A serious game for a lean construction training

Potential for implementation and user preferences

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Preface

This research is done as part of my thesis to graduate from my master Construction Management and Engineering (CME) at the department of the built environment of Eindhoven University of Technology (TU/e). Throughout my study I have always been interested in making construction projects more efficient and improving their process. I have always been surprised by the statement: *'We have always done it like this, why change?*' that is still too often the motto of people involved in the construction sector. Even though, most projects still face a lot of problems in budget and time while this is often not necessary. This makes it harder for the sector to innovate and become more sustainable like other sectors. While preparing this research project my attention was drawn to lean construction and I became very interested in its potential for the construction sector.

In my family multiple people are involved in education and I have also always been interested in this topic. Especially the potential for new training techniques and how education might look in the future is something that has drawn my interest. Finding a combination of lean construction with serious games as innovative training method was therefore a great theme for me to graduate on. Although for the last year the graduation project had its ups and downs for me, I have always been enthusiastic about this topic.

This report would not have been possible without the support of my supervisors Qi, Gamze and Bauke. Thank you for your feedback, fun meetings and patience. A special thanks to my parents that helped me see this project through the end. I could not have done this without them. Finally, I would like to thank my friends for their support that made this so much easier and way more fun.

I hope you enjoy reading this report and find its results useful.

Rikke de Jonge Mulock Houwer
Olst, April 2020

Content

Summary

The construction sector often faces problems in its projects. The majority of the construction projects exceed their time and budget, creating problems for the people involved. When the concept of lean construction (LC) is implemented these problems are often decreased. However, the implementation needs training for the all people involved to be successful. To improve the training in this concept, this study suggests to use a serious game. However, no research has yet been done regarding the potential of such a serious game and what characteristics it should have. This research aims to increase the knowledge regarding the potential of the serious game and user preferences for it. This resulted in the following research question: *How could a serious game of a training in lean construction be designed in order to motivate the users to follow the training?* This question is split into eight sub questions. The first four questions focus on the characteristics of lean construction, its trainings, serious games and how these are combined. The fifth and sixth sub question analyzed what kind of people are interested in learning more about lean construction and are willing to use a serious game for that. Finally, the user preferences of the serious game are analyzed and the potential design as a mock-up is discussed.

Lean construction is a concept that focusses on making the construction process more efficient. The main characteristics are: generation of value, removal of waste, focus on process and flow, continuous improvement, optimize the whole and respect for all people involved. In practice a large number of techniques are developed that can improve different problems in changing project phases. The effect of lean construction is very promising, since projects are less over budget and time and both the stakeholder satisfaction and the health and safety are increased. However, without basic training people are often resistant to working with the concept. Currently there are only a few trainings available for people and these are often workshops. Although this is an effective way to train individuals, it is harder to train large groups like in the construction sector. Additionally, there is a lot of difference in the depth and content of the training and in the certification system.

A training with a serious game would be an option to increase the reach of the training and give more people basic knowledge about lean construction. Serious games use game techniques in non-game contexts. The main characteristics are: goal orientation, achievement, reinforcement, competition and fun orientation. Again there are a number of techniques that could be applied in a serious game, such as badges, leaderboards, a virtual marketplace etc. Serious games can increase the motivation of the users and are efficient in providing basic knowledge. This research would therefore suggest to use a serious game for the basic training in lean construction and use the workshops for more advanced trainings in lean construction.

For the second part of the research a questionnaire was used. This survey consisted of socio-demographic, lean construction, serious game and innovation questions, for establishing the target group of the serious game, as well as a stated choice part for analyzing the preferences and choice behavior of potential users. The data set retrieved from the questionnaire was tested on its quality and showed that younger and higher educated respondents were over represented along with managers and technical employees. Additionally, the data showed

some multicollinearity and a low internal consistency. These findings should be taken into account for the conclusions.

For the fifth sub question an ordinal and multinomial logistic regression analyses are done. The dependent variable was the willingness to learn more about lean construction and the predictor variables are: *Age, Level of education, Project scale, LC training, Prior knowledge LC, LC techniques known, LC techniques used* and *Innovation level.* The analyses show that people of a younger age, with a high education or that consider themselves to be innovative are relatively likely to be interested to learn more. To understand if people are interested to use a serious game for learning about LC, a second regression analysis is done with the *Willingness SG in LC* as dependent variable. The same independent variables are used as in the previous analysis, but *LC learn more, LC 16h workshop* and *LC 40h workshop* were added. The results show again that younger and higher educated people are more interested. Additionally, people that have less prior knowledge of lean construction but are willing to learn more would be willing to use the serious game. Also people that would be interested in a 16 hour training but not a 40 hour training are interested, showing that the serious game should focus on a shorter training.

For the preferences for potential users a stated choice experiment is created. Each respondent had to choose nine times between two alternative options for the serious game. The serious game had five different attributes: *Presentation information, Assessment, Depth, Achievement system* and *Certificate.* A general stated choice analysis as well as a latent class, that showed the target group, are done. Both analyses showed that the respondents preferred the basic 16 hour training over the 40 hour and customized training. Secondly, most respondents found it quite important to end the training with an official certificate. Additionally, there was a clear preference for the use of videos and animations over text and images. The latent class analysis also showed that the respondents preferred the use of a competition as achievement system over the online economy. For the assessment system there were no preferences.

A combination of the conclusions of the previous analyses is created in the form of a mock-up. This consists of a number of fictional 'screenshots', visualizing what the serious game could look like if it was developed. The research ends with recommending to further look into the serious game as it clearly shows potential for implementation. Further research with, for example, a prototype would be useful. This research should focus more specifically on the target group that is described in this research. Additionally, there might be potential for more serious games in the construction sector for other types of training.

Samenvatting

Bouwprojecten kennen verschillende problemen, zoals het maken van te veel kosten en deadlines niet halen. Dit geeft een hoop problemen voor de mensen die bij de projecten betrokken zijn. Deze problemen worden vaak een stuk minder wanneer het concept lean construction (LC) wordt geïntroduceerd. Om het concept succesvol te implementeren is het belangrijk dat alle betrokkenen een basis training krijgen. Serious games worden voorgesteld als trainingsmethode, maar er is nog geen onderzoek gedaan naar de potentie van dit concept en welke eigenschappen het dan zou moeten hebben. Dit onderzoek heeft als doel om de kennis te vergroten rondom de potentie van een serious game en de voorkeuren van de gebruikers. Dit resulteerde in the volgende onderzoeksvraag: *Hoe kan een serious game van een training in lean construction ontworpen worden om gebruikers te motiveren de training te volgen?* Deze onderzoeksvraag is opgesplitst in acht deelvragen. De eerste vier vragen gaan in op de eigenschappen van lean construction, de trainingen, serious games en hoe deze concepten kunnen worden gecombineerd. De vijfde en zesde deelvraag analyseren welke mensen geïnteresseerd zouden zijn in lean construction en bereid zijn daar een serious game voor te gebruiken. Uiteindelijk worden de voorkeuren van de gebruikers geanalyseerd en wordt er een proefmodel gemaakt.

Lean construction is een concept dat zich focust op het efficiënter maken van het bouwproces. De belangrijkste eigenschappen zijn: waarde creëren, verspilling verwijderen, proces stroomlijnen, blijven verbeteren, het geheel optimaliseren en respect voor de mensen die betrokken zijn. In de praktijk zijn er allerlei technieken ontwikkeld die kunnen helpen bij verschillende fases in het bouwproces. Het effect van het concept is veelbelovend, omdat projecten minder over hun budget en tijdslimiet gaan, terwijl tevredenheid en bouwveiligheid verbeterden. Echter zonder een basis training geven de betrokkenen vaak weerstand tegen lean construction. De trainingen die nu beschikbaar zijn zijn over het algemeen workshops. Dit is een efficiënte trainingsmethode voor individuen, het is lastiger om grote groepen, zoals de bouwsector, te trainen. Verder is er een groot onderling verschil tussen de trainingen in diepte en inhoud van de training en hoe het gecertificeerd wordt.

Het zou een optie zijn om de training met behulp van een serious game te maken om een grotere groep basis kennis in lean construction te geven. Serious games gebruiken game technieken in niet-game contexten. De belangrijkste eigenschappen zijn: doel oriëntatie, prestatie, aanmoediging, competitie en plezier oriëntatie. Ook hier zijn verschillende technieken die kunnen worden toegepast, zoals het gebruik van badges, competitieborden, virtuele markten enz. Serious games kunnen motivatie van gebruikers verhogen en zijn een efficiënte methode om basis kennis te leren. Dit onderzoek stelt daarom voor om een serious game training te gebruiken voor basis training in lean construction in combinatie met workshops voor de diepgaandere trainingen.

Een enquête is gebruikt voor het tweede deel van het onderzoek. Deze enquête bestaat uit sociaal demografische-, lean construction-, serious game- en innovatie vragen om de doelgroep van de serious game vast te stellen. Daarnaast heeft de enquête een stated choice deel wat de voorkeuren van de potentiele gebruikers analyseert. De gegevens die zijn verzameld zijn op kwaliteit getest en lieten zien dat er relatief veel jongere en hoger opgeleide

respondenten waren, evenals managers en technici. Daarnaast liet de data veel correlatie tussen de variabelen zien en een lage interne consistentie. Hier moet bij de conclusies rekening mee gehouden worden.

Voor de vijfde deelvraag is een ordinale en multinomiale logistieke regressie analyse gedaan. De afhankelijke variabele is de bereidheid om meer te leren over lean construction en de onafhankelijke variabelen waren: *Leeftijd, Onderwijsniveau, Project schaal, LC training, Voorkennis LC, LC technieken kennis, LC technieken gebruikt* en *Innovatie level*. De analyse laat zien dat mensen met een jongere leeftijd, met een hogere educatie of die zichzelf innovatief beschouwen zijn relatief meer geïnteresseerd om meer over lean construction te leren. Om te begrijpen welke mensen geïnteresseerd zouden zijn om hier een serious game voor te gebruiken is een tweede regressie analyse gedaan met de bereidheid om een serious game te gebruiken voor een LC training als afhankelijke variabele. De zelfde onafhankelijke variabelen zijn gebruikt, met als toevoeging: *LC meer leren, LC 16u workshop, LC 40h workshop.* De resultaten laten zien dat opnieuw jongere mensen met een hoog opleidingsniveau meer geïnteresseerd zijn. Daarnaast zijn mensen met minder voorkennis in LC, maar bereid er meer over te leren geïnteresseerd evenals mensen die bereid zijn een 16 uur durende workshop te volgen, maar geen mensen die een 40 uur training willen volgen. Dit laat zien dat de serious game zou moeten focussen op kortere trainingen.

Een stated choice experiment is gemaakt om de voorkeuren van de potentiele gebruikers te analyseren. Elke respondent heeft negen keer een keuze gemaakt tussen twee alternatieve opties voor de serious game. De serious game had vijf verschillende elementen: *Presentatie van informatie, Beoordeling, Diepte, Prestatie systeem* en *Certificaat.* Een algemeen stated choice experiment en een latent class analyse laten zien dat de doelgroep een sterke voorkeur heeft voor de kortere 16 uur training in plaats van de 40 uur of de gebruikersspecifieke training. Verder vonden de respondenten het duidelijk belangrijk de training te eindigen met een officieel certificaat. Ook was er een voorkeur voor het gebruik van video's en animaties in plaats van tekst en afbeeldingen. De latent class analyse liet ook zien dat respondenten liever een competitie prestatie systeem hadden dan een online economie. Voor het beoordelingssysteem waren een geen voorkeuren.

Er is een proefmodel gemaakt die de conclusies van de vorige analyses combineert. Dit model bestaat uit een aantal fictieve 'screenshots' die visualiseren hoe de serious game eruit zo kunnen zien wanneer hij wordt ontwikkeld. Het onderzoek eindigt met de aanbeveling verder te kijken naar de serious game aangezien het duidelijk potentie heeft geïmplementeerd te worden. Verder onderzoek, met bijvoorbeeld een prototype, zou nuttig zijn. Dit onderzoek zou specifieker op de doelgroep kunnen focussen, zoals in dit onderzoek is beschreven. Verder zou er onderzocht kunnen worden of er potentie is voor andere serious games in de bouwsector voor andere soorten training.

Abstract

Construction projects often exceed their budget and deadline, creating a lot of problems in the sector. Lean construction (LC) is introduced as a potential solution to these problems, however to properly implement this, everyone in the construction team needs to have some training in the concept. A serious game training could provide a basic training for the large construction sector in combination with workshops for the more advanced LC training. However, no research has yet been done that shows if this would be successful.

By means of a questionnaire data is collected to analyze the potential target group of the serious game, as well as the user preferences. The analyses show that especially younger people, with a higher education level and consider themselves innovative are interested to learn more about LC. Additionally, people that do not have much prior knowledge and want to learn more in a, not too long, training are interested.

For the user preferences it was clear that the training should be basic instead of advanced and end with an official certificate. Additionally, the information should be given with videos and animations instead of text and images. Finally, a competition element in the serious game would be preferred. With this information a mock-up was created that visualizes the conclusions of this research. There seems to be potential for the serious game training of lean construction, however further research with a prototype and a feasibility study would be recommended.

List of Abbreviations

BIM	Building Information Modeling
CME	Construction Management and Engineering
DSM	Design Structure Matrix
H&S	Health and Safety
JIT	Just-in-Time
KMO	Kaiser-Meyer-Olkin
LC	Lean construction
LCA	Latent class analysis
LPS	Last Planner System
MEP	Mechanical, electrical and plumbing
MNL	Multinomial logistic
RQ	Research question
SC	Stated choice
SG	Serious game
SQ	Sub question
TU/e	Eindhoven University of Technology

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1 INTRODUCTION

The introduction of this research will sketch an idea of the current state of the construction sector and focus on the problems it is facing. The research gap for implementing a solution for these problems is discussed, resulting in the aim for this study and a research question. The research question is split into eight sub questions that make it more manageable to answer the research question. The second section of this chapter describes the research design that is used which also shows the general structure of this research as also discussed in the third section.

The construction industry is one of the biggest sectors in the most developed countries. However, a lot of projects face significant delays and cost overruns that could result in problems in quality and safety (Twana, 2015). Material wastage and not making the delivery deadlines contributes to the inefficiency of the construction process (Babalola, Ibem, & Ezema, 2019). A majority of the professionals in the construction sector says the average failure costs of their projects is 5% or higher (ABN AMRO, 2019). Internationally, 70% of the projects have a time overrun, while the average cost overrun is 14% of the contract costs and 10% of the total materials used are waste (Hussin, Abdul Rahman, & Memon, 2013). Most mega-projects have a cost overrun of more than 25% (PwC, 2013) and these high costs are almost accepted in the construction sector. Important factors that contribute to these overruns are, among others: poor estimates/missed deadlines, poorly defined goals and poor communication. A couple of the solutions ABN AMRO (2019) suggested to reduce these unexpected costs were: a realistic planning, tenders based on quality instead of price, apply previous experiences/ knowledge sharing, making a general planning with all parties involved, periodical meetings with construction site employees, shared responsibility for all stakeholders in the process, attention for feasibility in the design phase, standardization of products and processes and high involvement of the project developer. The solutions mentioned by ABN AMRO (2019) were summarized into five general points of attention:

- Good preparation
- Better collaboration
- Use of experience
- Innovation and standardization
- Share knowledge and learn from mistakes

Lean as solution

All five of these points of attention could be improve by implementing the concept of lean construction (LC) (Hamzeh, Kallassy, Lahoud, & Azar, 2016; Seed, 2015). This concept is in 1993 derived from the lean concept that is used mostly in the manufacturing and service industry (Babalola et al., 2019). It stimulates the focus on activities that add value to the end user, while removing process waste. In addition, lean construction increases process flow and continuous improvement, while having respect for the people involved in order to optimize the whole (Seed, 2015). To achieve this philosophy lean construction uses different techniques and tools for different improvements for problems in different phases of the construction process. Projects that implemented lean construction scored very well in terms of time and costs (Hamzeh et al., 2016) (Andersen, Belay, & Seim, 2012) (Eriksson, 2010). In addition, health and safety improved and the people involved were more satisfied.

Gamification for training

However, to implement lean construction well in the construction sector proper training is necessary for the entire construction team (Hamzeh et al., 2016). Currently training in lean is mostly given by means of workshops (Lean Construction Institute, 2019) (LeanConsultancyGroup, 2019) (Lean.nl, 2019). This type of training is done in small groups and takes quite some time and money. A solution that could reach much more people in the construction sector is to make a serious game of a lean construction training. This would be much more accessible and users could be more motivated to learn about lean construction. Additionally, this could create a standardization in the lean construction certification.

Research gap

However, no research has yet been done that describes if the construction sector is willing to learn more about the lean construction, use an serious game for the training of that, what the preferences of the potential users for the serious game are and what it should look like.

1.1 Research question

Aim

This research aims to increase the knowledge regarding the potential of a training in lean construction by means of a serious game. Additionally, it aims to get more insight in the preferences of potential users and create an example of how such a serious game could be made.

Research question

This resulted in the following research question:

RQ: How could a serious game of a training in lean construction be designed in order to motivate the users to follow the training?

This research question has the following sub questions:

- *SQ 1: What are the main characteristics of lean construction?*
- *SQ 2: How are people currently trained in using the concept of lean construction?*
- *SQ 3: What are the main characteristics of serious games?*
- *SQ 4: How can a serious game help lean construction training?*
- *SQ 5: What attributes influence the willingness to learn more about lean construction?*
- *SQ 6: What attributes influence the willingness to use a serious game for the training in lean construction?*
- *SQ 7: What serious game attributes should be included in a training of lean construction so that the serious game would be used?*
- *SQ 8: What would a serious game of a lean construction training for instance look like?*

1.2 Research design

A research design is created to give more insight in how this study is built up. This can be seen in Figure 1.1. The first four sub questions will be analysed with a literature review. SQ 1, 2 and 3 form a basic understanding of respectively lean construction, its trainings and serious games. The information found in these three questions can combined be used to answer the fourth sub question.

The second part of this study will focus on data that is retrieved from a survey that is conducted for this research. This survey and the analyses that follow can be divided into two parts. The first part focusses on sub questions 5 and 6 and answers what characteristics of people in the construction industry would have an influence on their willingness to learn more about LC and if they would use a serious game for that. For these analyses an ordinal and multinomial logistic (MNL) regression will be used, as will be explained in section 3.4. The second part of the survey, and research, will focus on a stated choice and latent class analysis (LCA) to answer SQ 7. This analysis will focus less on the characteristics of the potential users and more on the characteristics of the serious game itself. The characteristics of the potential users (target group) will however be used as input for the LCA to make sure the serious game will eventually be optimally adjusted to the preferences of the target group.

This research will end with the creation of a mock-up for SQ 8 that is based on the conclusions of the previous sub questions. This will give a clear overview of the results of this study as well as an suggestion for how the serious game training of lean construction eventually could be made and look like.

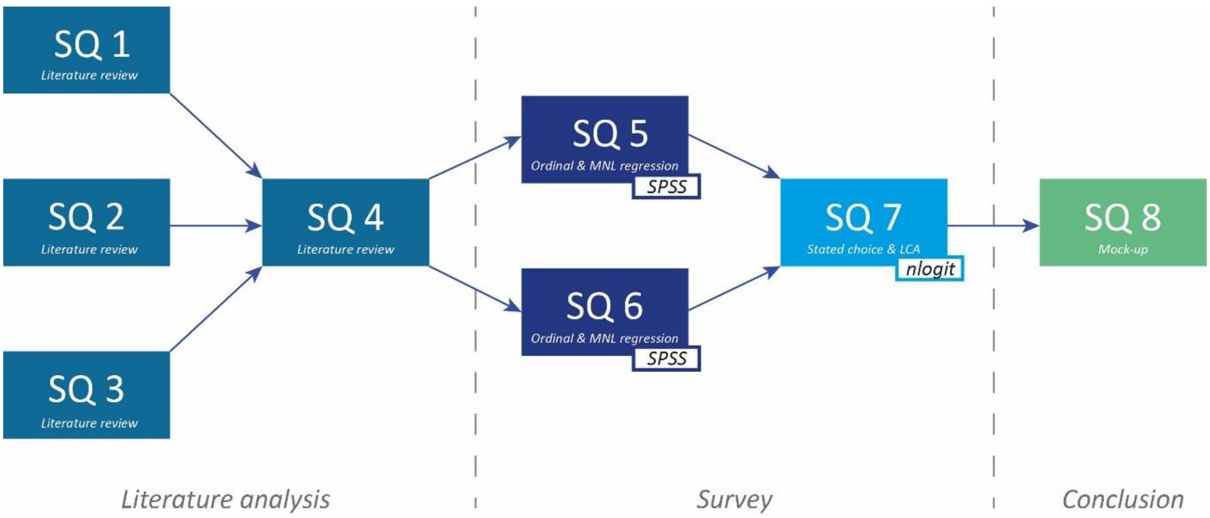

Figure 1.1 - Research design

1.3 Reading guide

As mentioned in the previous this study will start with a literature review. This review will start with describing lean construction, its history, characteristics and what effect it could have on the construction sector. Secondly it will discuss the types of training that are currently used for learning about LC. Then the characteristics of a new type of training, a serious game, is described and what effect it could have. Finally, the concept are combined into a framework of how serious games could improve the training in lean construction.

The third chapter describes the methodology of the analyses that were used for the second half of the sub questions. The chapter will start with an introduction followed by a description of the variables used for the fifth and sixth sub question and how these variables are retrieved from the questionnaire. Thirdly the different data test will be described that explore the quality of the data set. After that the regression analyses for SQ 5 and 6 will be discussed, followed by a description of the stated choice and latent class analysis used for the SQ 7. Finally the idea of the mock-up will be discussed and the chapter will end with the conclusions.

Chapter 4 has the same structure as the third chapter only now it focusses on the results instead of the methodology. The chapter consists again of sections that describe the data retrieved from the questionnaire, the quality tests of the data set, regression, stated choice, and latent class analyses. The results of these analyses are combined into a mock-up and the chapter ends with its conclusions.

The fifth chapter finishes the main content of this report. The conclusions are drawn, followed by a section about the scientific and societal relevance of this study. The chapter will also describe the limitations of the research and recommend how the serious game should be implemented and what further research should be done.

After the conclusions a list of the references is included followed by the appendices.

2

LITERATURE REVIEW

As indicated in the research design in section 1.2, the first four sub questions of the research design are answered by means of the literature research. First the concept of lean construction will be described (SQ1). Secondly, the current ways of training in lean construction will be analyzed including the problems that occur in the application (SQ2). This leads to the third part of the literature study that focusses on the attributes of serious games (SQ3). Finally, the conclusion of the literature review combined describes how serious games could help the training in lean construction (SQ4).

2.1 Lean construction

Seed (2015) describes lean construction as follows: "the concept of lean construction is an approach of the construction process in which all activities of the process are analyzed in order to reduce waste (i.e. waiting time and materials)". Several techniques can be applied in different phases of the construction process. This section will describe the history of lean construction, what it is, the effect it has and how it is implemented in the construction industry.

2.1.1 History lean construction

History Lean Six Sigma

Lean was first introduced in the Ford plants in Michigan in 1913. However, after the Second World War it was further developed and made more impeccable by the Toyota Production System (TPS) in Japan. Lean is a process improvement methodology that is used to deliver products and services better, faster and at a lower cost (Laureani & Antony, 2011). Although several production systems were developed at the time, lean became very dominant. Companies in Europe and the US started to adopt the concept under the name just-in-time (JIT) in order to remain competitive with Toyota (Pepper & Spedding, 2010).

In the US however, the concept Six Sigma was developed by the Motorola Research Centre. Six Sigma is a data driven process improvement methodology that is used to achieve stable and predictable process results, reducing process variation and defects (Laureani & Antony, 2011). In short, it can be said that lean increases the speed and efficiency of a process and Six Sigma increases accuracy. However, you can only increase the speed up to a certain extend until you seriously decrease the accuracy and vice versa (Pepper & Spedding, 2010). Therefore, the two concepts could really benefit from each other and the Lean Six Sigma concept was developed. It uses tools from both concepts in order to increase speed while also increase accuracy. This concept is mainly successful for the manufacturing and service industry that have a lot of repeating processes. Often lean and Lean Six Sigma are also referred to as lean manufacturing or lean management.

History lean construction

Lean construction is derived from Lean Six Sigma and was first introduced in 1993 (Babalola et al., 2019). In 1997 the Lean Construction Institute was formed by Glenn Ballard and Greg Howell (Lean Construction Institute, n.d.). This institute developed the Last Planner System, one of most important techniques of lean construction and the one that is most associated with lean construction (Babalola et al., 2019).

2.1.2 What is lean construction

The Lean Construction Institute describes six tenets of lean construction: generation of value, removal of waste, focus on process & flow, continuous improvement, optimize the whole and respect for all people involved as can be seen in Figure 2.1 (Seed, 2015). The same six principles are described by the study of Eriksson, (2010), although this study uses different names.

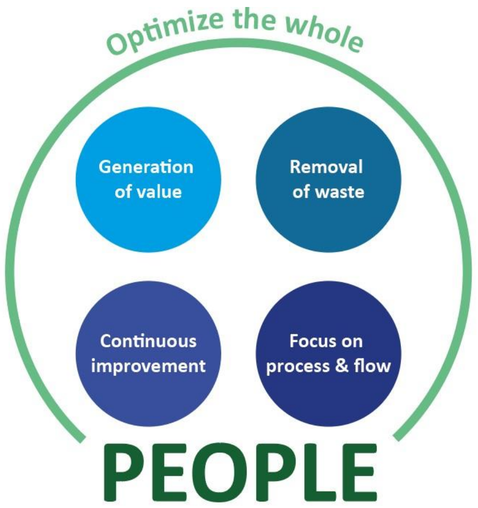

Figure 2.1 - Lean construction tenets (Seed, 2015)

Generation of value

One of the most important aspects of lean construction is to focus on activities in the construction process that add value to the final product. It encourages the constant reflection on value and determine if every resource is employed to generate and maximize this value (Seed, 2015). Focus on the end consumer is therefore one of the core elements of the concept. An important way to create this focus is by already communicating with the contractors and suppliers in an early stage so that they are more aware of what products are necessary. Secondly, customer satisfaction is not only created by increasing the value of the end product, but also the process during which the product is created (Eriksson, 2010). Service quality is therefore, for example, important for the customer as well, since this is also creating value.

