game for at least 2 days, since they get the first daily feedback report after the first day.

Since there is no control group during the gamified intervention in Nijkerk. For the IMI-test this is not a desired option to ask Shoppers to fill in the test before and after the intervention, since that would mean that Shoppers have to fill in the same questionnaire within 2 or 3 weeks. This would possibly bias the outcome of experiment. After filling in the first questionnaire, Shoppers could keep the questions about motivation in mind. This might affect how they experience the gamified intervention.

Instead, a group of Shoppers from the Picnic FC in Utrecht will be asked to fill in the questionnaire to serve as a control group. The Picnic FC in Utrecht has the exact same set-up of operations as the one in Nijkerk, except that the capacity of the FC in Utrecht was 1.5 times larger during the experiment. The order picking process, both in terms of material and procedure, is exactly the same in both Utrecht and Nijkerk. The demographics of the Shoppers in Utrecht is also very similar to those in Nijkerk.

As discussed before in chapter 2, IMI tests for the subscales interest/enjoyment, perceived competence, effort/importance and pressure/tension. The full questionnaire can be found in Appendix. With an independent samples t test (Field, 2000) is determined whether there is a significant difference between the gamification and the control group in Nijkerk and Utrecht.

5.3.2 Experiences of Shoppers and the FC leadership

To get a better understanding of how the gamified intervention was experienced by the involved Shoppers and leadership of the FC, two focus groups will be organized after the intervention. Furthermore, the janitor will be interviewed. Next to the experiences with the intervention as a whole, the game elements in particular will be discussed to find out how those were experienced specifically.

A focus group is “a research technique that collects data through group interaction on a topic determined by the researcher” (Morgan, 1996). The focus groups is guided by a moderator, often the same person as the researcher. A strength of focus groups is “the group effect”, because of the interaction and “synergy” the outcome of a focus group is often more than the sum of separate individual interviews (Carey, 1994; Carey & Smith, 1994). Furthermore, instead of aggregate individual data, the participants could be asked by the researcher to compare their views and opinions. A weakness of the methodology is the impact on the group of the moderator (Morgan, 1996).

For the first focus group six Shopper will be invited who participated in the gamified intervention. To collect data from different perspectives, Shoppers with a different level of experience will be asked to participate in the focus group: 2 trainees, 2 average, experienced Shoppers and 2 of the best performing, experienced Shoppers. The second focus group will be with members of the leadership of the FC: a Supervisor, 4 ambient Captains and a Shopper+. A Shopper+ is in rank placed between the Shopper and the Captain and supports the latter in the supervision of the department.

Besides the focus group with Shoppers, the janitor of the FC will be interviewed to get an honest understanding of the experiences of Shoppers during the intervention. A. van de Poll (Janitor FC Nijkerk, 2017) works for more than 2 years in the FC and he is in a good relationship with both the Shoppers as the leadership of the FC. In his position he has more often figured as a spokesperson for the Shoppers to the leadership and vice versa, without mentioning any individual names or opinions. It is therefore that there is the trust for Shoppers to give their honest opinion to him, letting him represent their opinion to the leadership. For this research A. van de Poll is therefore asked to inform the researcher how Shoppers will experienced the intervention and to share his observations and the honest opinion of the Shoppers during an interview.

5.4 Role of the researcher

The researcher who conducted this research was involved in the operations of the FC in Nijkerk in advance of the empirical study. From August 2016 to June 2017 he was working as a Supervisor of the daily operations in the FC and worked together with the FC leadership and part of the Shoppers. He had, together with other Supervisors, a managing role in relation to the Shoppers and Captains in this FC. In preparation of the intervention, during the execution and the evaluation of the intervention, he was no longer involved in any other role at the company than the role as researcher.

The deep insights in the order pick operations and the knowledge of the company, people and other internal processes are clear advantages of the history as Supervisor. However the effort to keep an open-minded view during the intervention and while collecting the results, the researcher might have been unconsciously biased. Besides, Shoppers and Captains might have been biased base on the previous relationship with the researcher.