Removal of waste

Not all activities in a construction process add value to the end product. These activities can be described as waste. Ansah, Sorooshian, & Bin Mustafa (2016) describes seven forms of waste:

- Defects/rework; scrap and fixing mistakes
- Overproduction; making more just in case, or making something too early
- Inventory/queue; excessive work in process inventory
- Over-processing; beyond what the customer needs
- Motion; unnecessary and awkward movements of employees, such as stretching, bending, lifting etc.
- Transport; unnecessary material movement
- Waiting; delay for an upstream activity to complete

Figure 2.2 - Seven types of waste

Generally the idea of lean construction is to remove of all waste. However, some activities are inevitable. Therefore, a distinction is made between two types of waste:

- Type one waste: these activities do not create value but are unavoidable
- Type two waste: these activities create no value and are avoidable

For instance, it is inevitable to transport materials to the construction area. This cannot be avoided but should, if possible, be reduced (type one). Transportation on site however, i.e. from one storage to another and back, should be removed (type two). Lean construction techniques such as Just-In-Time (JIT) stimulate synchronization between material delivery and use.

Focus on process & flow

Additionally to the generation of value and removal of waste it is important to focus on the flow of these activities as well in order to make the process more efficient. Lean construction describes flow as the movement of materials, information and equipment through a system (Abbasian-Hosseini, Nikakhtar, & Ghoddousi, 2014). Different techniques like Last Planner System (LPS) and Single Item Flow, as described in section 2.1.3, can help improve this flow. This could result in a process that decreases the amount of waste even further by, for example, reducing the time people have to wait for other tasks to be finished.

Continuous improvement

Within the lean construction concept continuous improvement is an important aspect as well. By motivating the team to keep evaluating the process and lean techniques they use, the entire process should become even more effective. A long term perspective on continuous improvements, within lean often revered to as Kaizen, is important to increase lasting enhancement instead of short-term gain (Eriksson, 2010). Giving employees sufficient opportunity to state their suggestions for improvements is therefore important.

Optimize the whole

Since processes are often linked to each other it is possible that certain changes in the process could have a negative effect on another part of the process. It is important to always look to the entire project and see whether the changes have a real benefit for the end user. This can be stimulated by getting all parties involved as early as possible in the process. Therefore, they are less focused on individual gain and more on that of the entire project, which can be counterintuitive for stakeholders in a traditional process (Seed, 2015).

Respect for all people involved

In addition to the other tenets, an important aspect of lean construction is also the respect for all people working on the project. This means, for instance, that the project benefits from making the best use of everyone's skills and idea's. In addition, it is important that everyone has the knowledge of what is happening in the project so they become more involved. Both aspects could create a higher sense of ownership of the project that will motivate the team. However, respect for all people also means that it is key to make sure the team does not overwork when the efficiency of the process increases. Finally, removing activities that are considered waste should not lead to the firing of employee's, but should make sure that the employees have more time to improve the quality of their value added tasks.

2.1.3 Lean construction techniques

Lean construction uses different techniques that could improve the construction process. Babalola et al. (2019) studied the literature regarding lean construction between 1996 and 2018 and found 32 different lean construction techniques, categorized into different areas of the construction process: design and engineering, planning and control, construction and site management, health and safety, etc.. This section will describe the most implemented techniques.

Last Planner System

One of the techniques that is most associated with lean construction is the Last Planner System. This is a technique in which the team works collectively on a planning and is pushed to make this planning as realistic as possible. The project schedule will be made in different levels (Salem, Solomon, Genaidy, & Luegring, 2005). The first level is the Master Schedule that gives an overall project schedule, including milestones. The second level is called Reverse Phase Scheduling (RPS), or Pull Planning, in which the team plans from the final deadline of a phase backwards to get a good idea of when all tasks need to be done. In the third level the team works with Six-Week Lookaheads (SWLA). These are based on the RPS and are moments the team looks a certain amount of weeks (usually 3-12. depending on the project) ahead to see what problems might arise or what needs to be done the coming weeks in order to make sure all tasks are planned in time. The fourth level is the Weekly Work Plan (WWP) that is made based on the SWLA and describes what tasks need to be done in the coming week. This weekly meeting covers the weekly schedule, safety issues, quality issues, material needs, manpower, construction methods, backlog or ready work and any problems that might occur in the field.

The Last Planner uses the percent plan complete (PPC) as a measurement metric to calculate the ratio of planned tasks that are actually done (Salem et al., 2005). The higher this percentage the more reliable the planning. Often projects have a PPC between 30% and 70%, however the goal with a lot of lean construction techniques is to increase this value.

During the meetings where the LPS is applied two analyses are taken into account:

- Constraint analysis, an overview of all the constraints of the different activities
- Variances analysis, an overview of the duration variance of the different activities

In the meetings it should be discussed how both the constrains and de variance could be reduced.

Just-in-time (JIT)

Just-in-time is focusing on delivering materials, information, drawings etc. just at the time it is needed in order to avoid waste, such as waiting and storage (Babalola et al., 2019). This technique is considered one of the base concepts of lean construction that has a large impact on the reduction of waste.

Daily clustering/huddle meetings (tool-box meetings)

A daily huddle meeting, or tool-box meeting, is a short daily startup in which team members quickly update everyone on their progress and what they plan to do next (Salem et al., 2005).

5S

The 5s process (or visual work place) is a lean construction technique that focusses on an organized and neat working place. It was developed by Toyota manufacturing and the five s's are therefore based on 5 Japanese words: seiri (sort, or organization), seiton (straighten, or flow improvement), seiso (shine, or cleaning), seiketsu (standardize) and shitsuke (sustain, or discipline) (Salem et al., 2005).

Kaizen

The concept of Kaizen originates from the Toyota manufacturing as well and focusses on a long term perspective on continuous improvements (Eriksson, 2010). This can be achieved by regularly evaluating the process and stimulating feedback from stakeholders.

Single item flow

To create the best flow it is more effective if employees make sure they immediately share the work they finished as soon as it is done instead of piling this up to a complete batch before sharing it. This way the people who are next in the process can already start working on the first items that were done. This reduces waiting time and therefore increases the flow of the process.

Fail safe for quality and safety

This technique stimulates the team to generate ideas that alert for potential problems so they can be prevented in time (Salem et al., 2005).

Big room

In this technique different designers work side by side in the same location. This enables more effective communication. This is best suited for large construction projects where designers only work on one project at the time (Tauriainen, Marttinen, Dave, & Koskela, 2016).

Knotworking

Knotworking is similar to big room but with this technique designers meet at the same location in the planned or spontaneous critical points of the project when cooperation benefits the most. This usually last a couple of days after which designers go back to their offices (Tauriainen et al., 2016).

Increase visualization

The increase visualization technique is a tool to communicate effectively in the workplace by means of various signs and labels that could increase the safety, the understanding of the schedule and the quality (Salem et al., 2005).

First run studies

In a first run study a team is stimulated to redesign critical tasks in order to improve them. The team plans an improvement to the process, does a first run of that improvement, checks the results and acts on this (Salem et al., 2005).

2.1.4 Effect of lean construction

In an extended literature review Babalola et al. (2019) describes the effects of lean construction techniques on construction projects. A distinction has been made between the economic, social and environmental benefits associated with the adoption of the concept. An overview of these benefits is given in Table 2.1. This shows all the benefits of LC the study found in other literature.

Most of the benefits were found in the economic and social category. These benefits were found in other literature as well, such as the reduction in project time (Issa, 2013; Oladapo, Ogunbiyi, & Goulding, 2019), in project cost (Nowotarski, Paslawski, & Matyja, 2016), the improvement in project quality (Andersen et al., 2012) and employee satisfaction (Hamzeh et al., 2016). However, the environmental benefits, also often associated with lean, seem to be limited to the reduction of project waste (Babalola et al., 2019; Oladapo et al., 2019).

Table 2.1 - Benefits associated with the adoption of LC techniques (Babalola et al., 2019)

Category	Benefits
Economic (cost, quality and time)	Reduction in project time/schedule
	Reduction of project cost
	Improvement of project quality
	Continuous Improvement of process
	More inventory control
	Increment in market share
	Risk minimization
	Decrease in variability of work flow
	Improvement in project delivery method
Social (relationship and people satisfaction)	Work efficiency increment/increased labour productivity and performance
	Generation of better value for client/customer satisfaction
	Employee satisfaction
	Improved health and safety
	Improved suppliers relationship
	Achievement of reliability, accountability, certainty (predictability) and honesty on projects
	Better cooperation among stakeholders
	Improvement of management and control
	Better coordination
Environmental	Reduction of project waste
	Attainment of green construction

Case studies

To further illustrate the benefits of lean construction three case studies are highlighted.

A case study conducted by Andersen, Belay, & Seim, (2012) analyzed the construction process of a hospital in Norway that faced a lot of problems regarding delays and extra costs in the first phase of their project. Lean construction was introduced in the second phase of the project and this phase clearly had better results regarding cost, time, quality and H&S.

The research of Tauriainen, Marttinen, Dave, & Koskela, (2016) used interviews to analyze whether designers and design managers believed specific lean construction techniques could have an impact on identified problems that occur during the design process. The study found that especially the techniques big room, knotworking, last planner system and set-based design could be recommended for problem solving. Big room had a big impact on information sharing and lowering the threshold for the team to collaborate. The last planner system increased project efficiency and transparency, and enhances the project collaboration, commitment and team work.

The study of Nowotarski, Paslawski, & Matyja, (2016) analyzed the effect of the lean construction technique the 5S method in three processes within the construction phase of a project. The result showed a high positive effect in terms of money savings and quick access to materials and a medium impact on the improvement of H&S and in-site transportation.

2.1.5 Implementation of lean construction

There is a lot of literature that states that the implementation of lean construction techniques could have a significant positive impact on a project. However, the concept is only implemented in a small part of the construction sector. Multiple studies mentioned in the previous section faced resistance from the team when they first introduced lean construction (Oladapo et al., 2019; Salem et al., 2005; Hamzeh et al., 2016). They experienced that the main difficulties in the implementation were that construction processes are relatively complex and there was too little understanding of the principles of lean construction. To solve this problem, they recommended that the entire team would be trained in lean construction and its techniques. This would be most effective if all team members are trained in LC at the beginning of the process. There are currently several trainings available for lean management. For lean construction however, there are only a few, despite the fact that it is important that all different levels of the construction team would have a training in the lean construction tools (Oladapo et al., 2019).

Effect training

Hamzeh et al. (2016) found that encouragement and motivation from lean champions and management helps to implement lean. However, team members often resist to change towards the new system. The study suggests that further training of team members would help to motivate these team members to change towards a lean culture.

2.1.6 Conclusion

Lean originates from the car manufacturing industry and is later converted into lean construction for the construction sector. The main characteristics of LC are the generation of value, the removal of waste, the focus on process and flow, continuous improvement, optimize the whole and respect for all people involved. Within the concept of lean construction 32 techniques can be identified which can be applied in different phases of the construction process. The Last Planner System and Just-in-time techniques are most associated with the LC concept.

Lean construction can have a large economic impact, in terms of cost, time and quality, and social impact, regarding customer and employee satisfaction. To gain the benefits of the concept it is important that all participants of a construction team are trained in working with LC. This would increase the motivation of the participant to apply the lean construction concept in their work.

2.2 Current lean construction training

This part of the literature review will focus on what lean construction trainings are currently provided, what training type is used, how they are certified and what the advantages and disadvantages are.

2.2.1 Lean construction training

Compared to the lean management training there are currently only few places where you can follow a lean construction training. In the US the Lean Construction Institute provides a basic training in Lean Construction (Lean Construction Institute, 2019). In the Netherlands there appear to be no trainings specifically for lean construction. There are however workshops in Lean management or Lean Six Sigma that can be customized to be more specific for the construction sector (Bureau Tromp, 2019; LeanConsultancyGroup, 2019; Lean.nl, 2019).

2.2.2 Types of training

As stated above, there are currently very few trainings available for lean construction. Lean trainings are mainly given internally and not by specialized external companies. There are also often trainings in lean management instead of lean construction. The trainings are available in the form of workshops or online.

Workshops

Currently there are already several organizations that provide training in lean management in the Netherlands. These types of trainings are mostly workshops for small groups of professionals. On average a group participating in such a workshops consists of about 8-16 people. A basic training usually takes 1-4 days while an advanced training takes 10-14 days. The costs of a basic training differ from 478-2722 euro per person; for the advanced training 3125-4950 euro (Bureau Tromp, 2019; Lean.nl, 2019; LeanConsultancyGroup, 2019).

Online training

There are currently already some apps available that can help to apply lean, but no apps that will train users in lean. Some apps give some very basic explanation of what lean is but no real training (Google Play, 2019). The only currently available online course in lean management is iLeanGO that developed a training for lean management that can be done in an internet browser. This tool uses slide shows to learn different topics of lean (iLeanGO, 2019).

2.2.3 Certification system

When Lean Six Sigma became more popular a certification system was developed that indicated how well people understood the concept of lean. People that participate in a lean training can be certified from a White Belt up to a Master Black Belt in lean. This certification system is based on the belt system used in Japanese fighting sports such as judo and karate. It differentiates between the White Belt, Yellow Belt, Green Belt, Black Belt and Master Black Belt, in increasing understanding of lean. The certification system used for lean construction is often based on the same principle as the system used for Lean Six Sigma.

Although Lean Six Sigma stimulates standardization, the certification of the concept is not standardized at all. Companies that provide a lean construction training use the belt system, but are very inconsistent in what qualifies as a certain certificate (Laureani & Antony, 2011). Additionally, almost two thirds of the professionals that are certified followed an internal program within their own company that is different for each organization (Hathaway, 2010).

Within the literature available about the lean belt system there is more consensus about the definition of the different belts (Laureani & Antony, 2011):

- White Belt: people that have a white belt followed a 40 hour training with the basics of lean and usually work within specific work cells instead of cross-functional projects.
- Yellow Belt: this belt is similar to the White Belt but a little bit more advanced and usually relevant for people that take up small lean roles in projects on top of their own responsibilities.
- Green Belt: when employees followed about 80 hours of lean training they receive a Green Belt that can be used to take up more advanced lean roles in projects. They use the same tools as Black Belts, but usually within a certain division or location.
- Black Belt: After 160 hours of training a professional can receive a Black Belt certificate. An employee can now work on large complex projects to coordinate lean within the project.
- Master Black Belt: this belt can be received when a Black Belt has practiced lean for some years and has gained experience in the field. This person can work full time in lean and mentor Green and Black Belts.

Laureani & Antony (2011) and Hathaway (2010) advertised for a standardization of the lean certification to make it more clear how familiar professionals are with lean. Laureani & Antony (2011) suggested that such a certificate should consist of three parts: knowledge, experience and maintaining. Knowledge mostly focusses on the theory and tools of lean, experience on lean in practice and maintaining focusses on re-certification after a certain amount of time since the concept develops over time.

2.2.4 Advantages and disadvantages of workshops

Within the Netherlands a training in the form of a workshop, either internal or external, is the most often used form of training in lean. Workshops are generally conducted by people with experience within the field, while the participant group is kept small in order to allow personal attention (Ørngreen & Levinsen, 2017). This training type is considered an effective way of training participants in new information (Grave, Zanting, Mansvelder-Longayroux, & Molenaar, 2013). Several advantages of workshops can be found in the literature like the increased effect of behavior change. Additionally, participants find the content of the workshops more helpful, relevant and useful.

Although workshops are effective ways of learning new information, there are also disadvantages. This is mainly due to the fact that workshops consist of only small groups. This means that it is hard to teach a large group of people like the people working in the construction sector. Organizations like Lean.nl have trained over 500 people in lean (Lean.nl, 2019), however this is only a small portion of the 396.000 jobs in the construction sector (CBS, 2016). Additionally, the workshop small groups make the training also relatively expensive, since the costs can only be shared with a small number of people.

2.2.5 Conclusion

Currently almost all trainings in lean are focused on lean management instead of lean construction. Usually this is done in the form of a workshop. For the certification a belt system is used in which the colors indicate the levels reached. Workshops are often given internally within a company resulting in a lack of standardization of both the content and the certification. Workshops are considered an effective way of training participants in new information. However, the small groups only reach a small amount of employees in the construction sector and raise the costs as well. Another type of training would be an interesting consideration in order to reach large numbers of employees and lower the costs of the training.

2.3 Serious games

This section will focus on answering the third sub question as described in section 1.1. First it will describe what serious games are and how they are related to other types of games. Additionally, the main characteristics of serious games will be described. Secondly different techniques and their purposes will be mentioned. Furthermore, this section describes how serious games could be applied and what the main effects of the concept are. Finally, it discusses how serious games are currently implemented.

2.3.1 What are serious games

Deterding, Dixon, Khaled, & Nacke (2011) describes different ways in which games can be categorized. First a distinction can be made between games that mainly have a playing purpose (digital games or playful design) or games that are used for another purpose. The latter category uses gaming as a means to motivate people to start or keep using an application. This can be achieved by integrating gaming elements in a non-game context. This is referred to as gamification. When these gamifications are full-fledged they can be considered serious games. The different types of games are shown in Figure 2.3. Gamification is, for example, used in social networks, while serious games is often applied in an education context (Sousa Borges, Durelli, Reis, & Isotani, 2014). Both gamification and serious games stimulate intrinsic motivation to enhance pleasure and satisfaction for the user. The gaming elements that are used in gamification are often also integrated in serious games and in the literature the two concepts often overlap. Therefore, the literature regarding the use and effects of gamification techniques are also used in this literature review.

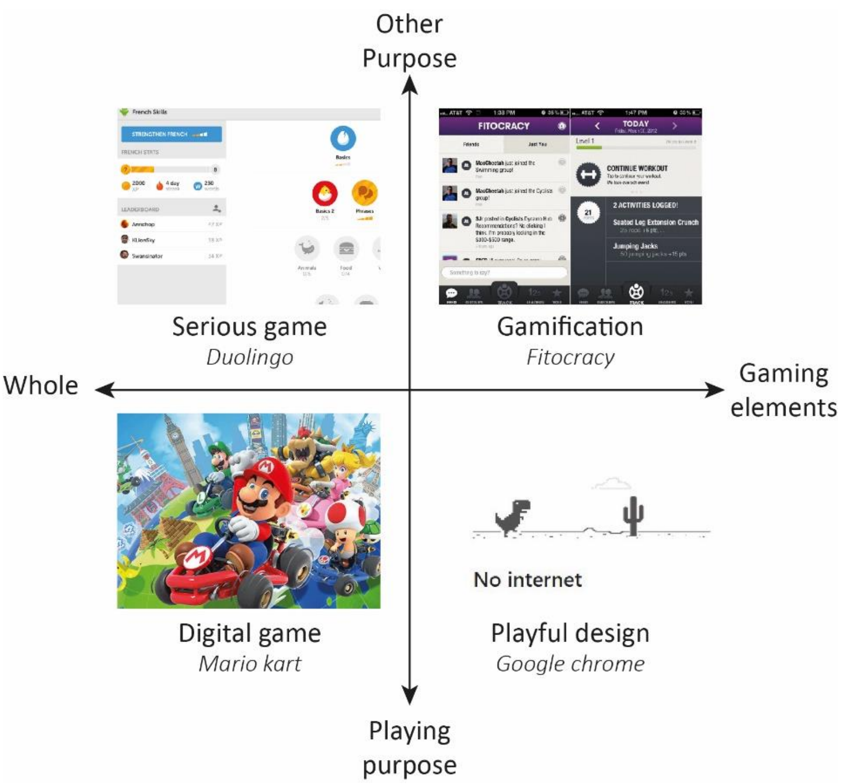

Figure 2.3 - Different game types with examples

The study of Fui-Hoon Nah, Telaprolu, Rallapalli, & Venkata, (2013) studied the concept of gamification for education purposes and provided a framework to describe what it is. They found five gaming principles that are used in gamification: goal orientation, achievement, reinforcement, competition and fun orientation.

Goal orientation

Gamification often uses a hierarchical system of goals for the long, medium and short term. The education program, which is a long term goal, is broken down into short, easier achievable goals. These lower layers could be balanced with the learners level, generally increasing the users knowledge and skills. It is important that the difficulty of the layers, created for the short term goals, match the skills and time of the users. As shown in Figure 2.4 keeping a good balance creates a continuous flow instead of user anxiety or boredom. Having these goals helps to sustain the users motivation and engagement (Fui-Hoon Nah et al., 2013). In order to keep the users motivation it is important that the goals are described clearly (Hamari, Koivisto, & Sarsa, 2014).

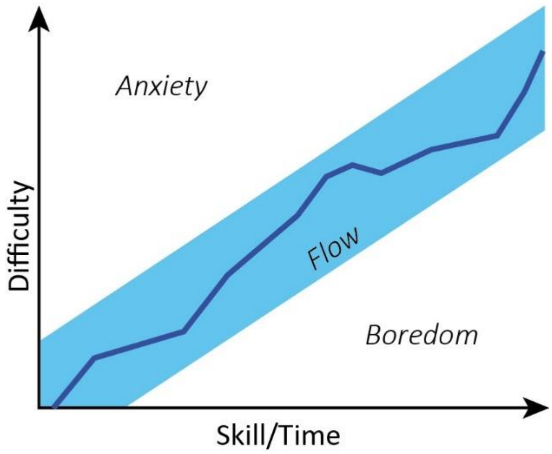

Figure 2.4 - The flow theory (Groh, 2012)

Achievement

An achievement is a virtual or physical representation of having accomplished something (Mishra & Dham, 2018). In gamifications users are often encouraged by means of an achievement system. This creates a sense of recognition for the progress of the learner and shows them the progress they are making to achieve their goals (Fui-Hoon Nah et al., 2013). Different techniques, such as the use of badges, are used in order create this sense of achievement. These techniques are described in section 2.3.2.

Reinforcement

Reinforcement is an important way of stimulating users to carry on according to the behavioral leaning model. This can be done by means of for example compliments or tangible/intangible rewards (Fui-Hoon Nah et al., 2013). In serious games reinforcement is often done by providing points or a virtual currency to the users. It is also possible to use social actors as described by (Fogg, 2002). These techniques are further described in section 2.3.2.

Competition

An important principle in most games is the competition element. Using the competition instinct that most people have is therefore also an important aspect of gamification (Glover, 2013). It increases the users engagement and focus on the learning task. Additionally, it further enhances the learners motivation (Fui-Hoon Nah et al., 2013).

Fun orientation

The characteristic which is probably the most associated with gaming is fun. Giving users the freedom to play in a fun environment shifts the feeling of 'have to do' to 'want to do' (Groh, 2012). A fun environment for the learners increases their engagement and ability to absorb new information. Additionally, the user could lose track of time which increases the time spent learning (Fui-Hoon Nah et al., 2013).

2.3.2 Serious game techniques

In both the research of Hamari et al. (2014) and Fui-Hoon Nah et al. (2013) a number of serious game techniques are mentioned. The most relevant techniques for this study are highlighted in this section.

Leaderboards

Leaderboards is one of the techniques that is most often found in literature that regards gamification (Hamari et al., 2014). It shows and compares the accomplishments of different users. This creates a form of competition motivating the users. A leaderboard can show a world ranking but can be limited to smaller groups, like a team, as well (Fui-Hoon Nah et al., 2013). However, leaderboards should be integrated with care in the applications since they could decrease motivation of users at the bottom of the leaderboard (Dias, 2017).

Levels/milestones

Levels and milestones create reachable goals for the user to pursue. In addition, it shows the progress the user has made and thus increases motivation (Glover, 2013). Finally, levels create a sense of achievement when a goal is attained.

Points

Similar to leaderboards, points are one of the most found techniques in gamification literature (Hamari et al., 2014). Point are generally used to keep track of the learners progress and score while simultaneously providing feedback to the user (Dias, 2017). Points can have all different forms, like experience points and skill points, and can be used in other mechanics, such as the leaderboard and the marketplace (Zichermann & Cunningbam, 2011).

Onboarding

Onboarding refers to the scaling of difficulty of the gamification to the level of the user (Zichermann & Cunningbam, 2011). This could prevent boredom or anxiety (Fui-Hoon Nah et al., 2013) and keeps the learner engaged (Dias, 2017).

Badges

Like leaderboards and points, badges is one of the techniques most commonly found in gamification literature (Hamari et al., 2014). Rewarding users with badges gives them a feeling of accomplishment. This system has long proven to work. The Boy Scouts of America, for example, already started handing out badges in 1911 for scouts that achieved goals (Deterding, 2012). Being able to showcase badges could create a feeling of higher social states for the user (Fui-Hoon Nah et al., 2013).

Marketplace

Virtual marketplaces create a place where the user can exchange a virtual currency for virtual things that can be used in the game. The economy that is created with the marketplace lets users experience the game more realistic and increases their engagement (Fui-Hoon Nah et al., 2013). The currency in the serious game is often gained by points the user gains after completing tasks (Zichermann & Cunningbam, 2011). However, developers could also use the marketplace to stimulate users to invest more real-life money in serious game.

2.3.3 Applying serious games

Baptista & Oliveira (2019) performed a literature meta-analysis on gamification and serious games. The study found that enjoyment, usefulness and the attitude towards gamification were the most important predictors of the willingness to use gamification. The literature often found the variables *ease of use, socialness, learning opportunities* and *recognition* to be important independent variables. It is therefore important to take these variables into account when creating a serious game.

Serious games could also provide different ways of learning. It could change from a traditional text and picture format, as is common in books, to a training that is more based on video's and animations (Laaser & Toloza, 2017). Wouters, Nimwegen, Oostendorp, & Spek (2013) suggests that having multiple instruction methods would have the best results.

Additionally, serious games can create new ways to assess a user's progress. Instead of traditional assessment methods, like a multiple choice test, gamification could create authentic activities and exercises. This could give a more accurate idea of the users achievements (Wood, Teräs, Reiners, & Gregory, 2013).

2.3.4 Effect of serious games

A lot of research has been done on the effect of serious games on education. Koivisto & Hamari (2019) reviewed the gamification research and found that the majority of the research was (almost) completely positive over the effects of gamification on education and learning. Wouters et al. (2013) performed a meta-analysis into the cognitive and motivation effects of serious games. Regarding the cognitive skills the study found that serious games were more effective than conventional instruction methods. Serious games provide a good base of prior knowledge that could help users further in their learning career. The study also found that serious games were more effective when combined with other instructional methods and when used in groups. Manochehr (2006) however describes that it is important to know that the effect is very different for people with different learning styles. People that prefer learning through thinking, watching and doing performed better with eLearning. People that prefer the use of case studies and brainstorming had better results with the traditional instructor-based learning.

Probably the most often used argumentation to apply serious games in learning is the positive effect on motivation and engagement (Da Rocha Seixas, Gomes, & De Melo Filho, 2016). To discuss motivation, it is important to distinguish intrinsic and extrinsic motivation (Kuvaas, Buch, Weibel, Dysvik, & Nerstad, 2017). Intrinsic motivation originates from someone's own desire to perform an activity which provides pleasure and satisfaction. Extrinsic motivation comes from the desire to attain positive consequence (reward driven) or to avoid negative consequences (punishment). Multiple studies show that intrinsic motivation is associated with more positive outcomes than extrinsic motivation (Kuvaas et al., 2017). However, when people are already internally motivated to pursue a goal, extrinsic motivators could enhance people's motivation (Lens, Paixão, & Herrera, 2009). Serious games can be considered extrinsic motivators that could affect the intrinsic motivation of the user. Although it has been argued that serious games could harm the intrinsic motivation, no empirical evidence has been found to support this claim (Mekler, Brühlmann, Opwis, & Tuch, 2013). Most literature seem to find a substantial increase in intrinsic motivation (Xi & Hamari, 2019). The study of Seaborn & Fels (2015) found an increase in user engagement, motivation and enjoyment as well.

Although the majority of the research shows a positive effect of the application of serious games, there are also studies that show no significant effect or even negative effects. The systematic review of Lumsden, Edwards, Lawrence, Coyle, & Munafo (2016) could, for instance, not find a significant relation between the increased engagement gained by gamification and more effective training. Serious games cannot be seen as a cure-all for education that can just be applied everywhere to improve performances (Koivisto & Hamari, 2019).

2.3.5 Serious game implementation

Serious games are currently implemented in almost all sectors, but are mostly used for education/learning and health/exercise (Koivisto & Hamari, 2019). One of the most successful examples is the learning app Duolingo that focusses on learning new languages. With about 300 million subscribers it is the largest language learning platform in the world (Duolingo, 2019). The application has integrated almost all gamification techniques mentioned by Fui-Hoon Nah et al. (2013) and Zichermann & Cunningbam (2011).

Within the construction industry serious games are not well integrated yet (Banerjee, 2017). There are some examples of learning within the construction industry where very basic forms of gamification are applied like the eLearning course of OSHA regarding health and safety on the construction site (OSHA, 2019). However, no big serious games are currently available.

Both Mohd, Ali, Bandi, & Ismail (2019) and Banerjee (2017) discuss the potential for serious games in the construction sector. These articles both focus on the use of this concept for the benefit of learning in health and safety. However, there is also potential for using serious games for planning and scheduling (Karshenas & Jaruhar, 2012).

2.3.6 Conclusion

Serious games could be defined as games that are used in a non-game context. Although they differ from gamification that only uses game elements, there is a lot of overlap. The main characteristics of serious games can be described as goal orientation, achievement, reinforcement, competition and fun orientation. To accomplish these characteristics a large number of gamification techniques can be applied in a serious game of which leaderboards, points and badges are the most commonly used. To make sure people use the application it is important to focus on usefulness, enjoyment and the attitude of people towards the game. Additionally, a serious game can also be used for new opportunities in learning, such as the use of videos and new assessment methods.

The effect of serious games is twofold. First there is an increase in the cognitive learning of users. The knowledge they gain can be seen as a good base for further learning. However, the effect is dependent on what type of learner the user is. Furthermore, serious games have an impact on the motivation and engagement of learners. If used well it could enhance the intrinsic motivation of the user. However, it is important to take into account that not all researches show a positive effect and it is important to study and evaluate the potential and possible effects of the application of a serious game.

There are multiple very successful serious games developed over the years. However, so far there are none for the construction sector even though multiple studies show that using serious games in the construction sector could have potential for further learning.

2.4 Conclusion

This literature research shows that the concept of lean construction has a large potential for the construction sector. It could decrease delays and costs while increasing quality and customer and employee satisfaction. However, the concept is not yet much integrated in the sector. When lean construction is applied there are often only a couple of people that have followed a training in lean while the literature shows this small group of people that understand LC could result in a decrease in the willingness of other employees to work with LC. Basic training of the entire team is necessary to implement lean in the construction sector.

Currently the lean construction trainings are mainly done by means of workshops. This is an effective way of training people and motivate them to use the things they have learned in practice. However, workshops done in small groups which makes them relatively expensive and unpractical for the scale of the construction sector. A new way of training can be found with the concept of serious games to provide basic training for the majority of the construction sector. To create a serious game, gaming techniques are used to motivate and engage users. This concept could provide an opportunity to train the construction sector a base in lean construction. A possible policy could be to train the majority of a team in a basic training of lean construction by means of the serious game (white or yellow belt level) and train a couple of people on a more export level (green or black belt) by means of workshops. This concept is illustrated with Figure 2.5.

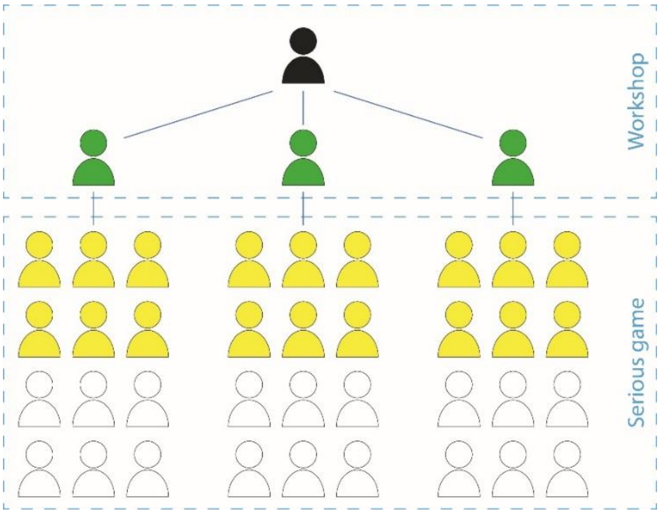

Figure 2.5 - Application serious game related to LC level

2.4.1 Research gap

Although the majority of the literature is very positive about the effects of serious games, there is also literature that shows that not all serious games are successful. Proper research is necessary to find if there is potential for a serious game training in lean construction. This would also give more insight in the possibility of implanting other serious games in the construction sector. Additionally, it is important to know what the preferences of future users are for such a training so it could be successfully implemented.

3

METHODOLOGY

This chapter describes the research approach of this study after the literature review. After the introduction to the chapter, the variables that are used for answering SQ 5 and 6 are described, as well as how they are retrieved from the questionnaire. Additionally, this chapter describes the techniques that are used to test the quality of the variables in the data set when the respondents have filled in the survey. Then the conceptual models for SQ 5 and 6 will be made and research methods for the regression analyses are explained, specifically an ordinal and a multinomial logistic regression analysis. The section after that will describe the stated choice experiment and how this is set up, followed by a section that describes the latent class analysis. Both these analysis types are used to answer the seventh sub question. The last sub question will be answered by means of a mock-up as described in section 3.6. Finally the conclusions of the methodology chapter will be discussed.

3.1 Introduction

The literature review in the previous chapter describes the characteristics of lean construction and serious games. Additionally, it describes how people are currently trained in LC and how serious game could have an influence on these trainings. The literature research is considered a qualitative study that answers the first four sub questions of the research question.

As described in section 2.1.4 lean construction has much potential in the construction industry. However, to obtain that it is necessary that a large number of people in the sector are familiar with this concept and would therefore need a training. So far it is still unclear who would be most interested in learning more about lean construction and would therefore be the best target group. Besides knowing what factors influence the willingness to learn more about lean construction (SQ 5), it is also necessary to know what variables influence the willingness to use a serious game for an LC training (SQ 6). Furthermore, the literature shows that it is important for a serious game to be well designed. The characteristics of the serious game can be very influential on the willingness of people to use the game (SQ 7). Therefore, research in what attributes the serious game needs should be done. Finally, it is important to know what such a serious game training should look like (SQ 8).

The literature does not provide answers to these questions, which is why the sub questions 5 to 8 are part of this study. Therefore data needs to be collected and prepared. Secondly, the data is tested on its quality with five tests. Sub question 5 and 6 (the target group) will be answered by means of regression analyses as described in section 3.4. For analyzing the user preferences (sub question 7) a general stated choice analysis and a latent class analyses will be used. How this analysis is set up is described in section 3.5. Sub question 8 will be the result of the conclusions of the previous sub questions and will make the conclusions more tangible.

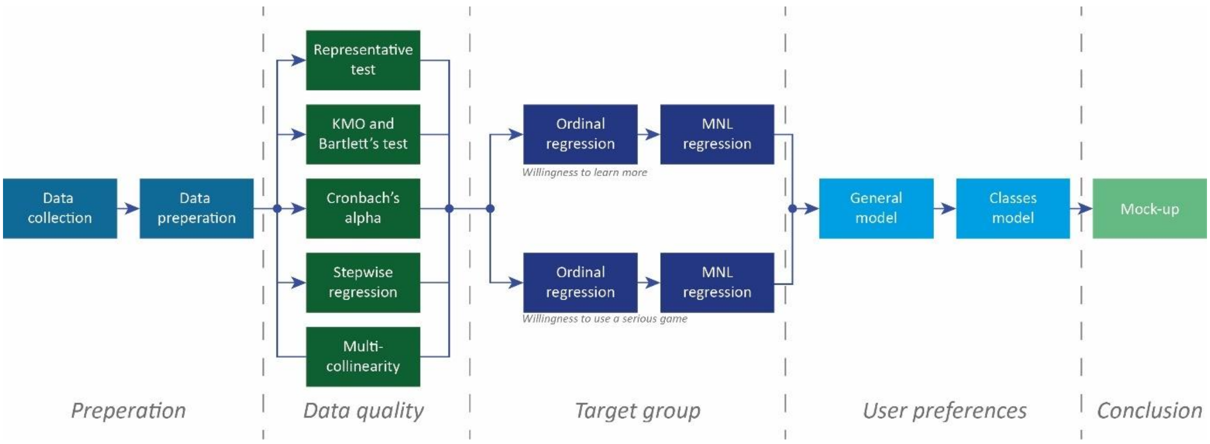

Figure 3.1 - Flow chart of research analysis

3.2 Variables and questionnaire

To collect the data necessary for this research a survey is set up. This survey includes the questions related to the regression analysis that are explained in section 3.4. Additionally, the stated choice analysis is included in the survey. This will be described in section 3.5. The questionnaire is created with the program LimeSurvey Professional. This is an open source survey tool that has a large community of people developing different tools that can be used for all sorts of questions and analyses (LimeSurvey, 2020).

The questionnaire will consist of six question parts:

- Sociodemographic questions
- Lean construction questions
- Serious game questions
- Stated choice questions
- Innovation statements
- Open question for comments

In between the question groups there will be explanations of the survey, lean construction and serious games. The final questionnaire is shown in Appendix B.

This section describes what variables are used for the ordinal and multinomial logistic (MNL) regression analyses. In addition to defining the variables it will also be discussed why these variables are implemented in this research. Finally the exact question as used in the final survey is described. The questions are split into four parts: sociodemographic questions, lean construction questions, serious game questions and innovation statements. The stated choice questions will be explained in section 3.5.1.

3.2.1 Sociodemographic questions

The six sociodemographic questions are described in this section.

Age

The research of Koivisto & Hamari (2014) shows that multiple studies found a relation between age and gamification characteristics. Younger generations have used a lot of digital technology in their youth and usually adopt new technology earlier than older generations that feel more computer anxiety and are less self-reliant. Older generations value ease of use therefore relatively more and are more influenced by social influence while younger employees usually prefer to be more autonomous. Their differences in serious game preferences could be interesting for the development of a serious game for a lean construction training in order to target specific or multiple groups. Additionally, younger people generally have a different mindset regarding their personal development than older people. The attitude towards learning usually declines when people get older (Vianen, Dalhoeven, & Pater, 2011). Therefore, the age of the respondents is included in the survey. The question used in the survey is: *What is your age?*

Gender

Multiple studies have found differences between gender regarding technology adoption (Koivisto & Hamari, 2014). Men usually are more task- and achievement orientated and more often act to satisfy a specific motive (instrumental behavior). Therefore, they are generally more affected by te usefulness of the technology than women who are influenced more by affiliation and interpersonally-orientation. Social influence is therefore on average more important for women, while men focus more on the pragmatic use. Additionally, since IT is more male-dominated, women usually feel more computer anxiety and are therefore less likely to enjoy computer use. It is however important to say that there is a high level of variety within the genders (Koivisto & Hamari, 2014). Since these differences could influence the development of a serious game this demographic question is included. The survey uses the question: *What is your gender?*

Level of education

Kim et al. (2015) described also the relationship between education level and smartphone use. People with a higher level of education use the smartphone more often than people with a lower level of education. There are also differences in the reasons for using a smartphone. While highly educated people use their smartphone relatively often for e-commerce, information, literacy and relational use, lower educated people use a smartphone more often for entertainment. These differences in use could have in influence on the willingness to adopt a serious game and the preferences for this game. Therefore, this sociodemographic factor is included in the survey.

The question used for the survey is: *What is the highest level of education you have completed?* The available options were: *Primary school, Pre-vocational secondary education, High school or vocational training* and *Bachelor's degree, Master's degree or PhD.*

Working situation

How much someone works in the construction sector might be of influence on how relevant a respondent finds a lean construction training. Additionally, students in the construction sector might have less experience with the problems that could occur in a construction process.

This resulted in the following question: *What is your working situation?* The answer options are: *Working (paid) more than 30 hours a week, Working (paid) 12-30 hours a week, Working (paid) less than 12 hours a week, Student or intern, Unemployed/looking for a job, Retired* and *No answer.*

Job type

Usually different disciplines are more active in different parts of de construction process. For example: architects are more involved in the design phase while a contractor is more involved in the later phases of the project. Lean construction techniques are sometimes more effective in specific phases. Therefore, it might be interesting if the serious game differentiates between different disciplines and for this reason the type of job is included in the survey.

The question used in the questionnaire is: *What type of job do you have (or which option describes your profession best)?* and the answer options are: *Contractor, Architect/Urban designer, Building physicist, Draughtsman, Construction laborer/execution, Structural designer, MEP engineer, Project manager, Real estate developer* and *Other, namely.*

Project scale

Santana (1990) described three categories for the complexity of construction projects: normal projects, complex projects and singular projects. This order includes social, economic and environmental impact and the number of specialists, consultants and contractors involved. This rule-of-thumb classification was further described by Safa et al. (2015) that stated that normal projects are generally dwellings, roads and earthworks, while complex buildings are most industrial projects, public works and town development schemes. Singular projects are very unique projects, like the tunnel between France and the UK. Since there are usually more stakeholders involved in complex projects, applying lean construction in the project has relatively more effect. Therefore, people working in more complex projects might be more willing to invest in a lean construction training. Since singular projects are very rare they are not included in the survey.

The question asked in the questionnaire is: *Is the complexity of the projects you are working on in general normal (dwellings, roads, etc.) or extra complex (train stations, area development plans, etc., where a lot of different stakeholders are involved)?* A 5-point-Likert-scale is used for the answers. The options are *Normal, Mostly normal, Neutral, Mostly complex, Complex* and *Not applicable*.

3.2.2 Lean construction questions

It is important to know the respondents view on lean construction and whether they are willing to learn more about the concept. Therefore, it is important to know how well they already know the concept since research has shown that people that already know about lean, or at least had some training, are more enthusiastic about the concept (Oladapo et al., 2019; Salem et al., 2005; Hamzeh et al., 2016). Therefore, the first five questions in this part of the survey are related to how well the respondent is already familiar with lean construction. The last questions are related to their willingness to learn more about the concept.

LC training

One of the easiest ways to know if they are familiar with the concept is to know if they have had any training in lean. This training could be done by an external company but also internally. The question asked is: *Did you have any training in lean in the past?*

LC training level

If the respondent had a training in lean the belt level of that training gives an indication of the depth of the knowledge of the respondent. This question is only asked if the previous question is answered with *yes.* The belt levels are described in section 2.2.3.

In the survey the question was asked: *What is the highest level you have achieved in a lean training?* The answer options are: *White belt, Yellow belt, Orange belt, Green belt, Black belt, Master black belt, No idea* and *Other, namely*.

Prior knowledge LC

Asking the respondent how much he/she knows about lean construction would give a good indication of how much they actually know. Of course the respondents could interpret their own knowledge differently, but it can still give a general idea. The questions the respondents got was: *How well did you already know the concept of lean construction before this survey?* This could be answered on a 5-point-Likert-scale from *Not at all* to *Very well.*

LC techniques known

A more objective way of knowing the knowledge of LC of the respondents is by asking them if they are familiar with the techniques used in lean construction.

The question the respondents were asked was therefore: *Which of the following lean construction techniques have you already heard of?* The respondents were presented with a list of 22 of the most common LC techniques: *Last Planner System, Just-In-Time, Pull Planning, Daily clustering/huddle meeting, 5S, Kaizen, Total Quality Management, Virtual Design Construction, Error Proofing (Poko-yoke), Kanban System, Standardization, First Run Study, Target Value Design, Gemba Walk, Design Workshop/Big Room, Knotworking, Benchmarking, Fail Safe for Quality and Safety, Design Structure Matrix (DSM), Location-Based Management System* and *Other, namely* (Babalola et al., 2019).

LC techniques used

Besides knowledge of lean construction and its techniques, the willingness to learn more about lean construction might also be influence by the extent to which respondents have implemented lean construction in their field. Therefore, respondents are asked: *Which of the following lean construction techniques have you applied in your work?* The options the respondents got were the options they checked in the previous question.

LC learn more

After establishing how well the respondent is familiar with lean construction, the respondents can be asked whether they are willing to learn more about the concept. This variable is one of the two dependent variables that is used in the regression analysis. It is important to have a good idea of what type of people are interested in learning more about the LC since this could indicate the target group of the serious game.

The respondents are asked if they agree with the following statement: *I am interested to learn more about lean construction.* Respondents could answer on a 5-point-Likert-scale with the answers: *Definitely not, Probably not, Neutral, Probably yes* and *Definitely yes*.

LC xxh training

There is a clear distinction between the length of a lean training in theory and in practice. For a yellow belt training the literature states that a training of 40 hours should be given (Laureani & Antony, 2011). However, in practice such a training takes 1-4 days depending on the company providing the workshop (Bureau Tromp, 2019; LeanConsultancyGroup, 2019; Lean.nl, 2019). On average a basic workshop in lean takes about 2 days. A reason for this difference between theory and practice might be that professionals consider a 40 hour training too long and not worth it. Therefore, it might be interesting to study the preferences of professionals following a training in lean regarding the length of such a training.

Respondents will therefore be asked how much they agree with the following two statements:

- I am willing to participate in a lean construction workshop of 16 hours
- I am willing to participate in a lean construction workshop of 40 hours

The same 5-point-Likert-scale as in the previous question is used as answer options.

3.2.3 Serious game question

After a short explanation of the concept of serious games the respondents will get questions regarding their willingness to use a serious game.

Willingness SG in LC

The other dependent variable in the regression analysis is the willingness to use a serious game for a lean construction training. This would show if there is potential for the serious game and give a direct view of its target group.

The respondents were asked how much they agreed with the following statement*: I am willing to follow a lean construction training by means of a serious game*. The answer options were given in a 5-point-Likert-scale with the options: *Definitely not, Probably not, Neutral, Probably yes* and *Definitely yes.*

3.2.4 Innovation statements

Not everyone is equally open to a new innovation. Rogers technology adoption model is often used to categorize people into innovators, early adopters, early majority, late majority and laggards (Rogers, 1995). A different approach is necessary for all different groups in order to make sure the serious game is well adopted. Therefore, it is necessary to have some idea of how innovative the respondents of the survey are. Therefore, the last category of the survey is dedicated to a set of statements regarding innovation. The respondents can fill in how much they agree with the statements in order to get some idea of how innovative the respondents are. Answers could be given in the same 5-point-Likert-scale as in the previous question.

Innovation level

The variable innovation level will consist of the unweighted average answer the respondents give to six statements regarding innovation. These are the following statements:

I am interested in new innovations

This statement gives a general idea of how open the respondent is to new technology.

I think the construction sector should be more innovative

The respondents are asked about their opinion about the innovation in construction sector. If the opinion is that the construction sector should not be more innovative the respondents might be less willing to learn more about lean construction than when the opinion is that it should be more innovative.

I often try to improve the way I work

Like the previous statement, this statement could tell something about the respondents willingness to learn more about lean in order to improve their work. Only this time the motivation is more on a personal level.

I like to learn new things

This statement tells something about the willingness to learn new things in general that could be an indication of the willingness to learn more about lean construction.

I often invest money in new innovations

There could be a gap between respondents being interested in the serious game and respondents that would actually use it. Therefore, it might be interesting to ask whether they usually really pursue their interest, because if there are only people interested in the serious game without using it, it cannot integrate well.

I have used other types of serious games to learn new things

Previous experiences with serious games for learning could have an influence on the respondents willingness to adopt another application as well.

3.3 Data quality

After the data is collected and prepared a series of analyses is done that describes the quality of the data set. This would determine what data can be scientifically used for this research. Additionally, these analyses show the context and limitations of the study.

3.3.1 Chi-square goodness of fit test

A chi-square analysis can determine how well the data collected represents the actual situation. Known distributions of variables such as *Age*, that could be retrieved from large data sets, are compared with the distribution of the data set of this research. If there are small differences in the data set, the data that is collected can be considered a good representation of the real situation. When there is a bid difference, this should be taken into account when drawing the conclusions of the research.

The chi-square goodness of fit test uses the observed (O) variables that are collected in this research, and compares them with the expected (E) variables that represent the actual situation. The following formula is used to calculate the chi-square (Statistics How To, 2020b):

$$X_c^2 = \sum \frac{(O_i - E_i)^2}{E_i} \qquad (1)$$

In the formula X_c^2 is the chi-square with *c* as degrees of freedom. O_i is the observed value of variable level *i* and E_i is the expected value of variable level *i.*

3.3.2 KMO and Bartlett's test

The Kaizer-Meyer-Olkin (KMO) measure of sampling adequacy is a statistical analysis that indicates the proportion of variance in the variables that might be caused by underlying factors (IBM, n.d.). Higher values, that are close to 1.00. are generally better and show that a factor analysis might be useful with your data. Values under 0.50 are probably not that useful.

The Bartlett's test of sphericity compares an observed correlation to the identity matrix in order to see if they are significantly different (Statology, 2019). When there is a significant difference (less than 0.05) a factor analysis could be useful with the data (IBM, n.d.).

3.3.3 Cronbach's alpha test

The Cronbach's alpha measures the internal consistency, or reliability of a data set. This means how well the data set measures what it should measure (Glen, 2014). This test is especially useful when multiple Likert scale analyses are done, like in this research. The Cronbach's α is a value between 0.00 and 1.00. The higher the value, the better. Usually a value of 0.7 of higher is considered acceptable, 0.6-0.7 is questionable and lower than 0.6 is poor or unacceptable (Kreulen, n.d.). The formula for the Cronbach's alpha is (Glen, 2014):

$$\alpha = \frac{N * \bar{c}}{\bar{v} + (N-1) * \bar{c}} \qquad (2)$$

In this formula N is the number of items, $\bar{c}$ is the average covariance between item-pairs and $\bar{v}$ is the average variance.

3.3.4 Stepwise regression analysis

In a stepwise analysis a model is built by adding or removing independent variables based on the F value of the variables. The analysis can be done with the forward and the backward method. In the forward method the predictor variables are added one by one based on the highest F value. In the backward method all variables are included at first but are removed one by one starting with the lowest F value (Glen, 2015b). Both methods result in a selection of the independent variables that could be considered to have the most influence on the dependent variable.

Although the stepwise analysis is an easy and quick way to analyze the possible predictors of an dependent variable, it also has some disadvantages. The analysis does not always give the most accurate view of the best predictors. There are often problems with multicollinearity in the analysis and R-square values are often predicted to high (Glen, 2015b). In this study the stepwise regression analysis is therefore only done to have a quick overview of what independent variables are important in the analysis but no mayor conclusions will be drawn from them.

3.3.5 Multicollinearity test

For the analysis it is important to know if there is any multicollinearity between the predictor variables. This would indicate if a relation between two variables could possibly also be caused by another variable. To analyze the correlation between two variables it is important to know their measurement levels.

When a categorical variables (nominal or ordinal) is compared with another categorical variable, a chi-square test of independence can be done (Statistics How To, 2020b). Two continuous variables (interval or ratio) can be compared in a Pearson's correlation matrix (Glen, 2016a). When a continuous variable is compared with a categorical variable an ANOVA test is used (Statistics How To, 2020a).

3.4 Target group

As previously mentioned sub question 5 and 6 will be analyzed by means of a regression analysis. A regression analysis can be described as a method to find the relationships between a set of independent variables and the dependent variable. A regression analysis can be done linear and nonlinear depending on the relation between the variables. To answer SQ 5 and 6 a ordinal and multinomial logistic regression are used which will be described in the next sections. The last section will discuss the conceptual models of the relation between the variables.

3.4.1 Ordinal logistic regression

The two dependent variables that are used for the regression analyses both have an ordinal measurement level. Therefore, an ordinal regression analysis can be used for the analyses. This type of analysis tells if (any of) the independent variables have an significant effect on the dependent variable (Laerd Statistics, 2019). Additionally, the strength of the effect is identified.

There are a couple of assumptions that need to be taken into account for this type of analysis (StatisticsSolutions, 2019):

- There should be only one dependent variable
- There is an adequate cell count for the majority of the cells. No cells should have zero count.
- The regression equation for each category is the same, except for the last (reference) category. This can be tested with the test of parallel lines.

In addition to these assumptions, it is important that there is no multicollinearity of the variables in the analysis. This will be checked with the multicollinearity test as described in the previous section.

3.4.2 Multinomial logistic (MNL) regression

Apart from the ordinal regression analysis, this study also includes a multinomial logistic regression analysis. This type of analysis is similar to the ordinal regression, but does not have the assumption of proportional odds (all equations are the same). This means that the analysis looks to all the levels of the dependent variable separately and compares them with the reference category . The ordinal regression would give a more general overview of what happens to all the different variables, while the MNL regression shows more in detail what happens to the variables in each category of the dependent variable.

3.4.3 Conceptual models

For the regression analyses it is important to have a good overview of relation between the dependent and independent variables. The variables that are used in this research are already explained in section 3.2, but to place them into context the conceptual models for sub question 5 and 6 are made. In addition the measurement levels are included in these models since these are also important to consider when performing the analyses.

Sub question 5 – LC learn more

For the fifth sub question the variable *LC learn more* as dependent variable. This variable describes whether the respondents are willing to learn more about lean construction. In this analysis 11 independent variables are used of which 4 have a nominal, 4 an ordinal, 1 an interval and two a ratio measurement level. The dependent variable has an ordinal measurement level, as can be seen in Figure 3.2.