6. Results

In this chapter the effect of the gamified intervention will be explored by both quantitative and qualitative results. To do so, first the performance indicators will be analyzed before and during the intervention as a quantitative measure. Secondly, the results of an Intrinsic Motivation Inventory (IMI) test (Intrinsic Motivation Inventory, 1994) will be presented to see how the intervention affected the motivation of the Shoppers. Thirdly, a set of focus group sessions and interviews are organized to collect qualitative feedback about the intervention from the Shoppers and leadership of the FC. The final section of this chapter will discuss the different results in a broader perspective.

6.1 Quantitative results

This is a public version of this Master thesis. Section 6.1 is non-disclosed in this version

6.2 Qualitative results

Next to the quantitative results in the previous section, a set of qualitative results is collected during and after the weeks of the gamified intervention. At first, the intrinsic motivation of the participants of the test was measured by means of the IMI-test. Secondly, qualitative feedback on the intervention and individual game element is collected during two focus groups and an interview. Finally, an overview of non-structured feedback and observations will be discussed.

6.2.1 Intrinsic Motivation Inventory

This is a public version of this Master thesis. Section 6.2.1 is non-disclosed in this version

6.2.2 Experiences of Shoppers and FC leadership

Next to the IMI test, qualitative results were gathered by means of observations, focus groups and an interview. This section will start with experiences of Shoppers, based on the results of the focus group with Shoppers and the interview with the janitor. Secondly, the results of the focus group with the FC leadership will be discussed. Finally, more general observations made by the researcher will be presented at the end of this section.

Shoppers

In Appendix a full description of the focus group with the Shoppers can be found, including a transcript. Table 2 presents the main findings from this focus group. The first thing that can be noticed is how the Shoppers with a different level of experience had different opinions about the intervention. Next to the difference in opinion, the most experienced Shoppers had also more outspoken ideas anyway. These differences were especially noticeable in how the different game elements were appreciated. The trainees were mainly interested in the individual scores and statistics to track their performance improvements, summarized in the weekly performance overview report. The average experienced Shoppers were less interested in this performance overview report, but thought the daily statistics had the most added value. The most experienced Shoppers liked the team competition and the badges the most, although they thought that the some of the less fast Shoppers did not care so much.

Secondly, it was remarkable that all the participants of the focus group were very positive about the gamified intervention in general. They all thought that Shoppers would be motivated to work a little

harder because of the scores and achievements, although they also thought that this would not address all their colleagues. The top performers believe that everyone can do 300 order lines per hour, but not everyone wants to. The average performers however indicate that they do not get how the top performers work that hard, because they think order picking is heavy work.

Overall, the focus group session was very positive and all Shoppers indicated that they would like to see a follow-up of the intervention, but with a different focus for the different levels of experience. Since the participants represent all levels of experience and were randomly asked, within their own level, to participate in this focus group, can be assumed that they represent the opinion of a large part of the Shoppers group. However, it should be considered that the moderator was also the creator of the intervention, so the Shoppers could have been a little reserved to give negative feedback. In order to find out which negative opinions there might have been, the janitor of the FC was interviewed (Appendix).

From this interview, a couple of new insights were added to the feedback that was gathered during the focus groups. Shoppers were quite negative when the intervention was announced, they thought it was childish and could not imagine how it would improve the process. When the intervention started, most Shoppers made laugh of it and judged the teams. Actually, this is how Shoppers always react on changes in work environment. After a few days though, almost everyone who participated in the intervention became to like the intervention, which was found surprising by A. van de Poll. Shoppers thought the picking process became faster and they liked the competing elements, especially the more experienced Shoppers. Comparing reports and scores breaks the routine, there was nobody that didn't like to see in the report what they had achieved in a day work.