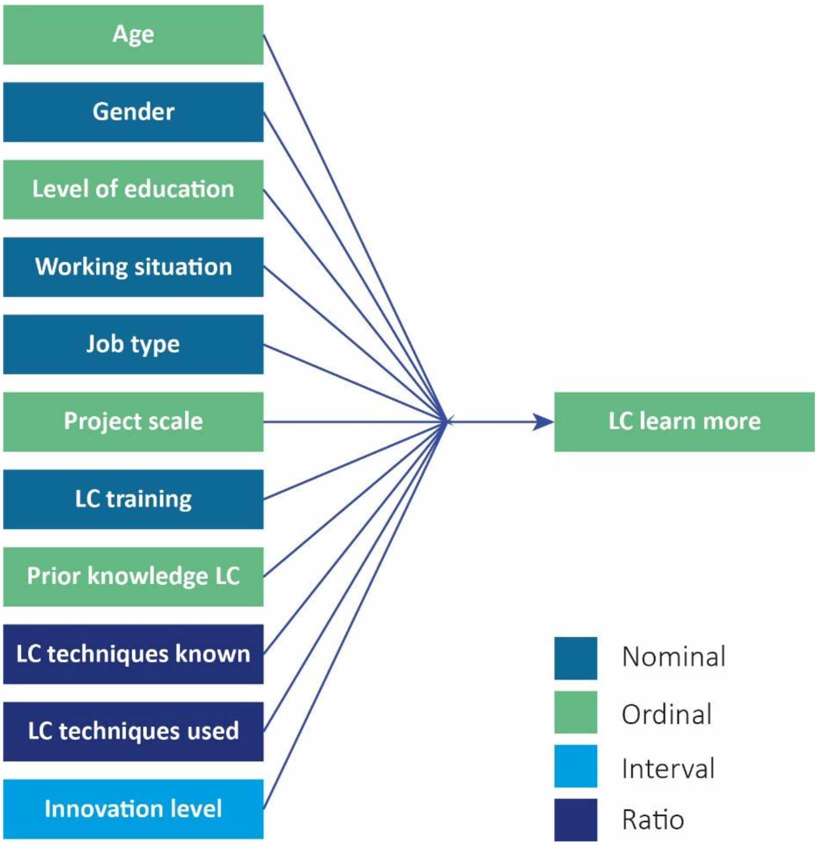

Figure 3.2 - Conceptual model LC learn more

Sub question 6 – Willingness SG in LC

The sixth sub question uses the variable *Willingness SG in LC* as dependent variable. This variable again has an ordinal measurement level. 14 variables are used as independent variables as can be seen in Figure 3.3. Of the independent variables there are 4 nominal, 7 ordinal, 1 interval and 2 ratio measurement levels.

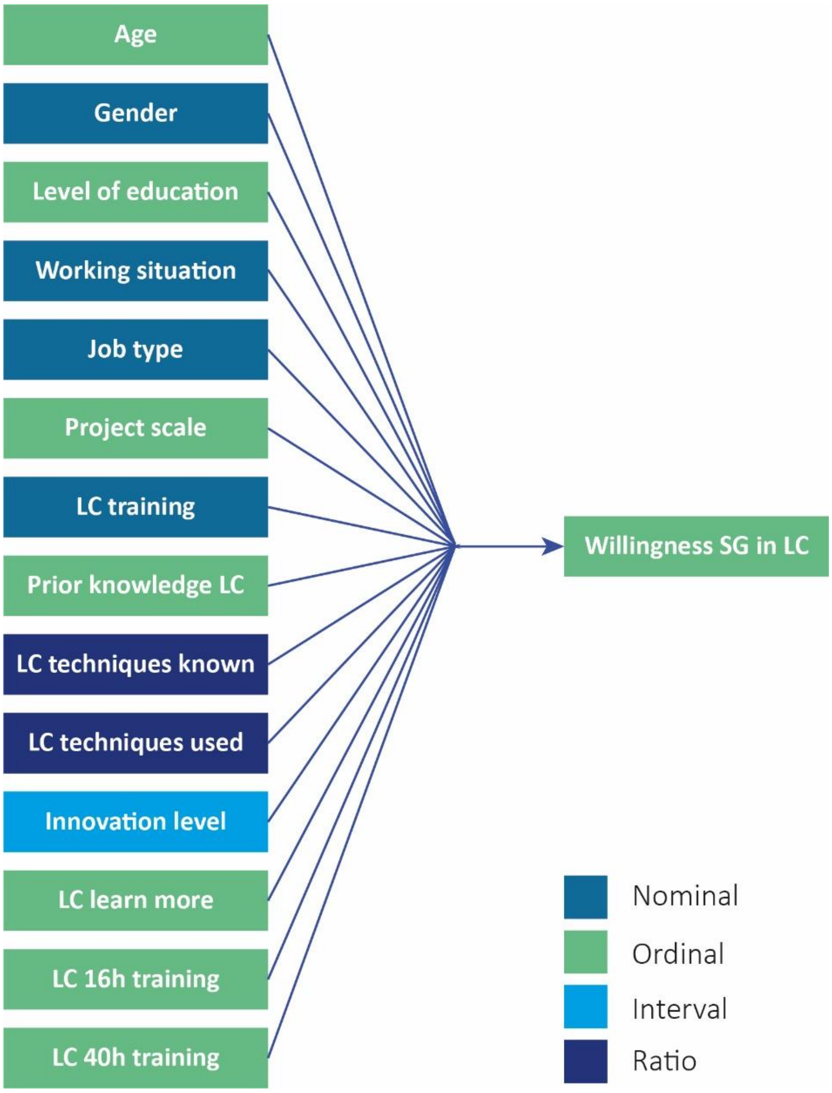

Figure 3.3 - Conceptual model Willingness SG in LC

3.5 User preferences

Section 3.4 describes what methods are used to answer sub question 5 and 6. Sub question 7 however is based on the preferences of potential users for the serious game. Therefore it would be helpful to analyze the choice behavior of respondents in order to see what attributes of a serious game are considered more important. Kemperman (2000) distinguishes different types of behavior choice analysis, as can be seen in Figure 3.4. Choice behavior can be analyzed in a revealed way (real life choices) or in a stated way (with hypothetical choices). Since there are no serious games for a lean construction training developed, it is not possible to analyze which choice people make in real life and therefore the hypothetical stated type is chosen.

3.5.1 Stated choice model

In this type of analysis a distinction can be made between stated preference and stated choice that would analyze the preferences and choices of the respondents. One way of determining the preference of respondents is by the compositional method. The respondent would then first evaluate each attribute level on its attractiveness and rate this on a scale. After that the respondents will weigh the importance of each attribute by, for example, allocating 100 points across the attributes.

With the decompositional method the respondent has to make a choice between different alternatives. This creates a trade-off between the attributes of the alternatives. With this method it is possible to analyze the preferences and choices of respondents and clearly show how important certain attributes are considered. This stated choice method is therefore chosen for this analysis. This approach is well-recognized as technique for measuring choice behavior and preferences for alternatives that do not yet exist (Kemperman, 2000).

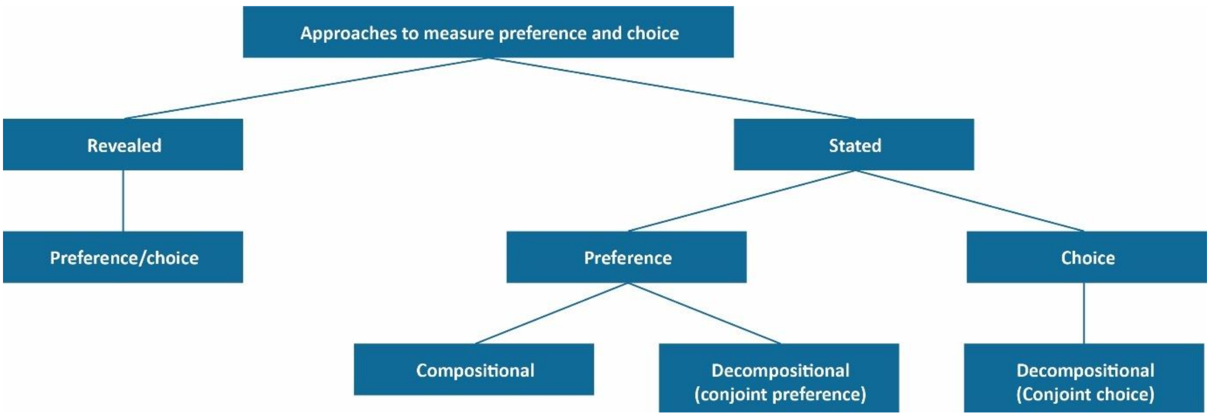

Figure 3.4 - Approaches to measure preference and choice, adapted from Kemperman (2000)

Hensher, Rose, & Greene (2015) developed a model for setting up stated choice experiments that will be used in this study. This experimental design process consists of eight stages: problem refinement, stimuli refinement, experimental design consideration, generate experimental design, allocate attributes to design columns, generate choice sets, randomize choice sets and construct survey instrument. This process can also be seen in Figure 3.5. The next sections will describe the decisions that are made for this study per stage.

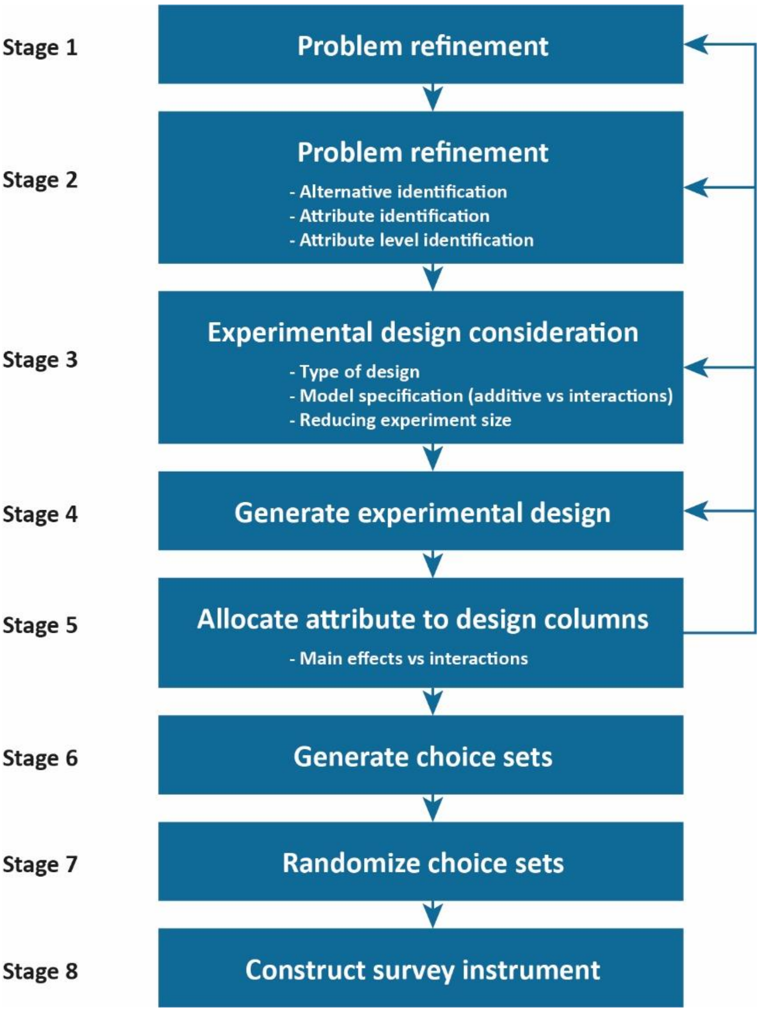

Figure 3.5 - Stated choice process adapted from Hensher et al. (2015)

Stage 1 - Problem refinement

The first stage of the model of Hensher et al. (2015) refines the research problem. By means of the regression analysis, described in the previous section, it is already analyzed what type of people would be interested in learning more about lean construction and would be willing to use a serious game for that. The next step would be to analyze what should be included in such a serious game. It is necessary to perform this analysis since there is no literature currently available regarding a serious game training for lean construction. This is important because serious games can be very unsuccessful if not well implemented (Koivisto & Hamari, 2019).

Stage 2 - Stimuli refinement

To measure the choice behavior of people, different alternatives are presented to the respondents. These alternatives have different attributes, which are the characteristics of the alternative. These attributes influence the choice of the respondents. It is therefore important that these attributes are well defined and independent of each other to prevent correlation. Each attribute has a number of levels which provides different options the specific attribute could have. This section describes the five attributes that are used for this experiment and the levels these attributes have.

Presentation information

A serious game could provide different ways of learning. It could change from a traditional text and picture format to a training that is more based on videos (Laaser & Toloza, 2017). Wouters, Nimwegen, Oostendorp, & Spek (2013) suggests that multiple instruction methods would have the best results. Therefore, the option to combine both the traditional text and picture format and the custom made animations and videos is also included in the survey.

Levels:

- Text and images
- Videos and animations
- A combination

Assessment

Besides the different ways in which the information could be presented to the user, there are also different ways in which it could be assessed. Laureani & Antony (2011) describes two ways of assessing the progress someone is making. This could be done by testing the knowledge someone has gained by, for example, a multiple choice test. Secondly the gained experience of people could be tested. This can be done with analyzing the performance of people when they make exercises that represent real life scenarios. Serious games could have the option to assess this way instead of the traditional multiple choice. This last option could give a more accurate idea of the users achievements (Wood et al., 2013). Alternatively, a combination of the two options would be possible. This would provide different options of testing for people with different learning strategies, which could be a very effective way of training (Wouters et al., 2013).

Levels:

- Multiple choice test
- Example exercises
- A combination

Depth

As described in the literature review in section 2.2, there is difference in length of the training between the theory and practice (Laureani & Antony, 2011). Therefore, it might be interesting to include this variable in the stated choice experiment. A distinction will be made between a 16 hour, which is often done in practice, and a 40 hour training, according to the theory of Laureani & Antony (2011). Additionally, a serious game is very suitable for making customized training programs that focus mostly on the lean construction techniques applicable for the user.

Levels:

- Basic (ca. 16h)
- Advanced (ca. 40h)
- Customized (variable length)

Achievement system

As described by Fui-Hoon Nah et al., (2013) an achievement system is an essential part of a serious game. The study mentioned a list of different ways such an achievement system could be set up. Some of these techniques can be easily implemented in a serious game and used in almost all of them, such as badges and levels. Other techniques have a bigger impact on the serious game and how the user experiences it. Two of these techniques, that were suitable for this particular serious game are therefore included in the stated choice, since it would be interesting to know how potential users might value these features. With the first one users could receive a virtual currency when finishing lessons that they could spend on buying things in a virtual marketplace included in the serious game. With the second technique users would participate in an online competition against other users. Finishing a lesson results in experience points that could raise the users position in an online leaderboard. Both techniques, and the 'neither' option are included in the stated choice.

Levels:

- No additional achievement system
- Points for online economy
- Experience for (anonymous) competition

Certificate

Professionals that would use a serious game for a lean training might be more motivated to end a specific course if this results in an official certificate (Laureani & Antony, 2011). On top of the virtual achievements, that usually do not matter at all in real life, users could receive a certificate that does. This could also be helpful for employers that want to implement lean construction and could ask their employees to be certified. Such a policy could give a user of the serious game more extrinsic motivation, which would be beneficial if the user was already intrinsically motivated (Lens et al., 2009).

Levels:

- Certificate
- No certificate

Table 3.1 shows an overview of all the attributes and attribute levels that are used in the stated choice experiment.

Table 3.1 - Overview attributes and attribute levels stated choice

Attribute		Attribute level	
1	Presentation information	1	Text and images
		2	Videos and animations
		3	A combination
2	Assessment	1	Multiple choice test
		2	Example exercises
		3	A combination
3	Depth	1	Basic (ca. 16h)
		2	Advanced (ca. 40h)
		3	Customized (variable length)
4	Achievement system	1	No additional achievement system
		2	Points for online economy
		3	Experience for (anonymous) competition
5	Certificate	1	Certificate
		2	No certificate

Stage 3 - Experimental design consideration

After the attributes and attribute levels are defined the different profiles can be made for the alternatives. Since there are 5 attributes with each 2 or 3 levels a total number of 162 profiles could be made that would all be unique. This would be the full factorial design. Creating this much profiles would be very inefficient and creates to much choice options for the respondents. Therefore, this research choses to use a fractional factorial design that select only a small group of profiles in which the attribute levels are spread in a way that all options are well represented.

All the alternatives that are made are options for the serious game and come from the same experiment design. They cannot be differentiated apart from the attribute levels and are therefore unlabeled.

In addition to the two serious game options there would also be the option for respondents to fill in 'neither' if they do not wish to use any of the two serious game options they were presented with.

Stage 4 - Generate experimental design

To make sure the selected profiles are well distributed the statistical program SAS (Statistical Analysis Software) is used for stage 4 to 6. The input in SAS to create the experimental design, for these stages, can be found in Appendix A. First, it is important to know how big the experimental design should be. As discussed in Table 3.1 there are four attributes with three levels and one attribute with two levels. When this is put in SAS it results in an advice for either 18 or 36 profiles. Both would create a design that is 100% efficient and therefore this research choses for the smaller option of 18 profiles.

Stage 5 - Allocate attributes to design columns

When the design size is determined SAS can distribute the attribute levels over the different profiles. This is done in a way that all options are well represented in the experimental design. The results are shown in Table 3.2.

Table 3.2 - Full experimental design stated choice

Profile	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5
1	3	1	3	2	1
2	1	2	3	1	2
3	3	3	1	1	2
4	1	1	2	2	2
5	1	3	2	3	1
6	1	2	1	3	1
7	2	1	1	3	2
8	2	3	1	2	2
9	3	1	2	3	2
10	2	2	3	3	2
11	2	1	3	1	1
12	3	2	1	2	1
13	1	1	1	1	1
14	1	3	3	2	2
15	2	2	2	2	1
16	3	3	3	3	1
17	3	2	2	1	2
18	2	3	2	1	1

Stage 6 - Generate choice sets

The 18 profiles described in the previous section are the ones used in the survey. They will be compared with each other in order to analyze the choices the respondents make. The respondents repeatedly have to make a choice between two of these profiles. This results in nine questions for each respondents which can still be considered achievable. The 18 profiles therefore need to be split in block A that will be compared with block B. In both blocks the attribute levels need to be well represented. Therefore SAS is used one more time to make a good distribution. The results are shown in Table 3.3 and Table 3.4.

Table 3.3 - Block A experimental design stated choice

Block	Profile	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5
A	1	1	2	3	1	2
	2	1	1	2	2	2
	3	1	3	2	3	1
	4	2	1	1	3	2
	5	2	3	1	2	2
	6	2	1	3	1	1
	7	3	2	1	2	1
	8	3	3	3	3	1
	9	3	2	2	1	2

Table 3.4 - Block B experimental design stated choice

Block	Profile	Attribute 1	Attribute 2	Attribute 3	Attribute 4	Attribute 5
B	10	3	1	3	2	1
	11	3	3	1	1	2
	12	1	2	1	3	1
	13	3	1	2	3	2
	14	2	2	3	3	2
	15	1	1	1	1	1
	16	1	3	3	2	2
	17	2	2	2	2	1
	18	2	3	2	1	1

Stage 7 - Randomize choice sets

By randomizing the choices the respondents have to make the quality of the data that is gained would be better. The respondents would always have a choice between a profile from block A and one from block B. The profiles in block A are always in the same order from 1 to 9. However, the order of the alternatives of block B changes randomly per respondent. Each combination between a profile from block A and B is possible. This creates a total of 9 different choice sets of which the respondent gets one randomly selected.

Stage 8 - Construct survey instrument

As described before, the survey is made with the program LimeSurvey. With this program it is possible to randomize the choice sets and create the rest of the survey. Of course not all respondents are familiar with the serious game concept and they might not understand the attributes and levels that are used in study. Additionally, a lot of respondents are not familiar with stated choice questions in surveys. It is therefore necessary that the survey includes a good explanation of the stated choice questions they would get. The explanation that is used for these questions can be found as part of Appendix B. Pop-overs are used that give additional information to the attribute levels. These pop-overs are also used in the stated choice questions themselves so respondents can have a quick look at what specific attribute levels mean again. Figure 3.6 shows what the stated choice questions eventually look like.

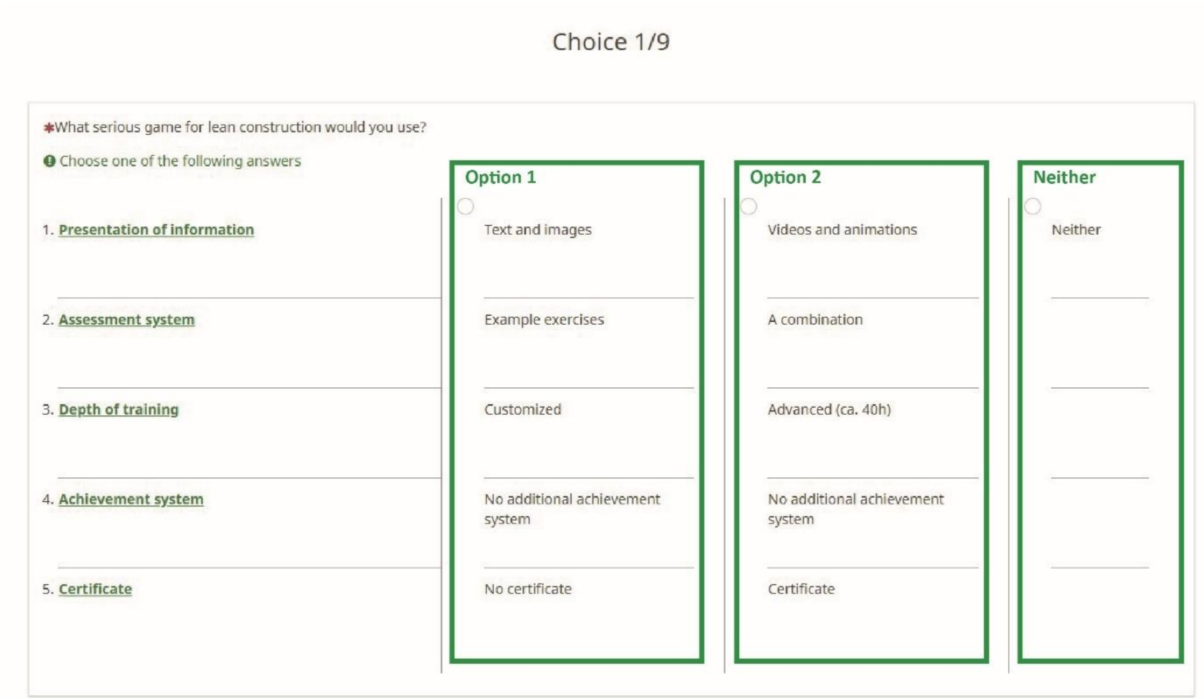

Figure 3.6 - Example stated choice question

3.5.2 Latent class analysis

The latent class analysis (LCA) is a statistical method that forms groups with similar, unobserved characteristics, from multivariate data. The data is analyzed on hidden (latent) patterns that could form groups (classes). These groups can then be compared with, in this case, the data retrieved from the stated choice analysis (Glen, 2015a). This would give new insights for the results.

The ordinal and MNL regression analysis will result in a number of variables that influence the willingness of respondents to learn more about lean construction and to use a serious game for that. These variables will be used as input for the LCA to form different classes. The purpose of this analysis is to have more insight in the preferences of specific groups for the serious game. This way the serious game could be more specified for the target group.

The program nlogit is used to perform the LCA and compare the data. To make sure the results have a high quality the model will be optimized to have the lowest Akaike's Information Criterion (AIC) value and lowest number of iterations. The optimization will be done by means of adjusting the tolerance for convergence on gradient (tlg) value (Greene, 2007). This optimization will define the optimal number of classes the model produces (Nylund & Muthén, 2007).

3.6 Mock-up

After all research has been done, from the literature review to the regression analyses, stated choice and latent class there will be a number of techniques that could be included in a serious game of a lean construction training. These different ideas, derived from the research, will be combined into a mock-up that would provide a clear overview of all the conclusions that are drawn from the analysis. A mock-up of the serious game would give an impression of what could eventually be included. In addition, a mock-up would be an interesting visual tool to can be used to better communicate the idea of the serious game.

Creating a prototype of the serious game as a (partially) functioning application would be an elaborate process and not fit in the scoop of this research. Therefore, a mock-up that consists of images as examples of what the serious game could look like would be more suitable. The images are created with Adobe Illustrator.

3.7 Conclusion

To conclude the chapter of this research it can be said that after the literature review there are still some questions left unanswered. A questionnaire is conducted to collect data that could help answer these questions. This questionnaire consists of a list of questions that result in variables that can be used for the analyses. The parts socio-demographic, lean construction, serious game and innovation level from the questionnaire will be used for answering SQ 5 and 6. This will be done by means of an ordinal and MNL regression analysis. However, the data will first be checked on its quality and if all variables should be used in the analysis. The tests that are used for this are the Chi-square goodness of fit test, the KMO and Bartlett's test, the Cronbach's alpha test, the stepwise regression analysis and the multicollinearity test.

After the regression analyses a stated choice analysis will be performed. This is also one of the parts of the questionnaire. The stated choice experiment uses five attributes: *presentation information, assessment, depth, achievement system* and *certificate*. The data retrieved from the stated choice questions will be combined with the conclusions of the previously performed ordinal and MNL regression analyses to use in the latent class analysis. The stated choice analysis and LCA will answer the seventh sub question by providing insight in what characteristics the serious game of an LC training should have.

Finally the study will combine the conclusions of the previously answered sub questions into a clear overview by means of a mock-up that would visualize the results of the analysis and shows what a serious game of a lean construction training could look like, answering sub question 8.

4

RESULTS

The fourth chapter of this study describes the results of the analyses. It will use the same structure as the previous chapter. It will start with describing the data that is retrieved from the questionnaire, their frequencies and if the data is adjusted for the further analyses. Secondly a number of tests will be done to analyze the representativeness and quality of the data set. After that the results of the ordinal and MNL regression analyses are shown and discussed, followed by the stated choice and latent class analyses. The last part is the mock-up combining the conclusions of the previous analyses, followed by the general conclusions of the results itself.

4.1 Data

The data used for the analysis in this study is retrieved from the survey as described in section 3.2. The survey was shared among companies in the construction sector and students of the master Construction Management and Engineering at the TU Eindhoven. Additionally the survey was shared with the personal network and shared by means of tables on a construction site in Eindhoven. Finally social media was used by means of LinkedIn to share the questionnaire.

In total there were 761 clicks on the link of the survey and 676 people started the study. Eventually 276 people finished the questionnaire, however 5 of them declared in the final question that they did not completely understood the questionnaire, especially the stated choice part. Therefore, these people are not included in the final target group leaving 271 as the total number of respondents.

4.1.1 Frequencies and adjustments data

This sub-chapter describes the variables that were used in this research, excluding the stated choice part. The frequencies are shown and, if relevant, the adjustments made to the data are described. In total there are 15 variables used in the data set of which 4 are nominal, 8 are ordinal and 3 have a continuous measurement level.