A negative occurrence was the behavior of the Shoppers who cut the corners, they were piggybacking with the faster team members. Shoppers who work hard, became irritated by this behavior. On the other hand, some Shoppers were irritated by the Shoppers who were too fanatic. This is why not everyone was enthusiastic about the team competition, according to the estimate of A. van de Poll about 80% of the Shoppers liked the team competition.

A final remark that was made during the interview, was the skepticism of the Shoppers that did not participate in the intervention (because they did not did order picking activities in the ambient zone). Those Shoppers kept the negative impression that almost everyone had before the start of the intervention.

Table 2: Main findings of the focus group with Shoppers

Subject	Trainees	Average Shoppers	Top Shoppers
Order picking (general)	- Most fun activity - Fun challenge to ramp quickly up during first days	- Fun activity - Improving own "score" - Nice to alternate different activities	- Most fun activity - Easy - Working on own pace - Challenge disappears for the best Shoppers - Nice to alternate different activities
What explains variance in pick speed?	- Experience	- Experience - Tiredness	- Own choice - Motivation - Some Shoppers just do not care
Overall experience during intervention		- The work itself did not change	- Speed increased, but not for everyone - People challenged each other
Team competition	- Little effect on the work - Bracelets were fun - Intermediate score during lunch was not checked	- Bracelets were too tight - Intermediate score during lunch was not checked	- Team composition was not fair - Everyone was pushing each other to perform, positive effect - Some Shoppers just do not care - Bracelets were fun - Intermediate score during lunch was not checked - Team feeling
Daily Feedback Report:	- Report was checked every day	- Report was checked every day	- Report was checked every day - It motivates to see what you've achieved - Hard to understand
Statistics and scores	- It is fun to see statistics - Creates awareness of achievements - Nice to link work to customers	- It is fun to see statistics	- It is fun to see statistics
Daily top 5		- Fun to see - Motivates to reach the top 5	- Missed a daily top 5
Game explanation in advance	- Clear	- Based character choice on this - Unclear	- Unclear
Characters and bonus scores	- Conscious choice for the bonus	- Conscious choice for the bonus	- Unconscious choice - Strange that slow pickers could choose fast characters
Badges	- Funny to get - Funny texts		- Very funny - Nice to get
Weekly performance overview report	- Report was checked weekly - Nice to see personal improvement	- Report was checked weekly (1/2) - Limited - Daily stats and scores should be summarized weekly	- Report was checked weekly
Final remarks	- Nice if Pick Game returns	- Nice if Pick Game returns - Teams more fair - Real remuneration is desired	- Nice if Pick Game returns - Work finished earlier during the game

FC Leadership

The full description and transcript of the focus group session with the FC leadership is presented in Appendix. The main findings are presented in Table 3. The findings from this focus group largely match those of the focus group with the Shoppers. The leadership was in general very positive about the gamified design, comments were mainly constructive about an improved design. The leadership believed that Shoppers liked the intervention and they felt like Shoppers worked harder during the intervention, although they were skeptical at the start. However, there was also a small group of Shoppers that did not really care about the team competition, just like was mentioned in previous section.

The team competition is the game element for which the most improvements points were mentioned, mostly about a more fair composition of the teams. Furthermore, there were a lot of ideas to further improve the design of the game elements: about the layout, more interactive, sub leagues for the ranking and implementation in the WMS that is under construction. All these suggestions strengthen the idea that the leadership was very positive about the intervention.

A remarkable comment that was made during the focus group session, was about the use of the pick game as a way to communicate with Shoppers. Every morning the work day starts with a general standup and a department standup, but often there is less to say next to the schedule of the day, which makes these standups meaningless. During the intervention, the Captains had something to talk about during the standup and for small talk during the rest of the day, which was appreciated.

Observations by the researcher

During the intervention, there were several moments when Shoppers gave feedback about the intervention on their own initiative, mostly through Slack (Appendix). This feedback will be listed here:

- After the publication of the Team scores and the daily top 5, many Shoppers placed emoticons as a reaction or even published comments. These messages were of a competitive nature.
- A part of the Shoppers responded on the daily feedback reports in direst messages. According to these responses, these Shoppers were pleased to get the feedback.
- One Shopper noticed within a few minutes that the daily feedback report of the 14th of September showed wrong information and asked why he had lost some of his badges. Therefore, new (correct) feedback reports could be sent within the hour.

Next to the short messages, one Shopper sent his elaborate view on the intervention (Appendix). He said that he was “hesitant” when the intervention was announced and indicated that he was not competitive at all. Therefore, the intervention didn’t motivate him, according to his message he was intrinsically motivated already to perform well. He had some critical points about the composition of the teams and once again noticed that he didn’t care. He liked the statistics in the daily feedback report though and was curious to his score rank after two weeks of work without showing any different behavior.

Slack has proven to be a very successful and easy way to communicate with Shoppers about the Pick game. Shoppers were good informed and responded to the messages with the reports and scores. It was clear that this way of communication is familiar within the company.

Table 3: Main findings of the focus group with FC leadership

Subject	Observations	Improvement points	Others
Overall experience during intervention	- Shoppers were skeptical at the start - most Shoppers really liked it - Real battle between teams - (some) Shoppers worked harder - a few people didn't liked it - More people than usual exceeded the 300 OLS/hr per day - More people exceeded the 1000 picks per day than usual - No decrease in quality (totes were neat)	- More feedback during the day for team competition - Realtime badge earning	
Team competition	- Real competitive behavior at some days - Most Shoppers were clearly aware of the competition - Some Shoppers did not care - Some Shoppers piggybacked on the top performers	- Team compositions was unbalanced at same days - Unfair for the teams to reassign Shoppers to other tasks - Shopper ratings to balance the teams - More feedback during the day would encourage Shoppers	- Communication about scores in the new WMS - Leadership can use the team competition to communicate with Shoppers
Daily top 5	- Shoppers reacted on Slack - Shoppers asked to do some picking after finishing other activities - Seems to inspire people	- Sub leagues for trainees, experienced Shoppers, etc.	
Statistics and scores		- More overall statistics - More leaderboards - Unnecessary shortages	
Badges	- Shoppers were happy while earning badges	- Improve pictures - Add physical badges - Badges for sub groups (trainees, etc)	
Characters and bonus scores	- Attractive since different Shoppers have different interests	- Improve layout - More interaction, upgrades	
Weekly performance overview report		- Daily stats and scores should be summarized weekly - More competition	
Final remarks		- Real numeration is desired - Statistics and scores implemented in the WMS	

7. Discussion, conclusion and recommendations

In the previous chapter the results of the experimental phase of this research were presented. In the first section of this chapter, these results will be discussed and reviewed from a theoretical perspective. In this section, the research sub questions 5 and 6 will be answered. In the next section, the main research question will be answered as final conclusion of this study, followed by some possible limitations of this study. Finally, a set of recommendations will be defined in the third section, theoretical for further scientific research and practical for the company.

7.1 Discussion of the results

In this section, the results presented in chapter 6 will be further discussed and compared with previous findings from literature and the expectations at the start of this study.

7.1.1 Productivity and quality

The main goal of this research was to introduce a gamified intervention in the order picking process of Picnic in order to test whether this intervention increased the motivation and performance of order pickers, while maintaining the quality. Concerning the productivity, it was showed that the average productivity was significantly higher during the intervention compared to the control weeks.

Based on the analysis of historical data in chapter 3, it seems that this increase in productivity can be partly explained by the high number of pick tasks per pick round during the intervention. However, a statistical analysis showed that even after controlling for this factor the productivity of the test group was significantly higher. The feedback from both the Shoppers and the leadership of the FC confirmed these results during the focus group sessions. It was observed that most Shoppers were motivated to pick a little faster because of the team competition. Shoppers stimulated and challenged each other to perform. It can therefore be concluded that the intervention as a whole had a positive effect on the pick productivity.