Age

The variable age of the respondent is categorized into age groups. As can be seen in Table 4.1 the categories are made in a way that there are no age groups with a frequency that is too small.

Table 4.1 - Age group frequencies

Age group	Frequency	Percentage
18-24	51	18.8
25-34	94	34.7
35-44	36	13.3
45-54	47	17.3
>55	43	15.9

Gender

No adjustments to the categorical variable *Gender* have been made. The frequencies can be seen in Table 4.2.

Table 4.2 - Gender frequencies

Gender	Frequency	Percentage
Male	203	77.8
Female	58	22.2
Missing	10	

Level of education

In the survey four levels of education were distinguished that described the respondents highest level of education: 'Primary school', 'Pre-vocational secondary education', 'High school or vocational training' and 'Bachelor's degree, Master's degree or PhD'. The first three categories are combined, resulting in two levels: 'Low and middle level of education' and 'High level of education' as can be seen in Table 4.3.

Table 4.3 - Level of education frequencies

Level of education	Frequency	Percentage
Low and middle	57	21.1
High	213	78.9
Missing	1	

Working situation

The variable *Working situation* had the categories as shown in Table 4.4.

Table 4.4 - Working situation frequencies 1

Working situation	Frequency	Percentage
Working (paid) more than 30 hours a week	195	72.0
Working (paid) 12-30 hours a week	7	2.6
Working (paid) less than 12 hours a week	2	0.7
Student or intern	53	19.6
Unemployed/looking for a job	6	2.2
Retired	6	2.2
Other	2	0.7

Table 4.4 clearly shows a big difference in frequencies of the different categories. Therefore, the first three categories are combined into the group 'Working'. 'Student or intern' and 'Other' (both respondents are dual students) are combined into the group 'Student' and 'Unemployed/looking for a job' and 'Retired' are combined into the group 'Unemployed/retired'. This results in the following frequencies as shown in Table 4.5.

Table 4.5 - Working situation frequencies 2

Working situation	Frequency	Percentage
Working	204	75.3
Student	55	20.3
Unemployed/retired	12	4.4

Job type

The variable *Job type* describes the field the respondents are working or studying in. Similar to the variable *Working situation* there are some categories that have very few respondents as can be seen in Table 4.6.

Table 4.6 - Job type frequencies 1

Job type	Frequency	Percentage
Contractor	50	18.5
Architect/Urban designer	78	28.8
Building physicist	16	5.9
Draughtsman	8	3.0
Construction laborer/execution	23	8.5
Structural designer	12	4.4
MEP engineer	6	2.2
Project manager	39	14.4
Real estate developer	12	4.4
Other	27	10.0

Therefore, multiple categories are combined again. 'Contractor', 'Project manager' and 'Real estate developer' are combined into the category 'Manager'. 'Building physicist', 'Structural designer' and 'MEP engineer' are combined into 'Technical engineer'. 'Architect/Urban designer' and 'Construction laborer' stay the same. 'Draughtsman' is added to the category 'Other'. This results in the following frequencies as shown in Table 4.7.

Table 4.7 - Job type frequencies 2

Job type	Frequency	Percentage
Manager	101	37.3
Architect/Urban Designer	78	28.8
Technical engineer	34	12.5
Construction laborer	23	8.5
Other	35	12.9

Project scale

The variable *Project scale* describes the complexity of the projects the respondents are usually working on. The respondents could answer on a 5-point-Likert-scale from 'Normal' to 'Complex'. The categories 'Normal' and 'Mostly normal' are combined into 'Normal' and the categories 'Complex' and 'Mostly complex' are combined into 'Complex'. The category 'Neutral' stays the same. Respondents that filled in 'Not applicable' will be described as missing values. The frequencies can be seen in Table 4.8.

Table 4.8 - Project scale frequencies

Project scale	Frequency	Percentage
Normal	80	31.7
Neutral	79	31.3
Complex	93	36.9
Missing	19	

LC training

This variable describes which respondents have followed a training in lean construction in the past. The results are shown in Table 4.9.

Table 4.9 - LC training

LC training	Frequency	Percentage
Yes	54	19.9
No	217	80.1

Prior knowledge LC

The variable *Prior knowledge LC* describes whether the respondent is already familiar with the concept of lean construction. A 5-point-Likert-scale is used to describe the knowledge from 'Not at all' to 'Very well'. The results are shown in Table 4.10.

Table 4.10 - Prior knowledge LC

Prior knowledge LC	Frequency	Percentage
Not at all	57	21.0
A little	100	36.9
Reasonable	61	22.5
Rather well	31	11.4
Very well	22	8.1

LC techniques known

The variable *LC techniques known* is a sum of all the lean construction techniques that the respondent has heard of. On average the respondents know 2.37 LC techniques. 80 respondents (29.5%) did not know any LC techniques and 60 (22.1%) only knew one. 7 of the respondents knew more than ten techniques.

LC techniques used

LC techniques used describes how many lean construction techniques the respondent has put into practice. The majority of the respondents (57.2%) has never used an LC technique. Only 6 respondents have used more than 5 techniques. On average the respondents have used 1.52 LC techniques.

Innovation level

As stated before, it is important to know how innovative the respondents see themselves in order to analyze if there is a relation between their innovation level and their willingness to use a serious game for al lean construction training. Therefore, six statements were included in the survey regarding different types of innovation as shown in section 3.2.4. Respondents could answer on a 5-point-Likert-scale that went from 'Definitely disagree' to 'Definitely agree'. This research is mainly interested in how innovative the respondents are in general and therefore it is more interesting to look into the average level of innovation instead of the statements separately. In order to make an average of the statements it is important that there is a relation between the different statements. Therefore, a chi-square analysis is done between the different statements to see if they are related to each other. The results are shown in Table 4.11.

Table 4.11 - Chi-square analysis innovation statements

Variable 1	Variable 2	Chi-square	Sig
Interest in innov	Constr sec innov	344.324	**0.000**
	Improve work	189.616	**0.000**
	Like to learn	322.104	**0.000**
	Invest money	38.176	**0.044**
	Other SG	45.455	**0.007**
Constr sec innov	Improve work	112.719	**0.000**
	Like to learn	375.889	**0.000**
	Invest money	55.174	**0.000**
	Other SG	34.196	0.104
Improve work	Like to learn	223.662	**0.000**
	Invest money	92.509	**0.000**
	Other SG	28.609	0.096
Like to learn	Invest money	41.803	**0.003**
	Other SG	36.517	**0.013**
Invest money	Other SG	66.213	**0.000**

Table 4.11 shows almost all relations between the statements are significant. Only the use of other types of serious games is not significant with whether the construction sector should be more innovative and whether the respondent tries to improve its own work. But with a significance of respectively 0.104 and 0.096 they can still be considered almost significant. Therefore, we can conclude that the statements are related to each other and an average can be calculated. The new variable 'Average innovation level' takes the average value of the six statements, excluding the 'Not applicable' answers. One respondent filled in 'Not applicable' in all six statements and is therefore considered as a missing value regarding the average innovation level.

This results in an average innovation level of 3.94. with a normal distribution as can be seen in Figure 4.1.

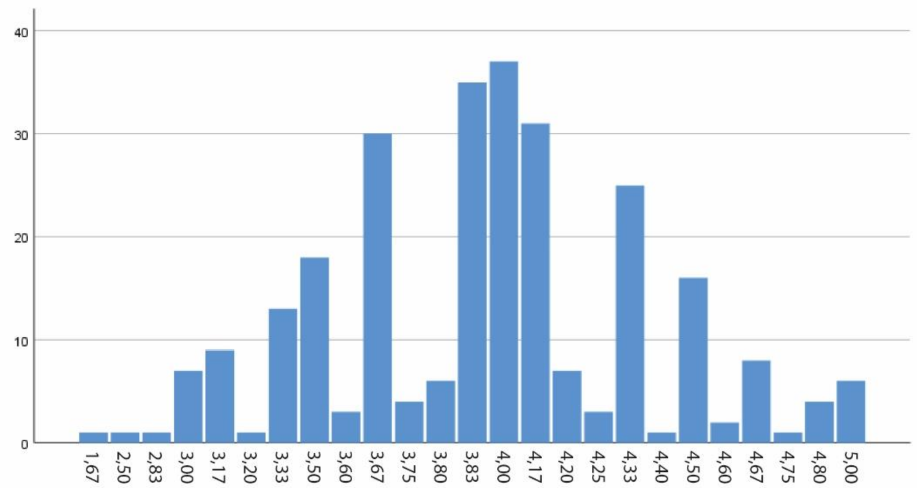

Figure 4.1 - Innovation level distribution

Willingness regarding LC training

There are four variables that give an indication of the respondents interest in a lean construction training: *LC learn more, LC 16h workshop, LC 40h workshop* and *Willingness SC in LC*. With all four of these variables a 5-point-Likert-scale was used ranging from 'Definitely not' to 'Definitely yes'. In case of the *LC learn more* and *Willingness SG in LC* factors the group of respondents that filled in 'Definitely not' was relatively small and in case of the *LC 40h workshop* the variable 'Definitely yes' was quite small. Since the variables can be better compared when they all have the same categories in all four of them the two upper and two lower levels are combined into 'Yes' and 'No'. The frequencies of these categories can be seen in Table 4.12 - Table 4.15

Table 4.12 - LC learn more frequencies

LC learn more	Frequency	Percentage
No	47	17.3
Neutral	69	25.5
Yes	155	57.2

Table 4.13 - LC 16h workshop frequencies

LC 16h workshop	Frequency	Percentage
No	83	30.6
Neutral	64	23.6
Yes	124	45.8

Table 4.14 - LC 40h workshop frequencies

LC 40h workshop	Frequency	Percentage
No	157	57.9
Neutral	54	19.9
Yes	60	22.1

Table 4.15 - Willingness SG in LC

Willingness SG in LC	Frequency	Percentage
No	60	22.1
Neutral	60	22.1
Yes	151	55.7

4.1.2 Interpretation data

When analyzing the data it is clear that there are some differences in category frequencies of the different variables. In the next section it will be discussed whether the data is a good representation of the construction industry regarding the socio-demographic factors. However, some results are already interesting to discuss.

First of all, a majority of the respondents has not have any training at all in lean construction. This is in line with what was described in the literature review. Of the people that did have a training in LC, a lot of people filled in that this was an internal training within their company. Additionally, a majority of the respondents declares that they do not have any prior knowledge of LC or just a little. This is also clear when looked at the variables *LC techniques known* and *LC techniques used* where a great number of respondents do not know or use more than 1 technique. It can therefore be concluded that among the respondents the concept of lean construction is relatively unknown which confirms the findings in the literature review.

When looked to the average innovation level there is a clear normal distribution with 4.00 as average level. This means that the respondents mostly agreed with the innovation statements and consider themselves relatively innovative.

Finally, there seems to be quite a high willingness to learn more about lean construction and to either use a 16 hour workshop for that or a serious game. Only the 40 hour workshop is considered less popular among respondents. This probably means that the length of this type of training is considered too long for people. Since the literature suggests that for a proper lean construction training 40 hours is necessary in order to implement LC well in the work field, this might be a problem for the integration of the concept.

4.2 Quality of data set

It is important to analyze the quality of the data set to see if the data is well suitable for the analyses later on. Therefore multiple analyses are done as described in section 3.3. In the last sub section the conclusions of the five types of analysis will be described and it will be decided how the data set needs to be adjusted.

4.2.1 Chi-square goodness of fit test

It is important to see if the data set is a good representation of the construction sector and if not, what groups are represented more and/or less than was expected. Four of the social-demographic variables are analyzed with a chi-square test in order to see if their distribution is similar to that of the construction sector (CBS, 2016). The variables are *Age, Gender, Level of education* and *Job type*. The results are shown in Table 4.16.

Table 4.16 - Chi-square representativeness test

Variable	Level	Observed N	Expected N (CBS, 2016)	Residual
Age (CBS, 2016)	18-24	51	21.5	29.5
	25-34	94	59.0	35.0
	35-44	36	75.1	-39.1
	45-54	47	72.5	-25.5
	>55	43	43.0	0.0
Gender (CBS, 2016)	Male	203	237.5	-34.5
	Female	58	23.5	34.5
Level of education (CBS, 2016)	Low level of education	9	92.3	-83.3
	Middle level of education	48	140.0	-92.0
	High level of education	213	37.7	175.3
Job type (CBS, 2016)	Managers	101	23.8	77.2
	Technical jobs	112	65.5	46.5
	Construction laborers	23	131.1	-108.1
	Other	35	50.6	-15.6

4.2.2 Representativeness comparison per variable

The chi-square tests resulted in the following results per variable:

Age

Considering the age of the respondents it is clear that there are relatively more people from the youngest two age groups (18-34). People by the age of 35-54 are relatively underrepresented. The number of people over 55 is the same as the expected number. That there are relatively more younger people is likely due to the fact that a lot of respondents are from a personal network who are mainly around the same age (26 years old). The analysis resulted in a significant chi-square value of 90.672 which is quite high, meaning there is a clear difference between the expected and observed results. This can also be seen in Figure 4.2.

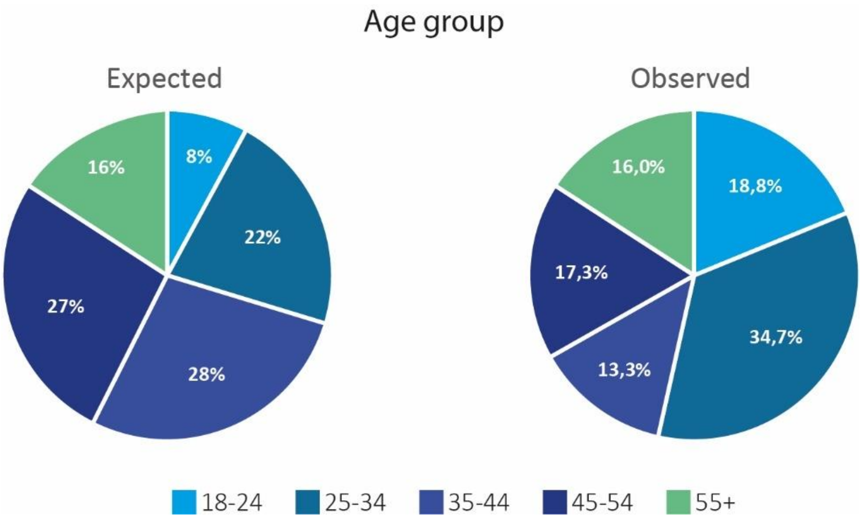

Figure 4.2 - Comparison age group

Gender

As shown in Figure 4.3 there are relatively many female respondents. The significant chi-square value of this variable is 55.661. This is possibly related to the fact that there are relatively much younger people as shown before and higher educated people as shown in the next section.

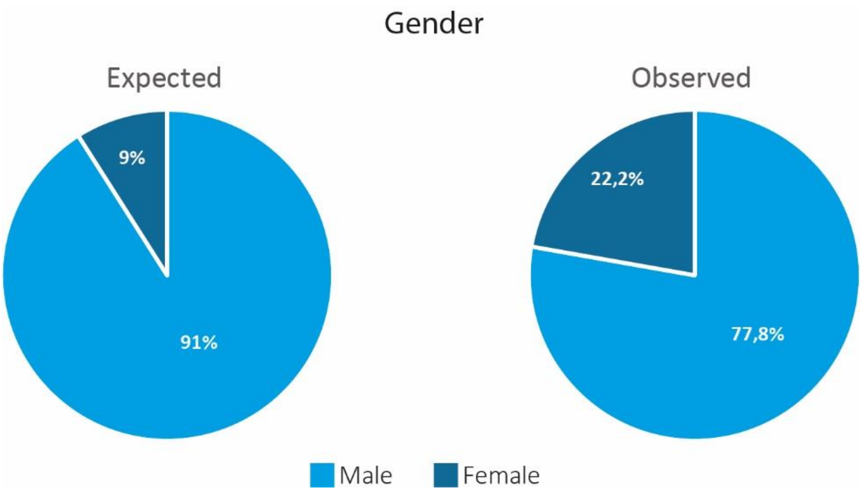

Figure 4.3 - Comparison gender

Level of education

The chi-square value of this analysis is 950.597 and is significant. The fact that this is so large can quickly be seen in Figure 4.4 that shows that the very big observed group of highly educated respondents should have been much smaller to be a good representation. Like the variable *Age* this is likely caused by the fact that there were a lot of respondents from the personal network of the writer and the survey was shared among master students at the TU Eindhoven.

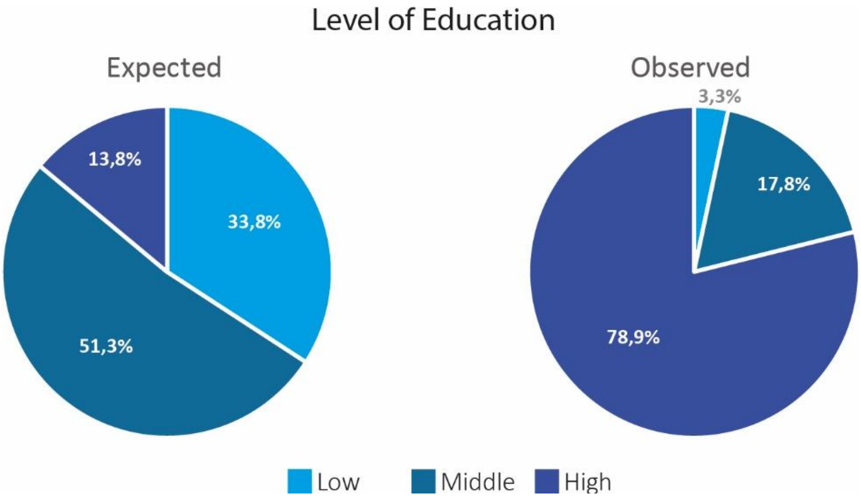

Figure 4.4 - Comparison level of education

Job type

Almost half of the people working in the construction sector are construction laborers, however this is only a small part of the observed respondents, as shown in Figure 4.5. Especially the group of managers is large compared to the expected number. Also the technical employees are relatively overrepresented. This group is a combination of the technical engineers and architects/urban designers since this was done by the CBS as well (CBS, 2016). The significant chi-square value of this comparison is, with 377.744. very big as well as can be expected.

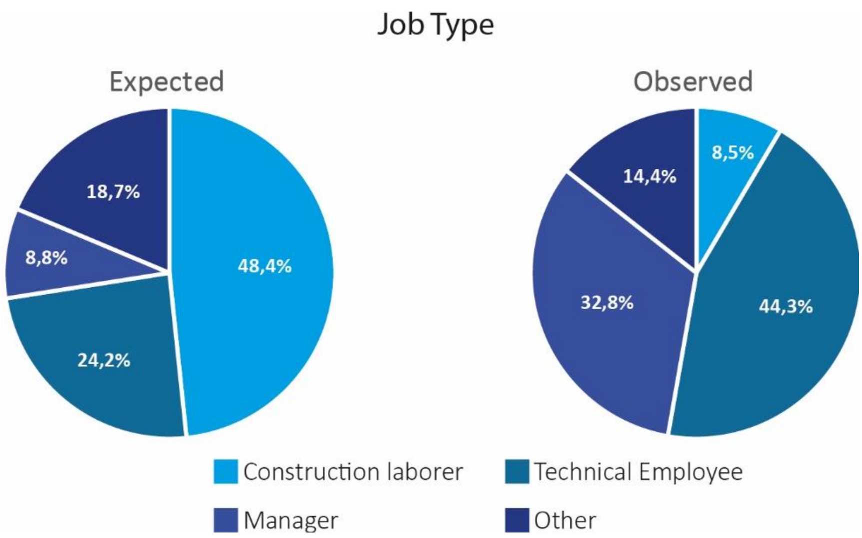

Figure 4.5 - Comparison job type

4.2.3 Variance

The KMO and Bartlett's test describes the proportion of variance in the data set. The higher the value is, the more suitable the data set is for factor analysis (IBM, n.d.). The results are shown in Table 4.17. The KMO analysis shows a value of 0.764 and since generally a value higher than 0.6 is acceptable (Glen, 2016b) this number is quite good. This means the data set is well suitable for factor analysis and so far there is no need to remove variables from the data set.

Table 4.17 - KMO and Bartlett's test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		**0.764**
Bartlett's Test of Sphericity	Approx. Chi-Square	1033.388
	df	105
	Sig.	0.000

4.2.4 Internal consistency

The Cronbach's alpha analysis is mainly used to describe the internal consistency of the data (Laerd Statistics, 2018). Generally speaking an alpha of more than 0.7 is considered acceptable (Kreulen, n.d.). This analysis can also be seen in Appendix D.

When including all variables the analysis results in an alpha of 0.589 which is considered poor (Kreulen, n.d.). The Item-Total Statistics table of the analysis suggests what factor could best be removed in further analysis in order have the highest alpha. In this case removing the variable *Age* would have the most effect, resulting in an alpha of 0.645. A new analysis shows that in order to further increase the alpha the factor *Job type* needs to be removed resulting in an alpha of 0.695 and after that removing *Working situation* to result in an alpha of 0.708. passing the threshold of 0.7. making it an acceptable data set.

However, the variable *Age* is in the literature considered one of the most important factors influencing peoples willingness to use serious games as described in section 3.2.1. Additionally, the next section describes the stepwise regression analysis, where *Age* has one of the highest R-square value if *LC learn more* is the dependent variable as well as when *Willingness SG in LC* is the dependent factor. Therefore, an additional scenario is made with the Cronbach's alpha where *Age* was included.

In the second scenario, apart from the variables *Job type* and *Working situation,* the variable *Gender* was removed from list instead of *Age*, resulting in an alpha of 0.668. This is the highest possible outcome when Age is included. Unfortunately this scenario does not pass the threshold of 0.7 and is therefore considered questionable according to Kreulen (n.d.).

4.2.5 Stepwise regression analysis

The stepwise regression analysis finds what independent variables can predict the dependent variable the best. Two different factors are used as a dependent variable: *LC learn more* and *Willingness SG in LC*. Therefore, two stepwise analyses will be done and both will be done both forward and backward. The full tables are shown in Appendix E.

The first analysis is done with *LC learn more* as the dependent variable. The variables *LC 16h workshop, LC 40h workshop* and *Willingness SG in LC* will not be included in the analysis as described in section 3.4.3. The forward analysis shows that there are four variables entered in the stepwise regression test: *Innovation level, Age, Prior knowledge LC* and *Level of education*. The four variables that were included in the analysis together predict 18.9% of the dependent variable. However, when the backwards analysis is performed the model keeps the variable Gender included as well. This results in an adjusted R square of 0.196. The results are shown in Table 4.18. All the other variables do not seem to uniquely predict the dependent variable in a significant way

Table 4.18 - Stepwise regression with LC lean more as dependent

Model	Variables entered	R	R Square	Adjusted R square	R square change	F change
1	Innovation level	0.317	0.101	0.097	0.101	26.901
2	Age	0.387	0.150	0.143	0.49	13.879
3	Prior Knowledge LC	0.428	0.183	0.173	0.33	9.586
4	Level of education	0.450	0.203	0.189	0.20	5.873
5	Gender*	0.461	0.213	0.196	0.10	-

** only included in the backwards analysis*

For the second analysis the variable *Willingness SG in LC* is the dependent variable. All other variables are included in the stepwise analysis. The results are shown in Table 4.19 and show that the variables *LC learn more, Age LC 16h workshop*, *LC 40h workshop* and *Level of education* are included in the analysis. Especially *LC learn more* has a big impact in predicting the dependent variable with an adjusted R square of 39.4%. In total the five independent variables predict 45.6% of the willingness to use a serious game for an LC training. The other variables, that were not included, are not considered to have an significant impact in predicting this variable.

Table 4.19 - Stepwise regression with Willingness SG in LC as dependent

Model	Variables entered	R	R Square	Adjusted R square	R square change	F change
1	LC learn more	0.629	0.396	0.394	0.396	157.392
2	Age	0.653	0.427	0.422	0.030	12.691
3	LC 16h workshop	0.668	0.446	0.439	0.019	8.352
4	LC 40h workshop	0.677	0.458	0.449	0.013	5.476
5	Level of education	0.684	0.468	0.456	0.009	4.051

4.2.6 Multicollinearity

For regression analyses it is important to reduce the multicollinearity if necessary. Therefore, multiple analyses are done to create an overview of the correlation between the independent variables. First Chi-square analyses are done in order to study the correlation between the eleven categorical variables. Secondly an ANOVA test is done to find the multicollinearity between the categorical and continues variables. Finally, a correlation matrix is created in order to see the correlation within all continues factors. An overview of the significance of all correlations is shown in Table 4.20 and the complete analyses are show in Appendix F.

Table 4.20 is slit up into two parts. The first part does not include the three variables that are not included in the first regression analysis where *LC learn more* is the dependent variable. These variables are included in the second part of the tables since they are also included in the second regression analysis where all independent variables are used.

Table 4.20 - Multicollinearity overview

	Age	Gender	Level of education	Working situation	Job Type	Project scale	LC Training	Prior knowledge LC	LC techniques known	LC techniques used	Innovation level	LC learn More	LC 16h training
Age	-												
Gender	**0.000**	-											
Level of education	0.434	**0.012**	-										
Working situation	**0.000**	**0.000**	0.297	-									
Job Type	**0.002**	**0.013**	**0.000**	**0.021**	-								
Project scale	**0.020**	0.466	0.072	0.053	0.068	-							
LC Training	**0.000**	**0.032**	0.823	**0.000**	**0.000**	0.114	-						
Prior knowledge LC	**0.015**	**0.018**	0.131	**0.001**	**0.007**	**0.026**	**0.000**	-					
LC techniques known	0.057	0.501	**0.034**	0.065	0.058	0.245	**0.000**	**0.000**	-				
LC techniques used	0.103	0.252	0.293	0.102	**0.027**	0.762	**0.000**	**0.000**	**0.000**	-			
Innovation level	**0.035**	0.722	**0.000**	**0.000**	0.515	0.172	0.482	0.054	**0.001**	**0.008**	-		
LC learn more	**0.000**	**0.011**	**0.002**	**0.001**	**0.001**	0.244	0.291	0.313	**0.040**	0.505	**0.000**	-	
LC 16h training	**0.000**	**0.018**	**0.009**	**0.026**	**0.005**	0.098	0.371	0.194	0.063	0.094	**0.000**	**0.000**	-
LC 40h training	**0.001**	0.423	0.397	**0.011**	**0.022**	0.225	0.260	0.513	0.354	0.763	**0.014**	**0.000**	**0.000**

The values in Table 4.20 are bold made when the correlation is significant. It is clear that a large number of variables have a significant correlation. Especially the variables *Age, Gender, Working situation, Job type, Prior knowledge, LC learn more* and *LC 16h workshop* have a high number of correlations with other variables. It is possible that the high number of correlations is due to the large number of respondents.