Next to the productivity, the pick quality was analyzed during the intervention. It has been shown that the average pick quality during the intervention was a bit higher than during the control weeks, which means that the constraint to maintain the pick quality is met. During the Focus group session, the Captains and Shopper+ confirmed this result based on their observations on the neatness of the order totes. It is their task to do random checks on the totes to guarantee neat totes and they did not observe differences in comparison to the neatness of totes before the intervention. They did observe different strategies to deliver neat totes by different Shoppers. Faster Shoppers finished their pick rounds with less neat totes, but spent some time to tidy up the totes afterwards. Less fast Shoppers delivered totes that were already neat after picking. These observations indicate that at least the faster Shoppers were actively trying to improve their pick speed, accepting that they had to do some extra work tidying up the order totes after a pick round. However, the Shoppers that delivered neat totes immediately after picking could score extra bonus for pick time. They had less idle time between two pick rounds, which made this strategy also useful for the Pick game. The total time of picking of these Shoppers was higher, which could lead to bonus points.

The results found on pick productivity and quality corresponds with the results that were found in an experimental study by Sailer et al. (2017) as described in section 4.2.2, in which a gamified intervention was tested in an experimental order picking environment. Both the quantitative and the qualitative performance of the test group was significantly higher in this study, measures comparable to the pick productivity and quality as defined in this study. The difference in performance between the test and the control group in the study of Sailer et al. (2017) is much larger though than it was in this study. In order to interpret these results, it must be said that the participants in the study by Sailer et al. (2017) were all unexperienced order pickers. This means that there was a learning effect in the performance of the order pickers, while the learning effect was excluded from this study by de selection criteria for the test group.

7.1.2 Motivation and Shopper experiences

The intrinsic motivation of the Shoppers during the intervention was measured by an IMI-test. According to the results of this test, the intrinsic motivation of Shoppers in the FC in Nijkerk was significantly higher than the intrinsic motivation of Shoppers in the FC in Utrecht. Furthermore, the Shoppers in Nijkerk felt less pressure during the picking activities compared to those in Utrecht. Since the circumstances in these two FC's are very similar, except that the gamified intervention only took place in Nijkerk, these results suggest that the intervention had a positive effect on the intrinsic motivation of Shoppers. Again, these results correspond with the results of Sailer et al. (2017), who proved that motivational indicators were higher for order pickers in a gamification environment compared to a control group. The feedback from the leadership of the FC (in Nijkerk) and the Shoppers during the focus group sessions confirmed these results as well. Shoppers indicated in this session that they felt motivated to perform a little better and experienced that colleagues did perform better as well.

The gamified design contained five game elements known from literature, from which the three components of the pick game were created that was introduced in the order picking process of Picnic. Based on the conducted research, it is not possible to link quantitative results about productivity and quality to these individual game elements. The gathered feedback from Shoppers and the FC leadership provided some more insights on the value of the different game elements though. It is noteworthy that the different game elements were valued quite differently by different persons. In chapter 2 was already discussed how individual differences could influence the picking performance of pickers using different pick strategies (de Vries, de Koster, & Stam, 2015). De Vries et al. (2015) discuss how the five factors of personality can be used to predict pick performances for different pick tools: extraversion, agreeableness, conscientiousness, neuroticism, and openness. Although the research of De Vries et al. (2015) does not include the use of game elements in the pick processes, it can be assumed that these factors also influence the experience of game elements. Extravert people might for example appreciate their name on a leaderboard more than someone who is introvert.

In the focus group with the Shoppers, it was observed that the interest in game elements certainly depends on the level of experience of the Shoppers. The trainees were especially interested in the weekly performance overview report, which showed their progress clearly, while the most experienced and top performing Shoppers had fun with the team competition and the badges. The performance overview report gave the trainees a clear view on their progress over time, which made them feel good about themselves and motivated them to reach for a better performance in the following week. These observations show that the need to feel competence (Edward L Deci & Ryan, 2012) was clearly satisfied for the trainees by the performance graphs. The top performing Shoppers did not have this need that much, or it was not satisfied by this report. This is not very surprising since they see their names on top of the existing Picnic leaderboards every day. Apparently, the need to get the feel of competence is depending on the skill level of a Shopper and the self-knowledge about these skills. It can also be said differently: if the feel of competence is already satisfied, the need for game elements that increase this feel is less present.

The statistics in the daily report were appreciated by everyone, just like the scores and ranking. These components gave the Shoppers a feel of importance of their work, knowing how many customers they have served or how many items they had picked. They found these facts fun to know and it gratified their curiosity, and in this way it might have contributed to their feel of being related to a community (Edward L Deci & Ryan, 2012); the employees of a company that serves people in delivering groceries.

Most Shoppers watched their badges on a daily base and experienced fun getting a reward for their achievements. The expected results were met, addressing the competence and relatedness of Shoppers (Antin & Churchill, 2011; Edward L Deci & Ryan, 2012). The advantage of the badges in comparison to the other game elements, is that this element could be adapted to the skill level of Shoppers easily. A trainee can feel very competent by completing his or her first hundred orders, while a very experienced Shopper could get this feeling after competing 100 orders in one day. Besides, badges as game element have a less competitive character than points and leaderboards and are therefore less likely to annoy Shoppers who do not like competition.

The avatars were the less developed game elements in the Pick game and got the least attention of both Shoppers and the leadership of the FC. Although part of the Shoppers mind the attached bonus scores, another part just choose a picture and did not care much afterwards. In the second focus group, suggestions were made to improve this element with interactive characters, upgrades and optional adaptions. With this improvements, the avatar might address the autonomy of Shoppers, but during the intervention it was just experienced as a funny picture on top of the daily report.

The team competition was especially appreciated by the better performing and experienced Shoppers. Overall, most Shoppers liked this component of the Pick game, although this component was the only one that got some negative feedback as well. Some Shoppers are not very competitive and there were even Shoppers who were annoyed by the behavior of competitive colleagues. These observations confirm the thought that personality influences how different game elements are appreciated. Next to the difference in personality, the skill level clearly influences how the team competition is experienced. Everyone preferred winning over losing and more skilled Shoppers really felt they could contribute to the victory of their team. This indicates, in contrast to the appreciation of the performance graphs, that there is a need of competence for those skilled Shoppers. Being on top of a leaderboard or winning a competition turned out to have another effect on the feel of competence than the performance graphs had, at least for top performing Shoppers. Simultaneously, average order pickers or trainees felt powerless sometimes if they knew another team would win and they could not change it by increasing their individual speed within their capabilities.

The team competition was also the game component that got critical comments from the Shoppers and leadership that liked the competition. These comments were mostly to improve the concept rather than disapprove it and can be very helpful in making this element enjoyable for every type of Shopper, or at least not annoying. To do so, it should be kept in mind that the next iteration of the team competition should address the feel of competence of every Shopper.

In the end, all game elements were experienced as positive in general. However, it is clear that different elements address different people, depending on personal characters and levels of experience. Besides, some elements need an improved design to improve the effectiveness or reduce annoyance, such as the scores in the team competition.