4.2.7 Conclusion

It is clear that there are significant differences between the expected and observed data. Younger and higher educated people are overrepresented as well as managers, technical employees and females. This is at the cost of middle aged, lower and middle educated people, males and construction laborers. Although a better representation would have been more ideal, it is considered acceptable that the *Level of education* and *Job type* is distributed like this. Lean construction is mostly relevant for people who are more involved in the decision making process than people who only execute. Generally most decisions in the construction process are made by (high educated) managers and technical employees.

The KMO and Bartlett's test shows that the data set has a low proportion of variance and is therefore suitable for factor analysis. The Cronbach's alpha analysis however shows either an acceptable scenario that excludes *Age* from the data, or a questionable scenario where *Age* is included, but other variables are excluded.

The stepwise regression analysis clearly shows that a lot of variables were not included in the model. The variables that seem to have the most effect on willingness to learn more are *Innovation level, Age, Prior Knowledge, Level of education* and (possibly) *Gender.* The variables that seem to describe the willingness to learn more about LC by means of an SG are *LC learn more, Age, LC 16h workshop, LC 40h workshop,* and *Level of education*. Since the variable *Age* describes both dependent variables quit significantly it is decided that this variable should be included in further analysis and therefore the second scenario of the Cronbach's alpha is chosen. This means that the variables *Job type, Working situation* and *Gender* are exclude from further analysis.

The large number of variables that is not included in the stepwise analysis suggests that there is a lot of multicollinearity between the independent variables. This is analyzed in the last section where a chi-square test, ANOVA and correlation matrix were applied on the data. Many variables are correlating with each other what might become a problem in the regression analyses and should be taken into account. Removing the variables as described before already reduces a lot of that multicollinearity.

4.3 Target group

As described in section 1.2 there are two regression analyses relevant for this study in order to find the target group. The first one analyzes what factors influence how much people are willing to learn more about lean construction (SQ 5). For this analysis the variable *LC learn more* will be used as dependent variable. The second regression analysis describes what variables influence the willingness of those people to use a serious game in order to learn more about lean construction (SQ 6). In this case the variable *Willingness SG in LC* will be the dependent variable. The results of the previous section should be taken into account in these studies.

4.3.1 Willingness to learn more

For the first regression analysis two different methods are used to determine what factors influence the willingness of respondents to learn more about lean construction. First an ordinal regression method will be used and secondly an MNL regression analysis.

Ordinal regression analysis

Since the dependent variable is an ordinal variable, the first analysis chosen is an ordinal regression analysis. This type of regression tries to fit a singular equation for all ordinal levels of the dependent variable as described in section 3.4.1. The analysis also includes a test of parallel lines in order to see if this equation is valid. As can be seen in Table 4.21, the result of this analysis is not significant (higher than 0.050). This means that the proportional odd assumption can be approved and the data set is suitable for an ordinal regression analysis.

Table 4.21 - Test of parallel lines in ordinal regression 1

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	433.980			
General	412.050	21.931	15	0.110

How well the independent variables predict the willingness to learn more about lean construction is analyzed with a pseudo R-square test. This test showed a Nagelkerke R-square of 0.236. Although just acceptable, this is not a very high value and shows that the independent factors selected for this analysis cannot predict the dependent variable very well. Possibly there are other variables that should be put in that analysis that this research did not take into account.

The results of the ordinal regression model are shown in Table 4.22 and Figure 4.6. Variables with a significance of 0.050 or lower are considered significant. If variables have a significance between 0.050 and 0.100 they are considered almost significant. As can be seen in Table 4.22, there are three variables that seem to have an impact on the willingness of the respondents to learn more about LC: *Innovation level, Age* and (almost significant) *Level of education.*

The innovation level of the respondents has a significant relation to their willingness to learn more about LC. Since the estimate of the variable is positive, it can be concluded that a higher innovation level results in more willingness. People that consider themselves more open to new innovations are more interested in learning more about the concept of lean.

Additionally, there is a significant difference between the *Age* categories from 18 to 44 when compared to an age of over 55. Again the estimates of the categories are positive, meaning that the younger *Age* categories are more likely to be willing to learn more about LC. The category of '45-54' is not significant.

Finally, the *Level of education* has an almost significant relation with the dependent variable. Since the 'low and middle' level is negative when compared to the reference category of 'high', the model suggests that people with a lower education level are less likely to be willing to learn more about lean construction.

Regarding the other variables like *Project scale, LC training, Prior Knowledge LC, LC techniques known* and *LC techniques used,* there does not seem to be a significant or almost significant relation with the dependent variable.

Table 4.22 - Model of ordinal regression 1

	Estimate	Sig.	
LC Learn more: No	3.042	0.050	
LC Learn more: Neutral	4.569	0.004	
LC techniques known	0.023	0.786	
LC techniques used	0.122	0.424	
Innovation level	1.086	0.001	***
Age 18-24	1.350	0.005	***
Age 25-34	1.089	0.004	***
Age 35-44	1.300	0.009	***
Age 45-54	-0.129	0.754	
Age >55	0[a]		
Level of education: low or middle	-0.583	0.082	*
Level of education: high	0[a]		
Project scale: normal	0.249	0.454	
Project scale: neutral	0.096	0.772	
Project scale: complex	0[a]		
LC training: no	0.197	0.605	
LC training: yes	0[a]		
Prior Knowledge LC: Not at all	-1.006	0.143	
Prior Knowledge LC: A little	-0.633	0.311	
Prior Knowledge LC: reasonable	-0.242	0.696	
Prior Knowledge LC: rather well	-0.229	0.734	
Prior Knowledge LC: Very well	0[a]		

[a] Is set 0 because it is a reference variable
***, **, * -> significant at a 1%, 5% or 10% level

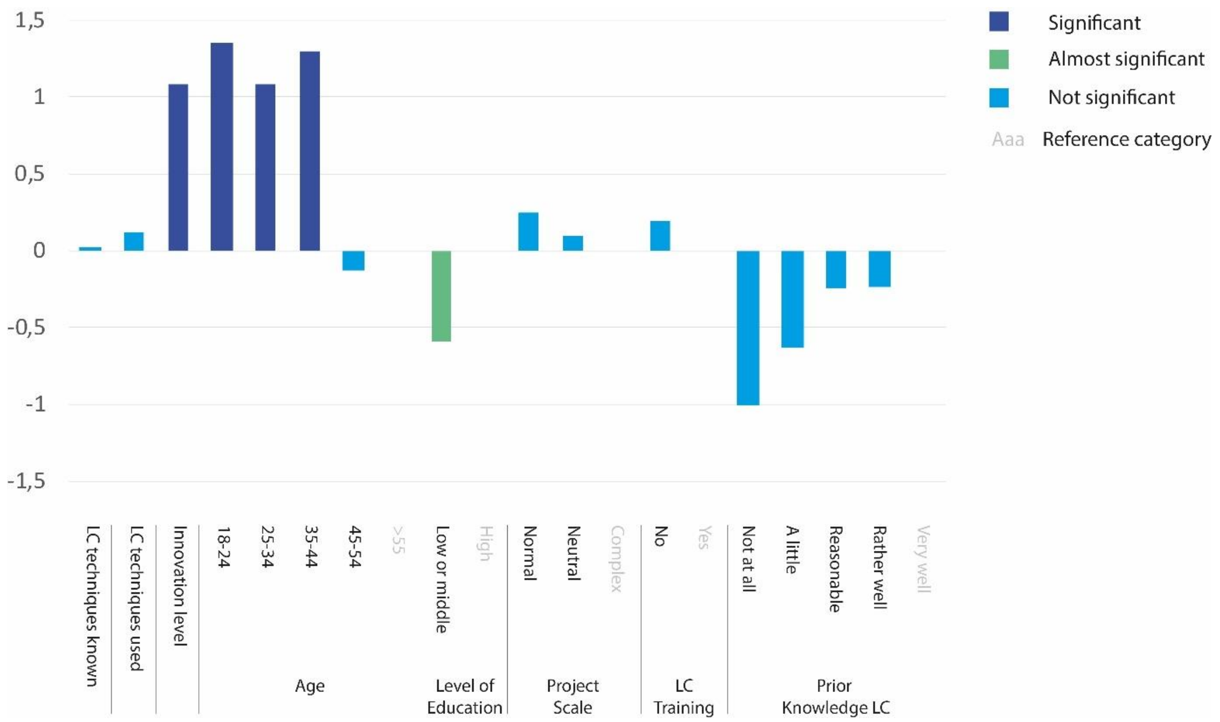

Figure 4.6 - Ordinal regression bar diagram 1

Multinomial logistic regression analysis

In addition to the ordinal regression analysis, a multinomial logistic regression (MNL) analysis is done as well. This type of analysis could show more specific how the different variables are related. The results are shown in Table 4.23 and show in this case a similar result as the ordinal regression analysis. Again the variables *Innovation level, Age* and *Level of education* have a significant relation to the dependent variable.

People who consider themselves to be more innovative are less likely to fill in 'No' or 'Neutral' regarding their willingness to learn more about LC. Also the age group 18-44 is less likely to fill in 'No', however for 'Neutral' this is only for the group of 25-44 year old people, since the group '18-24' is there no longer significant. Finally the *Level of education* is almost significant for the category 'No', meaning that people with a lower education level are probably less likely to be willing to learn more about LC than people with a higher education level.

Table 4.23 - Multinomial logistic regression with LC learn more as dependent

LC Learn More[a]		B	Sig.	
No	Intercept	2.871	0.235	
	LC techniques known	-0.089	0.558	
	LC techniques used	-0.160	0.540	
	Innovation level	-1.110	0.018	**
	Age 18-24	-3.302	0.004	***
	Age 25-34	-1.413	0.009	***
	Age 35-44	-1.724	0.031	**
	Age 45-54	0.232	0.683	
	Age >55	0[b]		
	Level of education: low or middle	0.924	0.057	*
	Level of education: high	0[b]		
	Project scale: normal	-0.070	0.891	
	Project scale: neutral	0.234	0.648	
	Project scale: complex	0[b]		
	LC training: no	-0.056	0.927	
	LC training: yes	0[b]		
	Prior Knowledge LC: Not at all	1.997	0.109	
	Prior Knowledge LC: A little	1.456	0.219	
	Prior Knowledge LC: reasonable	0.924	0.439	
	Prior Knowledge LC: rather well	0.733	0.591	
	Prior Knowledge LC: very well	0[b]		
Neutral	Intercept	4.915	0.010	
	LC techniques known	-0.006	0.951	
	LC techniques used	-0.058	0.736	
	Innovation level	-1.125	0.006	***
	Age 18-24	-0.551	0.316	
	Age 25-34	-1.055	0.027	**
	Age 35-44	-1.190	0.042	**
	Age 45-54	-0.491	0.375	
	Age >55	0[b]		
	Level of education: low or middle	0.225	0.606	
	Level of education: high	0[b]		
	Project scale: normal	-0.363	0.362	
	Project scale: neutral	-0.559	0.167	
	Project scale: complex	0[b]		
	LC training: no	-0.610	0.168	
	LC training: yes	0[b]		
	Prior Knowledge LC: Not at all	0.619	0.434	
	Prior Knowledge LC: A little	0.351	0.618	
	Prior Knowledge LC: reasonable	0.048	0.945	
	Prior Knowledge LC: rather well	-0.034	0.963	
	Prior Knowledge LC: very well	0[b]		

[a] Reference category is: yes [b] Is set 0 because it is a reference variable
***, **, * -> significant at a 1%, 5% or 10% level

Interpretation of results

A possible explanation for the differences in age group could be that people of a younger age are generally in the beginning of their career and therefore more open to further develop themselves, knowing that this could benefit them in the future. People from over 45 years old already have built up some experience and might therefore feel less need to learn more within their field. Additionally, younger people are often more interested in making changes in their sector than their older colleges who generally are more conservative. A similar explanation can be given for the factor *Innovation* level. People that are generally more innovative are more open to changes, which could explain why they are more interested in learning about LC.

People with a higher level of education seem to be more open toward learning more about LC than people with a lower education level. A possible explanation for this could be that people with a higher education level are often more trained in thinking about how something could change, while in lower education levels there is more focus on learning what is already known. Additionally, people that are already generally more interested in learning more might be more willing to study longer and therefore end up with a higher education level.

It should be taken into account that there is a correlation between *Age* and *Innovation level* and between *Level of education* and *Innovation level* as described in Table 4.20. Therefore, there might be some overlap between the variables in relation to the dependent variable.

4.3.2 Willingness to use a serious game for an LC training

As described in section 3.4, a regression analysis will be done with the factor *Willingness SG in LC* as dependent variable to answer the sixth sub question. This variable describes whether respondents are willing to use a serious game for the training in lean construction. All independent variables are included in this analysis except the ones that were excluded in the Cronbach's alpha analysis in section 4.2.7. Again an ordinal regression and an MNL regression are done in order to analyze the relation between the independent and the dependent variables.

Ordinal regression analysis

A test of parallel lines is performed to test if the equation of created in the ordinal regression analysis is valid. Since this test results in the insignificant value of 0.845 (Table 4.24) it can be assumed that the ordinal regression can be used.

Table 4.24 - Test of parallel lines in ordinal regression 2

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Null Hypothesis	347.016			
General	332.476	14.541	21	0.845

A pseudo R-square test is performed in order to see how well the independent variables cover the dependent variable. The Nagelkerke R-square value of the analysis is 0.533, which is quite good and shows that the variables can predict the dependent variable relatively well.

Table 4.25 shows the results of the ordinal regression analysis. Like in the previous analysis *Age* has a significant relation with the dependent variable, however this time only for the lowest two age groups, meaning that the serious game is more interesting among younger respondents. In addition to the age of the respondents, the *Level of education* seems to have an significant impact as well. Since the estimate is negative, for the 'Low and middle level of education' group, this group seems to be less likely to use a serious game for an LC training.

Additionally, the factor *Prior Knowledge LC* seems to influence the willingness to use a serious game for a lean construction training. Respondents that filled in that they had a 'reasonable' or 'rather well' knowledge of LC seem to be more interested in using a serious game for further training than people with a 'very well' knowledge of LC. The two lower levels 'not at all' and 'a little' did not have a significant difference in willingness compared to the reference category.

The willingness to learn more about LC has an effect on the dependent variable as well. Especially the group of respondents that do not want to learn more about lean construction are also not willing to use a serious game for that. Similar to that, the group of people that are not willing to participate in a 16 hour workshop of lean construction are also not willing to have an LC training by means of a serious game. However, the group of people that are not willing to follow a 40 hour workshop seem to be more likely to use the SG version than the people that are willing to follow the 40 hour training. Thus, there seems to be a significant difference in willingness between people that would follow a 40 hour training and people to those only willing to follow a 16 hour training.

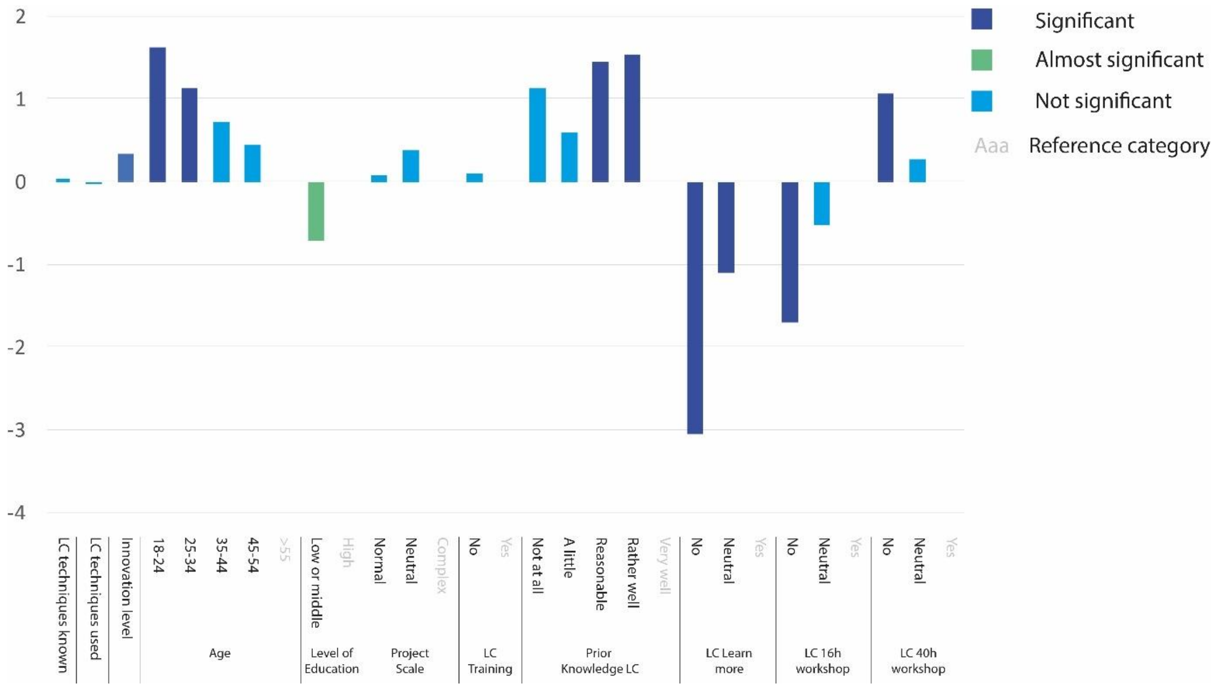

Figure 4.7 - Ordinal regression bar diagram 2

Table 4.25 - Model of ordinal regression 2

	Estimate	Sig.	
Willingness SG in LC: No	0.481	0.795	
Willingness SG in LC: Neutral	2.330	0.209	
LC techniques known	0.041	0.661	
LC techniques used	-0.006	0.970	
Innovation level	0.331	0.378	
Age 18-24	1.613	0.005	***
Age 25-34	1.124	0.011	**
Age 35-44	0.725	0.173	
Age 45-54	0.442	0.355	
Age >55	0[a]		
Level of education: low or middle	-0.715	0.067	*
Level of education: high	0[a]		
Project scale: normal	0.067	0.856	
Project scale: neutral	0.377	0.327	
Project scale: complex	0[a]		
LC training: no	0.107	0.800	
LC training: yes	0[a]		
Prior Knowledge LC: Not at all	1.117	0.112	
Prior Knowledge LC: A little	0.593	0.329	
Prior Knowledge LC: reasonable	1.453	0.017	**
Prior Knowledge LC: rather well	1.540	0.026	**
Prior Knowledge LC: very well	0[a]		
LC learn more: No	-3.055	0.000	***
LC learn more: Neutral	-1.095	0.004	***
LC learn more: Yes	0[a]		
LC 16h workshop: No	-1.701	0.001	***
LC 16h workshop: Neutral	-0.533	0.249	
LC 16h workshop: Yes	0[a]		
LC 40h workshop: No	1.073	0.039	***
LC 40h workshop: Neutral	0.275	0.612	
LC 40h workshop: Yes	0[a]		

[a] Is set 0 because it is a reference variable
***, **, * -> significant at a 1%, 5% or 10% level

Multinomial logistic regression analysis

To better understand how the separate categories of the dependent variable have a relation with the independent variable a multinomial logistic regression analysis is performed. The same variables are used as in the ordinal regression analysis and the results are shown in Table 4.26. The reference category of the dependent variable is 'yes'.

The variables that have an (almost) significant relation with the willingness to use a serious game for a lean construction training are similar to that of the ordinal regression model. Lower age groups are again more likely to have a positive attitude towards the dependent variable. This matches with the literature that was described in section 3.2.1.

Secondly, there is a significant difference between people that have no, reasonable or rather well prior knowledge of LC with people that have 'very well' prior knowledge. The less knowledge the respondents have, the more likely they seem to be willing to use an SG of an LC training. Additionally, there seems to be a very strong positive relation between the willingness to learn more about LC and the willingness to use an SG for that. Especially people that are not willing to learn more about lean construction are on average also strongly against learning more about lean. This is shown with the high B-value of the 'No' category of *LC learn more* (4.641) that However, there is no significant relation when the neutral attitude is compared to the positive attitude towards the use of a serious game. Another strong positive relation with the dependent variable is the variable *LC 16h workshop* that describes the willingness to follow a 16 hour workshop in LC. This is likely due to the fact that people that are willing to follow a 16 hour workshop in lean construction are already willing to invest time in this training and are therefore also more likely to use the SG. Finally, the variable *LC 40h workshop* has an almost significant relation with the dependent variable. Other than with the 16 hour workshop this seems to be a negative relation. People that are not willing to participate in a 40 hour workshop are more willing to use the serious game.

Table 4.26 - Multinomial logistic regression with Willingness SG in LC as dependent

Willingness SG in LC[a]		B	Sig.	
No	Intercept	2.813	0.349	
	LC techniques known	-0.144	0.403	
	LC techniques used	-0.005	0.988	
	Innovation level	-0.301	0.616	
	Age 18-24	-1.869	0.069	*
	Age 25-34	-1.732	0.020	**
	Age 35-44	-1.218	0.158	
	Age 45-54	-0.850	0.287	
	Age >55	0[b]		
	Level of education: low or middle	0.764	0.254	
	Level of education: high	0[b]		
	Project scale: normal	-0.160	0.797	
	Project scale: neutral	-1.015	0.147	
	Project scale: complex	0[b]		
	LC training: no	-0.642	0.379	
	LC training: yes	0[b]		
	Prior Knowledge LC: Not at all	-2.187	0.060	*
	Prior Knowledge LC: A little	-1.169	0.229	
	Prior Knowledge LC: reasonable	-3.372	0.002	***
	Prior Knowledge LC: rather well	-2.449	0.041	**
	Prior Knowledge LC: very well	0[b]		
	LC learn more: No	4.641	0.000	***
	LC learn more: Neutral	1.808	0.008	***
	LC learn more: Yes	0[b]		
	LC 16h workshop: No	2.558	0.009	***
	LC 16h workshop: Neutral	0.189	0.838	
	LC 16h workshop: Yes	0[b]		
	LC 40h workshop: No	-2.014	0.062	*

	LC 40h workshop: Neutral	-0.992	0.347	
	LC 40h workshop: Yes	0[b]		
Neutral	Intercept	0.876	0.712	
	LC techniques known	0.079	0.469	
	LC techniques used	0.091	0.644	
	Innovation level	-0.631	0.191	
	Age 18-24	-1.874	0.009	***
	Age 25-34	-1.164	0.039	**
	Age 35-44	-0.798	0.240	
	Age 45-54	-0.055	0.928	
	Age >55	0[b]		
	Level of education: low or middle	0.688	0.169	
	Level of education: high	0[b]		
	Project scale: normal	0.112	0.806	
	Project scale: neutral	-0.247	0.598	
	Project scale: complex	0[b]		
	LC training: no	0.773	0.166	
	LC training: yes	0[b]		
	Prior Knowledge LC: Not at all	0.696	0.440	
	Prior Knowledge LC: A little	0.183	0.819	
	Prior Knowledge LC: reasonable	-0.050	0.948	
	Prior Knowledge LC: rather well	-0.726	0.399	
	Prior Knowledge LC: very well	0[b]		
	LC learn more: No	1.081	0.172	
	LC learn more: Neutral	0.760	0.087	*
	LC learn more: Yes	0[b]		
	LC 16h workshop: No	0.922	0.133	
	LC 16h workshop: Neutral	0.801	0.116	
	LC 16h workshop: Yes	0[b]		
	LC 40h workshop: No	-0.631	0.275	
	LC 40h workshop: Neutral	0.085	0.890	
	LC 40h workshop: Yes	0[b]		

[a] Reference category is: yes [b] Is set 0 because it is a reference variable
***, **, * -> significant at a 1%, 5% or 10% level

Interpretation of results

This regression analysis shows similarities with the previous analysis regarding the willingness to learn more about lean construction. Again younger people and people with a higher level of education seem have an effect on the dependent variable. Possible explanations could be that this group is more interested in new concepts since they might have more to gain from it. However, in case of the willingness to lean more about LC the border between willing and not willing seems to be at a higher age (44 years old). This could indicate that although people of 35-44 are interested in learning more about LC, they do not consider a serious game to be the best learning technique for them.

In addition it seems that the prior knowledge of lean construction impacts the willingness to use a serious game for an LC training. People that consider their prior knowledge of lean construction to be 'very well' are less interested in using a serious game. It is possible that these people are more interested in other types of training since those have so far worked for them resulting in a good knowledge of the concept. People with less knowledge seem to be more interested. This would of course also be the group that benefits more from a training in lean construction and would be most interesting as a target group for the serious game.

People that want to learn more about lean construction are also more willing to use a serious game for that. This is important because if people are not motivated to use a serious game the application is very likely to fail as was discussed in the literature review. Intrinsic motivation is necessary to learn something but can be increased by means of a extrinsic motivation of a serious game.

The results show a clear difference between the people willing to do a 16 hour and a 40 hour workshop in lean construction. People that want a 16 training would be interested in a serious game, however people willing to follow a 40 workshop would not. This indicates that the serious game might be more successful when it focusses on a shorter, more basic training.

4.3.3 Conclusion regression analyses

This section focused on answering sub question 5 and 6. From the results of this research it is possible to conclude that a number of variables influence the willingness of respondents to learn more about lean construction. Specifically people of younger age groups and people that are generally inclined to innovate are more interested in learning more about the concept. Additionally people who have a higher level of education are also more inclined to learn more about LC. These are the type of people that would be intrinsically motivated for a training in lean construction.

For the sixth sub question the variable *Willingness SG in LC* is used as dependent variable. The independent variables that had an (almost) significant effect on this variable were: *age, level of education, prior knowledge LC, LC learn more, LC 16h workshop* and *LC 40h workshop*. Again people of an lower age and with a higher education level had a more positive effect on the dependent variable. People that are willing to learn more about the concept are generally also more willing to use a serious game for their training. This is a good sign for the serious game since these people are also important for the target group.

It seems that people that that have a lot of prior knowledge of the LC concept are less inclined to use a serious game than people that have no or a reasonable amount of knowledge. In addition, people that would be interested in a 16 hour workshop would also be interested in a serious game variant, while people willing to participate in a 40 hour workshop are not. These conclusions suggest that the serious game would be mostly interesting for basic trainings in lean construction while if you want to understand the concept in depth other training types would be more interesting.

4.4 User preferences

To answer the seventh sub question of the research question, as described in section 3.5, a stated choice study is performed as part of the questionnaire. This stated choice has five attributes: *Presentation information, Assessment, Depth, Achievement system* and *Certificate*. The first four have 3 levels, the last one has only two as described in Table 3.1. The program nlogit is used to analyze the data and present the results. A stated choice analysis is performed that includes all 271 respondents of which the results are described in the next section. Secondly a Latent Class Analysis is performed looking at the results for specific groups to see if there are relevant unseen differences. These analyses will answer sub question 7.