7.1.3 Answering the research sub questions

Based on the results presented in chapter 6 and the discussion in this chapter, research sub questions 5 and 6 could be answered:

5. *How could a tail-off of the intervention effect be prevented?*
6. *How does a gamified intervention for order picking activities look like?*

Sub question 5 is maybe the hardest sub question to answer, because of the time available for this research. The intervention took only 2 weeks, in which there was no tail-off observed. This does not say anything about a tail-off later on though, which was observed in other studies. Nicholson (2015) states for instance that gamification could create boredom if the goals do not become more challenging to match the skill level of the players. In this study, it was already observed that the weekly feedback report was not very interesting for the very experienced Shoppers. It seems that the effect of this element disappears for Shoppers above a certain level of experience, although this element is highly appreciated by the trainees. The dependence of the experience level for the appreciation of a game elements indicates that experience-based game elements could be the answer to prevent the tail-off of gamification in order picking. In the focus group sessions was already suggested that sub leagues could be an improvement for the ranks, badges and the team competition. Another suggestion was a remuneration linked to the scores or an interactive avatar with upgrades available.

In this research, a gamified design was tested with five game elements: points, badges, leaderboards, performance graphs and avatars. These five elements were used to create a pick game with three main components: a daily feedback report, a weekly performance graph and a team competition. The previous section was concluded with the statement that all elements were experienced as positive in general, but with a set of possible improvements and the remark that not all game elements are suitable for all levels of experience. Considering these remarks and improvements, an iteration of the initial gamified design is how a gamified intervention for order picking could look like.

7.2 Conclusions

A lot of research has been done on order picking activities in logistics, one of the most labor-intensive and costly processes of warehousing. However, the human factors were often ignored in this field of research. Recently, multiple studies addressed the importance of human characteristics of order picking. The motivation of employees is one of these characteristics, and the use of gamification has been shown a very promising method to increase the intrinsic motivation of order pickers in both theoretical as empirical research. Empirical results from a study in a real working environment were not yet published though.

The objective of this research was to test whether the use of game elements would show the same results in terms of increased motivation and performance as was shown in previous studies. For this purpose, a case study was executed in the fulfilment center in Nijkerk of online supermarket Picnic. In this section, the main research question will be answered and the limitations of this research will be discussed.

7.2.1 Answering the main research question

With the objective of this research as a starting point, the main research was defined as:

How can a gamified intervention in the order picking process increase the motivation of order pickers and therewith increase the pick productivity, while maintaining the quality?

To find an answer on this question, primary six research sub questions were answered. Before a gamified design could be created, the research fields of order picking and gamification were examined to find what possibilities there are to use game elements to increase the motivation of employees in an order picking environment. Next to that, a measurement tool was found to assess the intrinsic motivation of employees performing the pick tasks. Furthermore, the order picking process in the FC in Picnic was analyzed, which lead to the key performance indicators to measure productivity and quality and the requirements for an intervention. After these steps, a gamified intervention was designed and tested for a period of two weeks in the FC in Nijkerk. Based on the results of the experiment, it was discussed how a gamified intervention for order picking activities could look like and how a tail-off could be prevented.

The gamified intervention, designed in this study, existed of three main components, including five game elements: a daily feedback report with an *avatar, scores, badges,* a personal rank and informative statistics, a weekly feedback report with *performance graphs* and a daily competition with team *scores*. Reports and team scores were successfully shared through the messenger application Slack, just like a daily *leaderboard* showing the Shoppers with the top 5 highest scores.

After the experiment, it was established that the experiences of the intervention were mainly positive. Both Shoppers and leadership liked all different game elements, although there were differences observed in the appreciation of different game elements by different Shoppers. These differences exist especially between Shoppers with a different level of experience. Besides, the personality of Shoppers affects how different game elements were experienced. From the focus groups and interview can be concluded that the intervention contributed to the enjoyment of all Shoppers during their work. An Intrinsic Motivation Inventory showed that the intrinsic motivation of Shoppers in the FC in Nijkerk during the intervention was significantly higher than a control group op Shopper in the FC in Utrecht. Combining these results, the conclusion can be drawn that the intervention increased the motivation of Shoppers.

According to both Shoppers and leadership, the overall performance of the order pickers was improved during the intervention. Quantitative results endorse these results, since the average pick productivity for a test group of 22 Shoppers was significant higher than before the intervention, while the pick quality was at least maintained. This conclusion can be drawn after an statistical analysis and a correction for other factors of influence.