4.4.1 General user preferences

First a model is made that includes all respondents in the stated choice analysis. The analysis uses the last level of the attribute as a reference category to compare with the other variable(s). This results in the following comparisons:

- Within the attribute *Presentation information* the level 'A combination' is compared with 'Text and images' and 'Videos and animations'
- For the attribute *Assessment* the reference category is 'a combination' that is compared to 'Multiple choice test' and 'Example exercises'
- Within the attribute *Depth* the category 'Customized (variable length)' is compared with 'Basic (ca. 16h)' and 'Advanced (ca. 40h)'
- For the variable *Achievement system* the level 'Experience for anonymous competition' is the reference category that is compared with 'No additional achievement system' and 'Points for online economy'
- Finally, the reference category 'No certificate' is compared with 'Certificate'

The results are shown in Table 4.27 and Figure 4.8.

Table 4.27 - General stated choice model

Choice	Coefficient	Sig	
Pres. information: text and images	-0.18729	0.0000	***
Pres. information: videos and animations	0.11929	0.0050	***
Assessment: Multiple choice test	-0.03626	0.4060	
Assessment: Example exercises	-0.01757	0.6805	
Depth: Basic (16h)	0.19110	0.0000	***
Depth: Advanced (40h)	-0.47910	0.0000	***
Achieve. syst.: No additional achievement system	-0.04566	0.2878	
Achieve. syst.: Points for online economy	- 0.04676	0.2784	
Certificate: Certificate	0.28371	0.0000	***
Alternative 1	0.59548	0.0000	***
Alternative 2	0.67363	0.0000	***

***, **, * -> significant at a 1%, 5% or 10% level

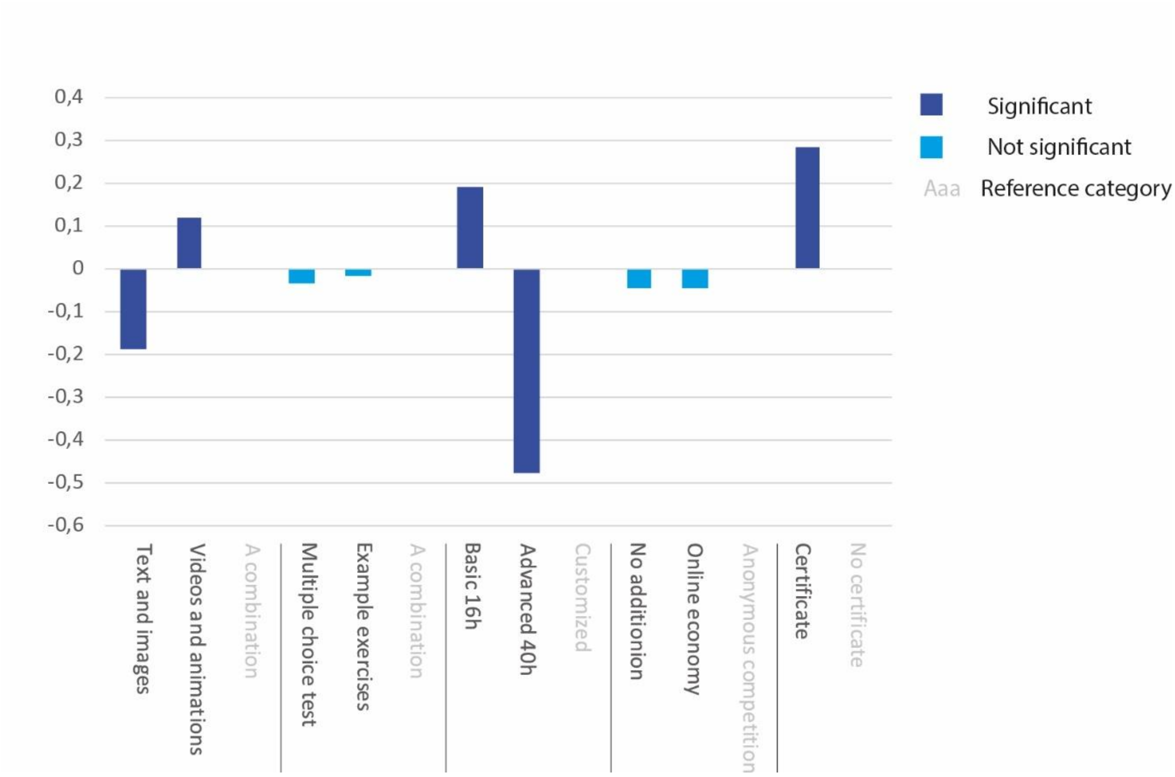

Figure 4.8 - Bar diagram of general stated choice analysis results

As Table 4.27 clearly shows, the variable *Presentation information* has a significant influence on the choices of the respondents. The choice 'Text and images' has a negative coefficient meaning that this alternative is less favorite than the option 'A combination' for this attribute. More favorite than 'A combination' however is the second option 'Videos and animation' that has a positive coefficient. This means that in general people would prefer the videos and animations over the text and images even if these text and images were combined with videos and animations.

Additionally the depth of the training has a strong significant impact on the choice of the respondents. It is clear that training with less depth that takes only 16 hours is more popular than a more advanced training of 40 hours. In general people do not want the training to take too long. Remarkable is the fact that a training of 16 hours is preferred over an customized length of a training which could be adjusted to the specific preferences of the user. It is possible that the respondents generally were going for the shortest option and since the length of the customized options was variable this could mean it would take longer than the 16h training.

Finally, the factor *Certificate* has an influence on the decisions respondents make regarding the choice of SG. Receiving a certificate at the end of a course seems to be an important factor for people when they are following a training. This finding agrees with the literature that shows that people can be motivated by rewards they receive.

Table 4.27 also shows that only the variables *Assessment* and *Achievements system* are not significant variables for the respondents. These two variables do not seem to have an impact on whether people would use the serious game for the training of lean construction. Or at least the other variables are too important for the respondents that the preference they might have within these two variables is overshadowed. The fact that *Achievement system* is not significant, while *Certificate* is, shows that people are more interested in rewards in real life than in fictional achievements.

The variables Alternative 1 and Alternative 2 show if the two alternative options the respondents could choose from are significantly more chosen compared to the option 'Neither', if respondents did not want to use any of the two serios game options. This means that the respondents generally would prefer to choose one of the alternatives instead of no serious game at all.

For the general analysis it is also clear that alternative 1 and 2 were chosen significantly more often over the option 'Neither' meaning that in general people preferred one of the SG alternatives than not doing any of them. The 'Neither' options was chosen only 20.5% of the time while the other options were almost equally chosen.

4.4.2 User preferences per class

A latent class analysis is performed in order to find if there are differences in the serious game preferences of different groups. A number of variables used in the regression analyses is used as input for this analysis. Specifically the variables that had an (almost) significant effect on the willingness to learn more about lean construction and on the willingness to use a serious game for that, since these variables could indicate the target group. These variables are: *Age, Level of Education, Prior Knowledge LC, Innovation Level, LC learn more, LC 16h workshop* and *LC 40h workshop*. For this analysis the program nlogit is used. The commands used for this analysis are shown in Appendix I.

Classes

Creating the classes in nlogit takes some optimization with the tolerance for convergence on gradient (tlg) value. Not all tlg values resulted in useful, significant result. The AIC values and number of iterations are shown in Table 4.28 as well as an indication of how useful the scenarios are. The usefulness is determined on whether the results show significant differences between the classes.

Table 4.28 - Latent class overview of values per class

Classes	Tlg	AIC	Iterations	Usefulness
2	*1*	*4100.1*	*25*	*No*
	5	*4101.3*	*23*	*No*
	10	**4112.2**	**19**	**A little**
	15	*4764.3*	*22*	*No*
	20	*4824.1*	*12*	*No*
3	*1*	*3978.9*	*49*	*No*
	5	*3992.7*	*30*	*No*
	10	*3999.1*	*26*	*No*
	15	**4295.9**	**27**	**Reasonable**

	20	**4321.7**	**25**	**Very**
	25	*4877.4*	*5*	*No*
4	*Error*			

As can be seen in Table 4.28 there are three scenarios that could be seen as at least a little useful. There are no large differences between the AIC values and all the iterations can still be considered reasonable. Therefore, this study decided to focus on the scenario with the most significant differences between the groups. This is the scenario with 3 classes and a tlg value of 20. Other LCA's were tried as well with less *Age* and *Prior knowledge LC* categories, however this did not result in better models or different insights.

Class characteristics

It is important to describe the differences between the three classes that were created in the LCA. The third class will be used as a reference category for the other two classes. The first class created by the LCA contains only 6 people, counting for 2.2% of the total group of respondents. The group is therefore too small for significant differences with the reference group and will not be used in the rest of the analysis.

Table 4.29 - Differences class 2 with the reference class 3

Variable	Coefficient	Sig	
One	-3.04178	0.0000	***
Age: 18-24	-0.67144	0.3262	
Age: 25-34	-1.09390	0.0396	**
Age: 35-44	2.69055	0.0000	***
Age: 45-54	-0.14701	0.8037	
Age: >55	0[a]		
Level of education: Low or middle	-1.10065	0.0004	***
Level of education: High	0[a]		
Prior Knowledge LC: Not at all	-1.94660	0.0006	***
Prior Knowledge LC: A little	-1.75305	0.0010	***
Prior Knowledge LC: Reasonable	-1.39678	0.0179	**
Prior Knowledge LC: Rather well	0.20298	0.7581	
Prior Knowledge LC: Very well	0[a]		
Innovation level	0.08746	0.7685	
LC learn more: No	6.87087	0.0000	***
LC learn more: Neutral	1.32581	0.0124	**
LC learn more: Yes	0[a]		
LC 16h workshop: No	4.45935	0.0009	***
LC 16h workshop: Neutral	3.61032	0.0002	***
LC 16h workshop: Yes	0[a]		
LC 40h workshop: No	-7.09092	0.0000	***
LC 40h workshop: Neutral	-2.33312	0.0271	**
LC 40h workshop: Yes	0[a]		

[a] Is set 0 because it is a reference variable

***, **, * -> significant at a 1%, 5% or 10% level

The second class is significantly different from the third group. This group counts for 10.5% of the respondents, a total of 28 people. As shown in Table 4.29 there is a number of differences between the two classes. The second group consists largely of people that are not interested in learning more about lean construction or following a 16 hour workshop for that. However, the people that do not want to follow a 40 hour workshop are more represented in the third class. Regarding these variables the third group would correspond better with the target group as described in section 4.3.3. Additionally, the second group represents relatively less people that do not have a lot of prior knowledge. Most people that do not have prior knowledge of lean construction are in class 3. The second class has a relatively high number of people with the age between 35 and 44. while missing mostly people with the age of 25-34. As established in the regression analysis, people younger than 35 are more likely to be interested in a serious game than older people. Finally, there is a difference in the level of education of the respondents in the second class and in the third class. In the second class contains relatively less people with a low or middle level of education. This is the only variable that is contrasting the conclusions of the regression analysis for the target groups since these analyses showed that the respondents with a low or middle level of education were relatively less likely willing to learn more about LC. However, this variable was only 'almost' significant instead of fully significant like the other variables.

Despite the difference in *Level of education* the third class in the latent class analysis can be considered a good representation of what could be defined as the target group of the serious game in lean construction. This group includes 87.3% of the respondents and is therefore still a group that is large enough to give significant results.

Results of classes

The results of the LCA show no significant results in the second class of the model as shown in Table 4.30. Possible reasons for this could be the small size of the group, as well as the fact that this group is less interested in the serious game and possibly filled in the neither option more often, resulting in less data to differentiate between the attribute levels.

For the third class however there are significant results. These results are shown in Table 4.30 and show a similar result to that of the stated choice analysis. Again the attribute levels of *Presentation information, Depth* and *Certificate* are significant with the same preferences. The difference however is that now the coefficients are all slightly increased when positive, and decreased when negative. This means that when looked at class 3. the target group, the preferences are a little more distinctively, making it more clear.

Table 4.30 - Results LCA for class 2 and 3

Class	Choice	Coefficient	Sig	
2	Pres. information: **text and images**	-1.50071	0.7698	
	Pres. information: **videos and animations**	0.28578	0.9786	
	Assessment: **Multiple choice test**	0.66679	0.9389	
	Assessment: **Example exercises**	0.53382	0.9484	
	Depth: **Basic (16h)**	0.59153	0.8322	
	Depth: **Advanced (40h)**	-0.89110	0.5015	
	Achieve. syst.: **No additional achievement system**	-0.44438	0.9515	
	Achieve. syst.: **Points for online economy**	-1.68397	0.8128	
	Certificate: **Certificate**	1.43410	0.8731	
	Alternative 1	-5.24533	0.8129	
	Alternative 2	-3.76177	0.5701	
3	Pres. information: **text and images**	-0.23619	0.0000	***
	Pres. information: **videos and animations**	0.16248	0.0006	***
	Assessment: **Multiple choice test**	-0.05568	0.3098	
	Assessment: **Example exercises**	0.00581	0.9138	
	Depth: **Basic (16h)**	0.27799	0.0000	***
	Depth: **Advanced (40h)**	-0.58521	0.0000	***
	Achieve. syst.: **No additional achievement system**	0.06080	0.2132	
	Achieve. syst.: **Points for online economy**	-0.14225	0.0048	***
	Certificate: **Certificate**	0.31585	0.0000	***
	Alternative 1	1.55588	0.0000	***
	Alternative 2	1.60634	0.0000	***

***, **, * -> significant at a 1%, 5% or 10% level

In addition, the attribute level ‘Points for online economy’ within the *Achievement system* has a significant negative coefficient compared to the reference category ‘Experience for anonymous competition’. This would mean that the respondents are more interested in the competition than in the virtual marketplace.

When looked at the coefficients of the LCA it is clear that certain values are more positive or negative than others. Especially the advanced depth, with about 40 hours of training is viewed negatively by the respondents. They would clearly prefer to have a shorter, more basic training or customized for their personal preferences. Also the level ‘certificate’ is valued high among the respondents compared to ‘no certificate’.

The category ‘No additional achievement system’ for the *Achievement system* attribute is not significant. Also the attribute levels ‘Multiple choice test’ and ‘Example exercises’ do not have a significant difference with the reference category ‘A combination’. This is the same as in the stated choice experiment in the previous section.

4.4.3 Interpretation and conclusion

The results of the stated choice and the latent class analysis show clear similarities. Significant differences were found in the respondents preference regarding the way the information of the training was presented, the depth of the training, the achievement system it is using and whether or not to end the training with a certificate. Respondents show a clear preference for a shorter, more basic serious game training in lean construction. This is in line with the results of the preferences of the respondents regarding the workshops. There people were also much more interested in the 16 hour training than the 40 hour training. Surprisingly, the basic training was also preferred over the customized training that could be specifically adjusted to the content the users want to learn. Possibly the respondents assumed the length of the customized training would generally be somewhere between the basic and advanced training and then they would prefer it if the training would be kept short.

The results also clearly show that people find the certificate important for the serious game. Having something tangible at the end of the training seems to be important for the respondents. It was also often mentioned in the comments at the end of the survey that respondents found that an important feature. This would mean that before launching the serious game it would be meaningful to first look into a standardization of the certification system of lean construction trainings that could be used in the serious game.

Thirdly the presentation of information would be a significant variable in the execution of serious game. Respondents clearly preferred the use of videos and animations, that were custom made for the content of the training, over the use of the more traditional text and images. This was also preferred over a combination of text, images, videos and animations. A possibly explanation could be that the respondents would really prefer the videos and animations and would not want parts of it to be textual. However, as the literature points out, people have different ways they prefer to learn. Having only videos and animations as an option to learn could therefore also discourage a number of people to use the application. Using text and images *in addition* to the videos and animations rather than *instead of* could therefore be interesting.

Finally, although the general stated choice did not find a significant difference in the attribute levels of the *Achievement system,* the LCA did. This analysis shows that people were more interested in using a competition system as a competitive way to keep motivated to use the serious game, over the use of a virtual marketplace. The competition was not significantly differently valued as ‘No additional achievement system’ which indicates that the achievement systems are not considered that important. Possibly this is not one of the factors that is people take much into account when choosing to use the serious game, but is more important for motivating the users to keep using it. However, other research is necessary to confirm this.

The assessment method does not seem to be important enough for the respondents to see significant differences. Developers of the application could choose what they think is the best way to assess what the users have learned. Possibly this changes for different topics.

4.5 Mock-up

As in section 3.6 a mock-up of the serious game is made. This consists of graphical images that show what the serious game could, not should, look like when implemented. The images made are based on the literature review and the results found in analyses. They provide a more visual insight in the conclusions of this research and how future developers could make it. This section shows multiple 'screenshots' of the application and describes what is shown and why.

First the home screen of the application shows the different parts that are part of the mock-up application, as shown in Figure 4.9. First there is the option to start the training with 'Learn Lean', the second and third options are achievement systems, then there is an option for useful tools that are recommended to use when applying LC, and last there are the settings for the application.

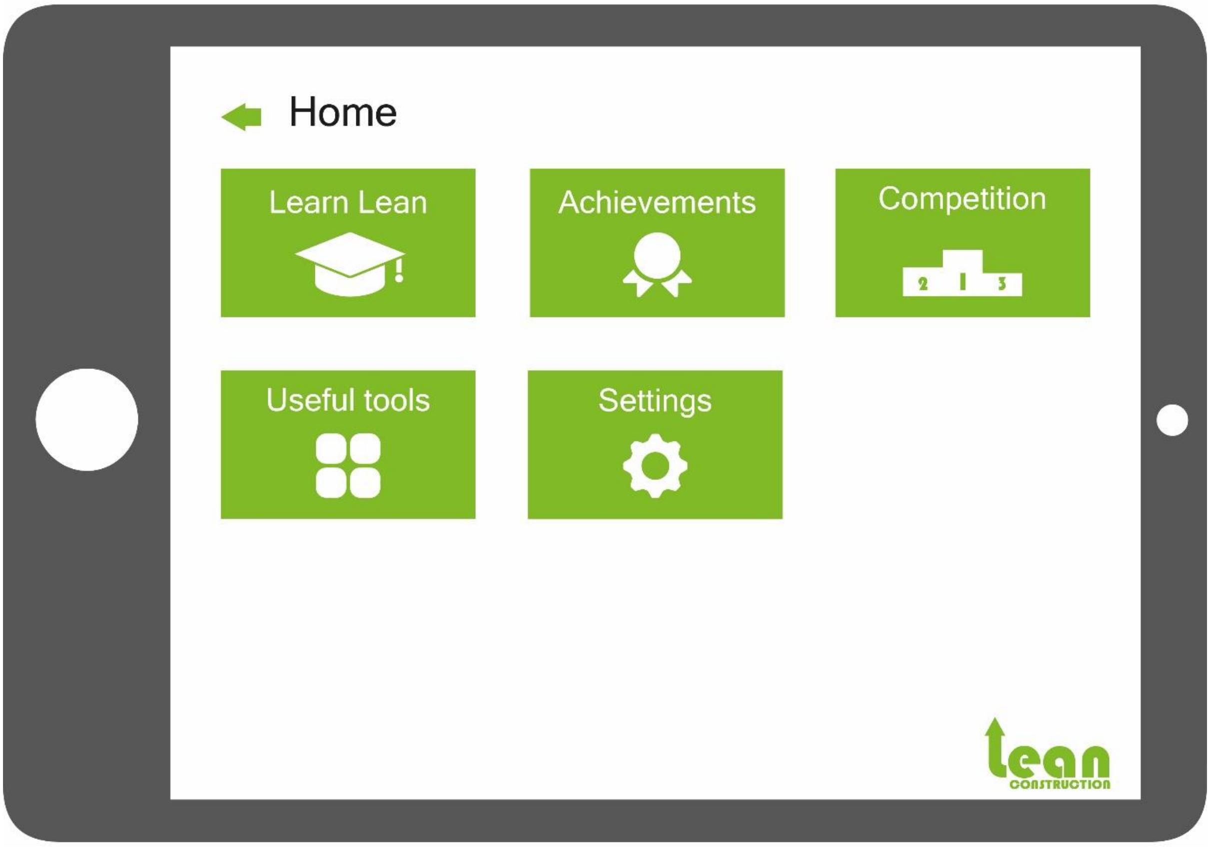

Figure 4.9 - Mock-up home screen

When selecting the 'Learn Lean' option the different lesson chapters are shown as medium term goals. The order of these chapters is fixed as this was preferred over the customized option. This is shown in Figure 4.10. Users can only start another lesson when the previous one was ended. Advantages are that the training has a logical order and the user has the necessary prior knowledge for each lesson. However not all people might be interested in each topic since some techniques are not useful for their projects. A more customized option as in Figure 4.11 might therefore also be an option for the developers to use. Here users can train each chapter in their own order and depth.

Figure 4.10 - Mock up fixed order of training

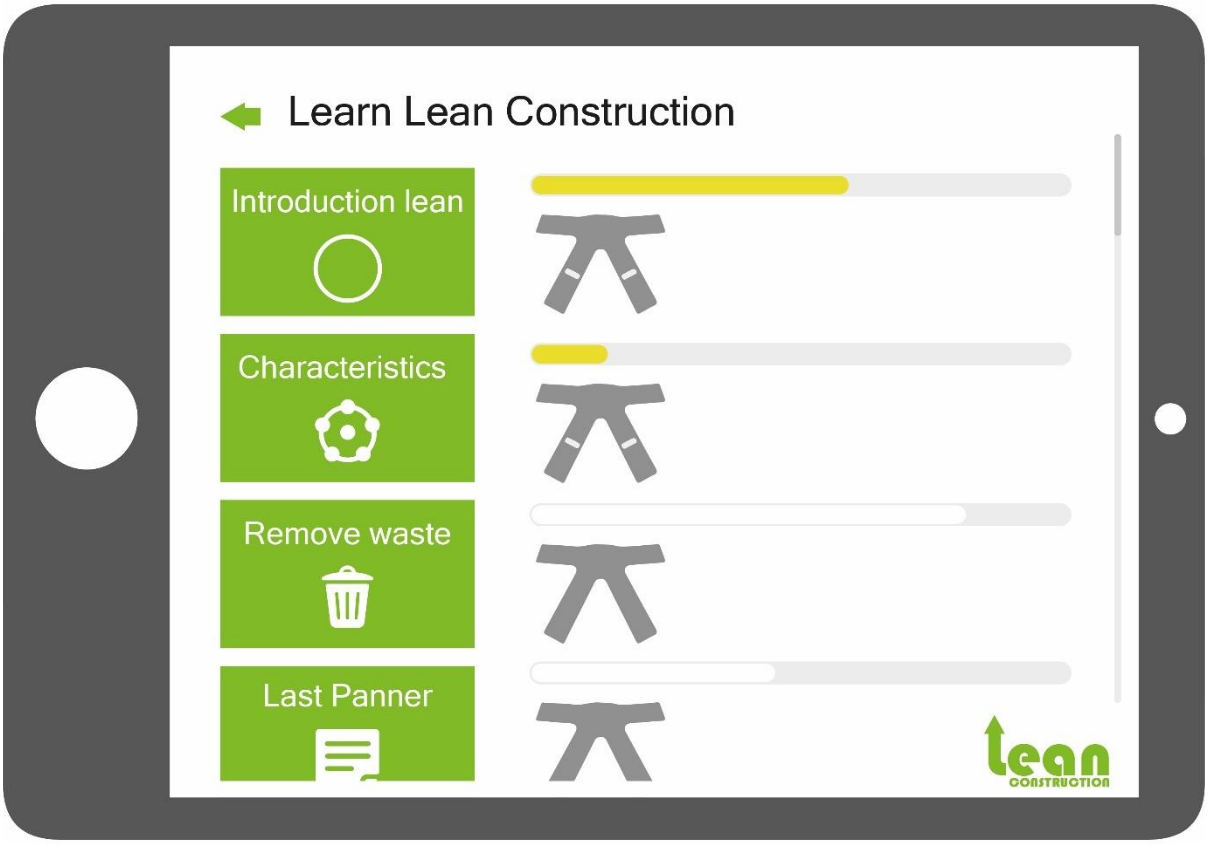

Figure 4.11 - Mock up customized training

When selecting a specific chapter it consists of shorter lessons as shown in Figure 4.12. These are the short term goals of the training. The icons on the buttons show how the information in the lesson is presented. All lessons are given by means of videos and animations, but with some lessons text and images are also provided as alternative way of learning for students that prefer that.

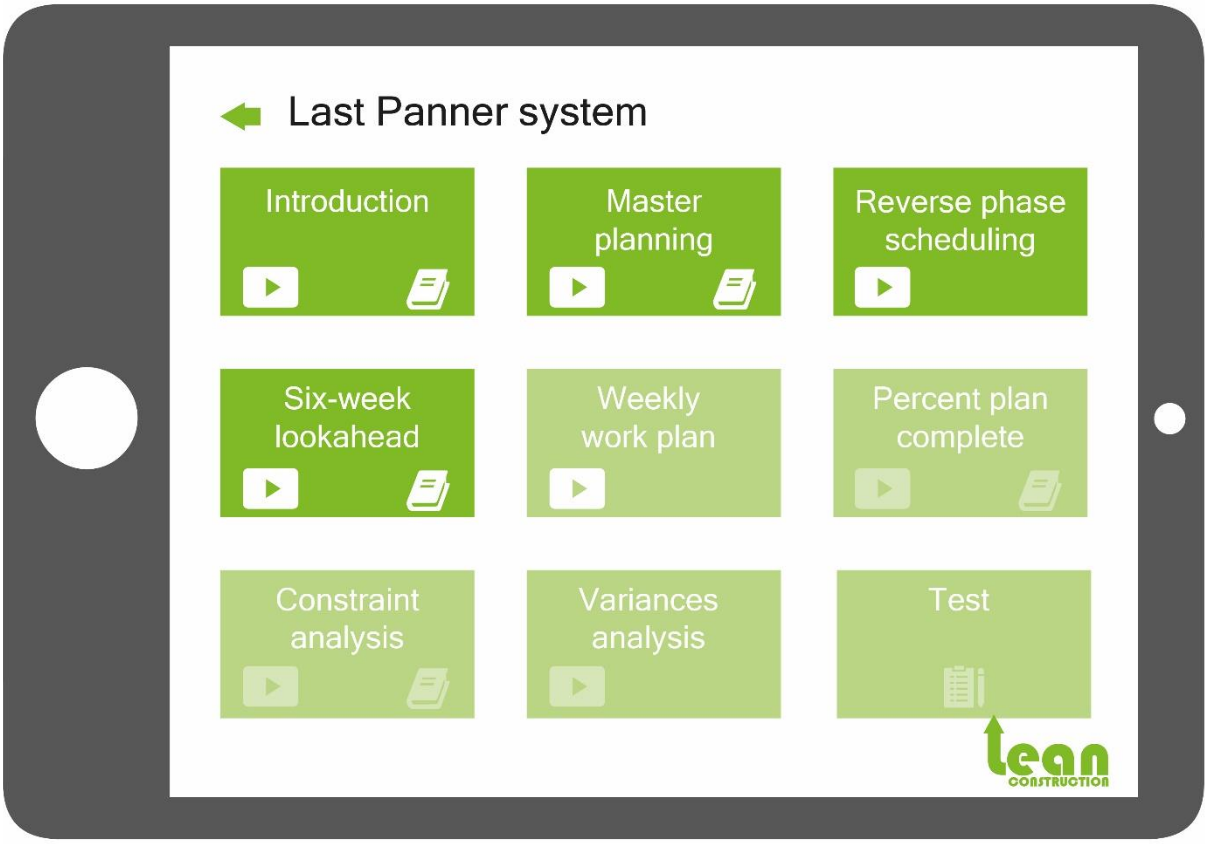

Figure 4.12 – Mock-up lessons within a chapter

Figure 4.13 shows a page with all different videos about a certain lesson. Videos and animations were the preferred way of learning for people. However, text and images could still be an option for people that are have a different way of learning. This is shown in Figure 4.14.