Considering all the results together, the main research question could be answered: Based on the results in this study, it can be concluded that a gamified intervention in an order picking process increased the motivation of order pickers and therewith increased the pick productivity, maintaining the pick quality.

7.2.2 Limitations of the study

Just like any other research, this study has some limitations which should be taken into account. The most important limitation is that this study was executed in a real working environment. A real working environment means that it is not possible to control all environmental factors. An analysis of historical data has examined which factors could affect the pick productivity, although it might be possible that not all factors were found during this analysis. Next to this, the research data was dependent of the Shopper schedules that were made independently of this research. This means that after the intervention a test group could be selected existing of only 22 Shoppers, based on the requirements in chapter 5. A final limitation of this study is that the control group for the IMI-test existed of Shoppers from the FC in Utrecht.

7.3 Recommendations

In this final section, a set of recommendations will be defined. First, a some theoretical recommendations will be listed for further scientific research. Second, a list of practical recommendations are given for Picnic.

7.3.1 Theoretical recommendations

During this research, it has been shown that a gamified intervention could increase motivation and pick productivity in an order picking environment. In the gamified design, five different game elements were used. Based on this research, it is not clear how the different elements have contributed to the quantitative results. Further research should isolate the different game elements to determine the impact of the single game elements on motivation and productivity.

The quantitative results of this study were only based on a test group of 22 order pickers over a period of two weeks, with 2 weeks of control data for comparison. These results were promising, but further research should focus on a more elaborated empirical study in the real world with more participants and over a longer period of time to validate the results of this study.

A third recommendations for further research is about the long-term effects of gamification. In this study, the long term effect of the gamified intervention wasn't measured since the experiment was only done over a period of two weeks. However, it was found that different game elements were liked differently, depending on the level of experience of the order picker. Further research should focus on the long-term effects of gamification in order picking and could focus on how a combination of the use of different game elements could affect these effects.

In this study, of the mentioned human factors that affect the performance of order pickers, only the motivation of order pickers was addressed in this study. Future research should focus on the other human factors to see how the performance of order pickers could be further improved.

7.3.2 Practical recommendations

In general, the experiences with the gamified intervention were very positive according to the Shoppers and FC leadership and the results in terms of productivity were promising. Besides, multiple Shoppers indicated that they felt sorry that the intervention was over. It is therefore recommended for the company to implement one or multiple game elements in the operational processes of order picking. For the communication concerning the game elements, Slack has been proven to work very well.

The weekly performance overview report, as developed in this study, is ready for implementation in both Picnic FCs. This report was very much liked by the trainees, from who it is for the company very important to ramp-up as fast as possible in a pleasant way. An additional benefit of the report is that it can be used by the trainers to help trainees to make steps in their development. Trainers, who already kept track of the progress of trainees, could easily create these reports. Experienced Shoppers were less enthusiastic about this report. Therefore, it is recommended to implement the weekly performance overview report for trainees during their training period as a quick win for the company.

Secondly, it is recommended to implement the team competition. The tools for the team competition are provided during this research, so implementation of the team competition is also a quick win for the company. The focus groups and interviews showed quite a set of possible improvements for a more fair and fun competition, so further development of the team competition is recommended.

A third and final recommendations is to research how the components of the daily feedback report could be incorporated in the Picnic WMS that is under development. The daily feedback report as distributed in this study was very labor-intensive to make, while the calculations behind the report were quite simple. Since Picnic is developing its own WMS to use in order picking, it should consider to include automated statistics and badges for instance in the user-interface of the WMS.

At the end of this study, Picnic has indicated to see the advantages of the use of gamification in the FCs and will, as a start, implementation the weekly performance overview report for trainees at short notice.

8. Literature

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Appendices

This is a public version of this Master thesis. The appendices are non-disclosed in this version