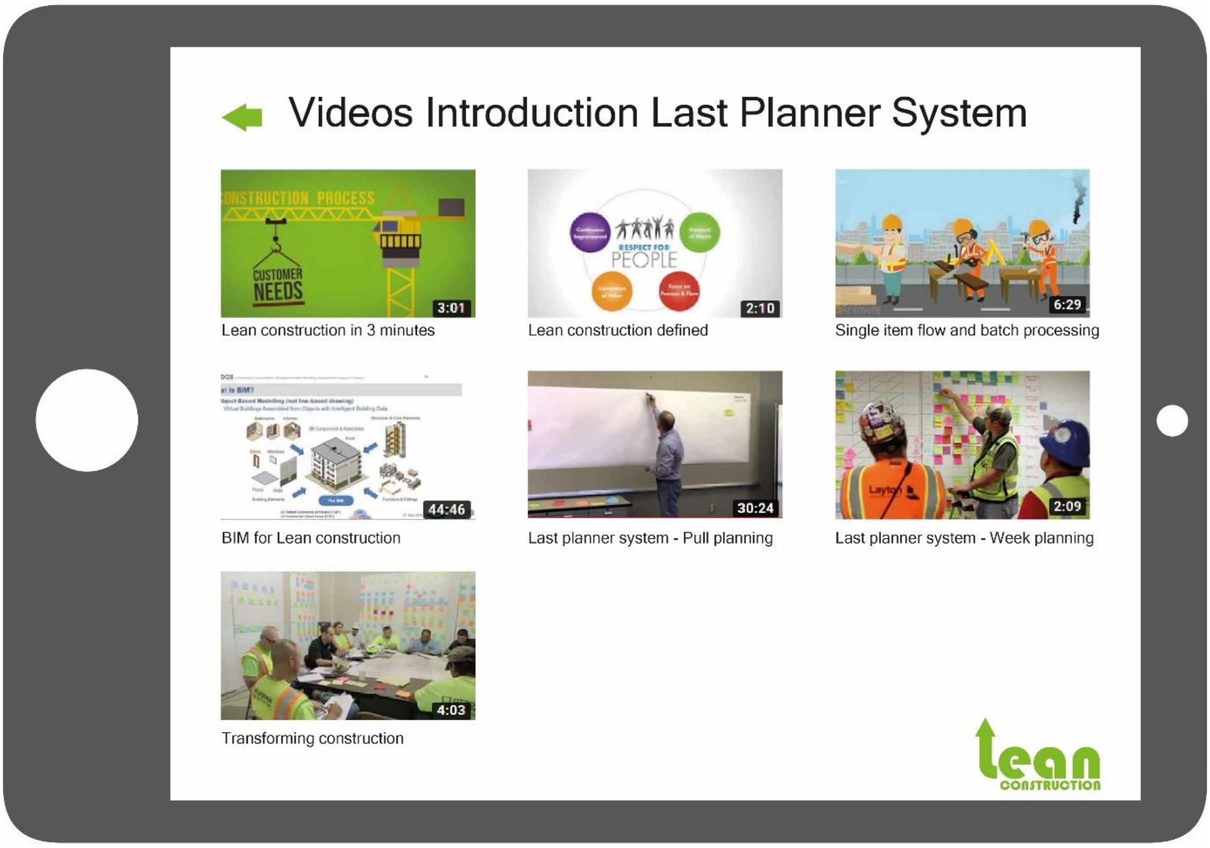

Figure 4.13 - Mock-up custom made videos and animations

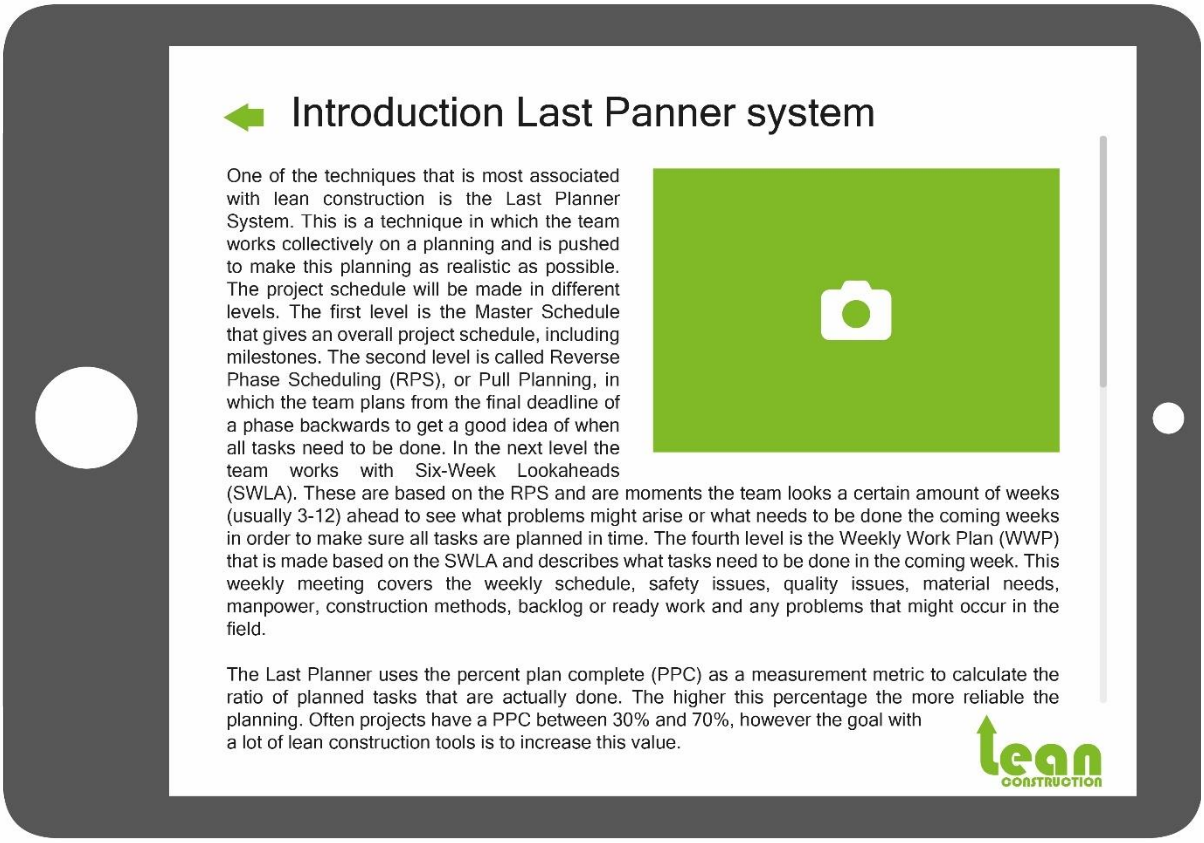

Figure 4.14 - Mock-up text and images

The analyses did not find a significant preference for a type of assessment. The developers of the serious game are therefore free in what type they prefer. The more traditional way of assessing is with a multiple choice test at the end of each lesson and/or chapter as shown in Figure 4.15. Another way would be by means of exercises specifically made for the topics that people could do to show that they could apply the theory they have learned. This can be seen in Figure 4.16.

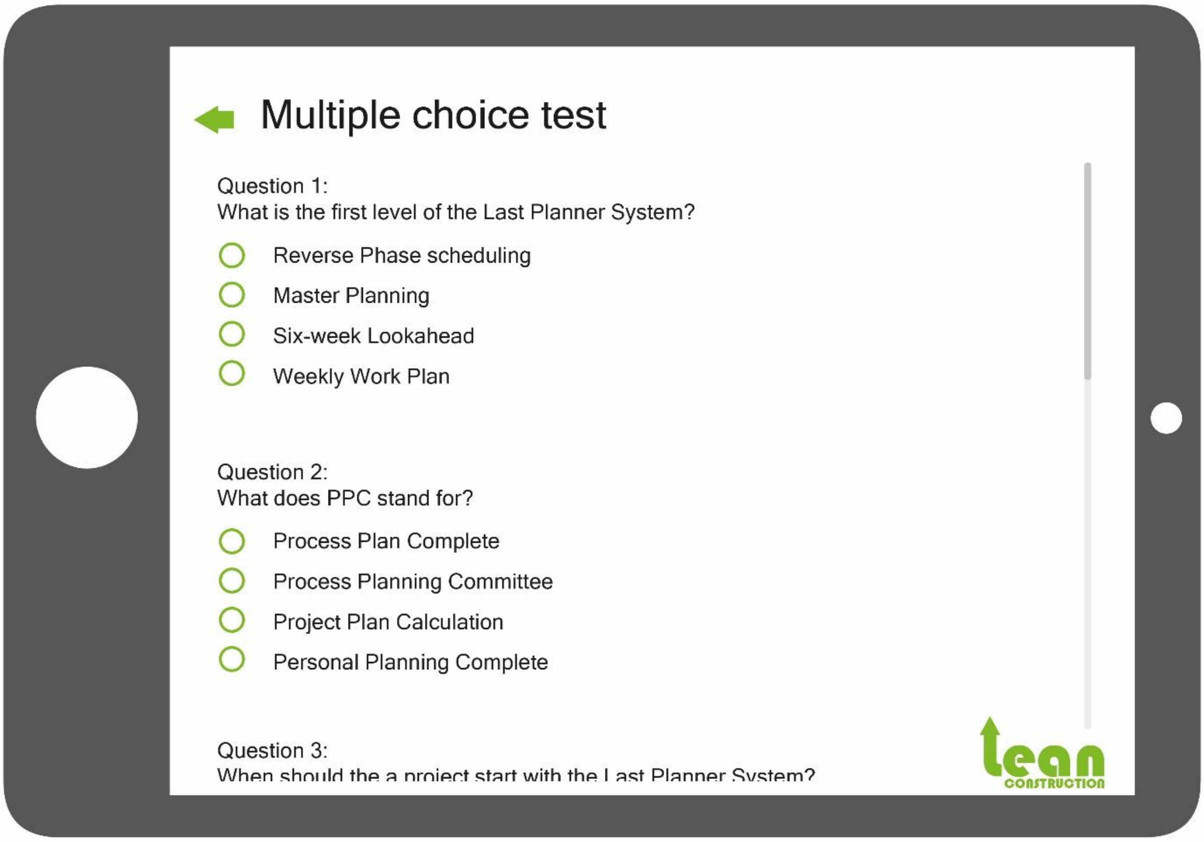

Figure 4.15 - Mock-up assessment multiple choice test

Multiple choice tests can be used for testing the knowledge of the theory of a topic while exercises can be better used for testing the knowledge in practice. A combination of the two would therefore also certainly be an interesting option for developers.

Figure 4.16 - Mock-up assessment exercises

Finally, when going back to the 'Home' page of the application, there were still some options regarding the achievement systems. The first one is a very basic system that can easily be implemented in the serious game: the badges system. The user has a list of challenges that can be accomplished. This is one of the most standard elements of serious games.

Secondly there is a leaderboard as part of an achievement system. This shows the current stand of a competition. By completing lessons in the training the user could farm experience and raise in the leaderboard or even win the competition. This technique was preferred by the respondents, however possibly it has less influence on choosing to use the application and more on keeping them interested.

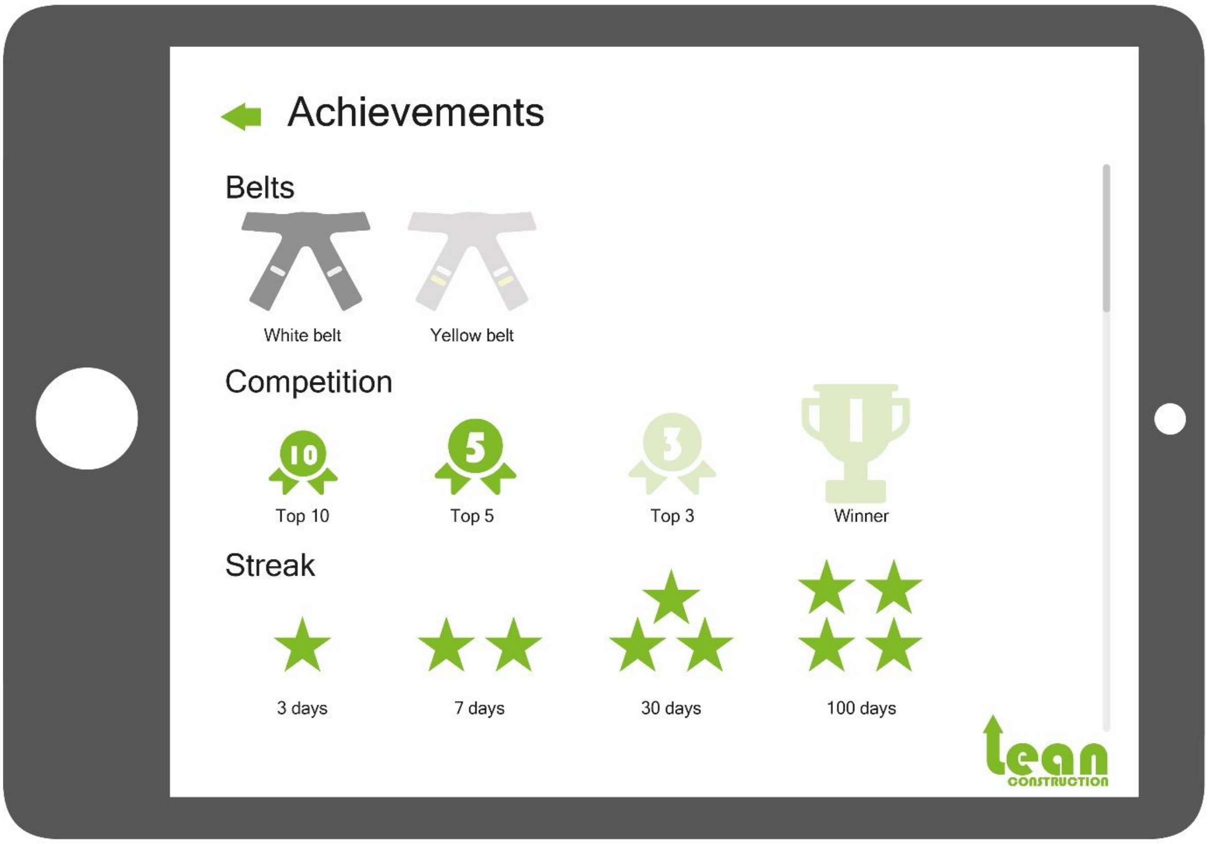

Figure 4.17 - Mock-up achievement system badges

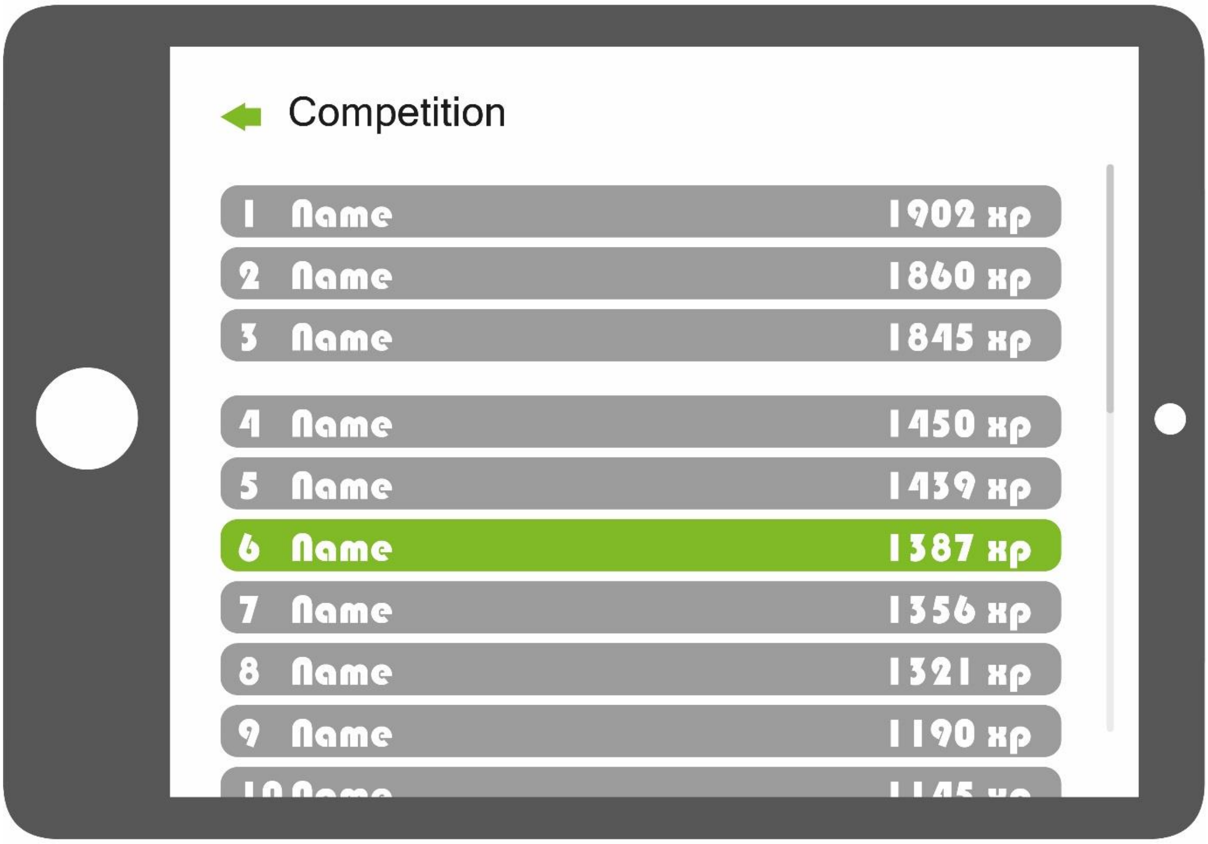

Figure 4.18 - Mock-up achievement system competition

4.6 Conclusion

This chapter shows some interesting results. First a couple of analyses are done that describe the data that is collected and how the collected data was used. The respondents are not a great representation of the construction sector. It is clear that there are relatively more young people and people of a higher education level represented in the data. Additionally, the number of technical employees and managers is relatively high as well, while the number of construction laborers is limited.

When testing the quality of the data set this study found that the variance level of the data can be considered suitable. However, the internal tolerance of the data is, even when removing the variables *Job type, Working situation* and *Gender*, still questionable, which should be taken into account. The stepwise analysis show that the most important variables that describe the dependent variable *Learn more* are *Innovation level, Age, Prior knowledge LC* and *Level of education*. For the dependent variable *Willingness SG in LC* these variables were *LC learn more, Age LC 16h workshop*, *LC 40h workshop* and *Level of education.* Finally, the data was tested on multicollinearity. The analyses show that a lot of the variables seem to correlate with each other.

By means of an ordinal and MNL regression analysis the fifth and sixth sub question were answered. People that are willing to learn more about lean construction are often younger people, that consider themselves to be innovative and have a higher education level. People that want to use the serious game for the training in LC are often also from a younger age and with a higher education level. Additionally, these are people that do not have too much prior knowledge of LC but are interested to learn more about it. These people are not willing to follow a 40 hour workshop for that, however a shorter training, of 16 hours, would be interesting.

For the seventh sub question a stated choice experiment is used. The respondents showed their preference for the characteristics of the serious game. Again it was clear that people were less interested in the longer, advanced training and would prefer the shorter basic training. This was even preferred over the customized training. Secondly, the respondents showed that receiving a certificate at the end of the training was quite important to them. Thirdly it was clear that the videos and animations were preferred over text and images and a competition was the preferred achievement system.

Finally a mock-up was made as an answer to the eight sub question. This combined the different conclusions of the previous analysis into a model for the serious game showing what it could look like when developed.

5 CONCLUSIONS

The conclusions of the different analysis are drawn in this chapter. This includes not only the conclusions of the analysis as described in chapter 4. but also the conclusions of the literature review. Secondly the relevance of this research is discussed. The research is both relevant on a scientific as on a societal level as is described in section 5.2. Thirdly, all researches have their limitations and the ones of this research are discussed in section 5.3. The chapter ends with the recommendations. These are recommendations for both the implementation of the serious game, as the recommendations for further research.

5.1 Conclusions

This research has focused on the question: *How could a serious game of a training in lean construction be designed in order to motivate the users to follow the training?* A literature review is done in order to understand the concept of lean construction, its trainings, serious games and how they can fit together. However more research was necessary in order to understand what the potential users could be and how the serious game should be designed.

The literature shows that lean construction is a concept that could have a good impact on the construction sector. The concept consists of six tenets: generation of value, removal of waste, focus on process and flow, continuous improvement, optimize the whole and respect for all people involved. In practice this results in a number of techniques, such as the Last Planner System and Just-In-Time, that could be applied in construction processes. Multiple studies have shown that when these techniques are well applied; the projects faces significantly less delays and would stay within budget. In addition, everyone involved would be more satisfied with the process and its results and health and safety would be increased. However, to make sure the LC concept is well applied it is important that everyone involved in using LC would get a basic training in how to use LC techniques and why.

Despite the potential of LC, the amount of training in the concept is still limited. Often these trainings are provided internally by companies to educated a small group of their employees or lean management workshops are given by external companies. However these workshops are not always specified to the construction sector. There is no good view on whether all these different trainings are consistent with each other. In addition, workshops are a type of training that could very well provide an in depth training in a concept and motivate people to use it, but they are relatively time consuming and cost a lot of money per person that is trained, since workshops are only given in small groups.

The concept of serious games could be an interesting alternative way of training more people in LC. Serious games uses gaming techniques to motivate and engage users. A serious game consists of goal orientations, achievements, reinforcement, competition and fun orientation. A large number of gaming techniques is applied in a serious game to make sure the user is motivated to continue their training. Serious games could reach a large number of people, however they are limited in how advanced the training could be. For a lean construction training it would therefore be mostly suitable to train the majority of the construction sector basic information (white or yellow belt level) about the concept and train a few experts (green or black belt level) by means of a workshop.

It is important that research has been done regarding the potential for implementing the serious game. Therefore, it is necessary to understand what kind of people would be interested in learning more about lean construction and would be willing to use a serious game for it. This research found a number of factors that would influence these variables. First, the study found that people of a younger age are generally more interested in learning about LC and are also more interested in using a serious game for this. In addition to the difference in age, the innovation level seems to influence the willingness to learn more about the concept. People who consider themselves to be more innovative are generally more inclined to learn more about LC. However, they are not significantly more interested in using the serious game application for this training.

People willing to use the serious game for the lean construction training are often people that do not have much prior knowledge about the concept yet. They do want to learn more about it, but are only interested in a shorter, more basic training than an advanced training. This group of people can be considered the target group.

Apart from finding the people that would use the serious game, it is important to find what should be included in the serious game. By means of a stated choice analysis and an LCA this study found, again, that people would prefer the serious game to be a basic training of limited length. Secondly, the choice behavior of the respondents clearly favored the options that resulted in official certificates when finishing the training. Furthermore, the respondents showed a preference for videos and animations as the way to present the information. Text and images were clearly less popular for the respondents. Finally, the target group for the serious game showed that people were more interested in using a competition as an achievement system than a virtual marketplace. However, generally the achievement system did not seem to be very important for people in their choice behavior.

Finally, a mock-up is made that shows how the serious game could potentially be made and what choices future developers should make if they are interested in making this type of training. This graphical tool visualizes the conclusions of this research.

5.2 Relevance

It is important for a research to be relevant. This section describes the relevance of this study, both scientific and societal.

5.2.1 Scientific relevance

The literature study found several research gaps that still needed to be explored. For instance, previous studies never researched the potential for combining the concept of serious games with the training in lean construction. It is therefore necessary to understand what kind of people want to learn more about LC and would be willing to use a serious game for that. This could give insight in whether there would be people willing to use this type of serious game training and what kind of people this would be (the target group). Additionally, more information was necessary regarding the choice behavior of people regarding the serious game, specifically for the target group. The literature suggests a lot of different ways in which the serious game could be made, however it was still unclear how important these different techniques are when they are compared with each other. What characteristics of the serious game are considered more important for the target group and would therefore increase the chance of people using the serious game? This research provides some insight in this question and adds therefore to the knowledge regarding the implementation of serious games. Furthermore, the research could be used as a base for further research regarding implementation of serious games in the construction sector.

In addition to the new insights in implementing a serious game for the training in lean construction, this study also consists of a literature research that could provide more understanding of lean construction, different types of training and serious games. Of course a literature research consists only of insights that were already provided in other studies, but combining these studies could lead to new views on the concepts.

5.2.2 Societal relevance

Regarding the societal benefits, this study mainly provides that with the implementation of the serious game of a lean construction training. The research done could help develop this serious game and make it more successful and more useful for the user. When well implemented the serious game could provide a new way of training basic knowledge of lean construction to a large group of people in the construction sector. This would not only increase their knowledge of LC but hopefully also make them more motivated to use the concept in their work. This type of training could be considered more fun for users to do than other types of training and could open the way for other serious games to be implemented in the construction sector.

If the knowledge of people in the constructions sector regarding LC would be increased and the concept would be used this could have a large impact on the construction processes. Projects would be more optimized resulting in an increase of projects that stay within their budget and time limits. Additionally, people involved would be more satisfied with the work done and the end result that could have more quality. Finally, implementation of lean construction increases the health and safety of the construction site resulting in less incidents.

5.3 Limitations

Like all studies, also this one has its limitations, as will be mentioned in this section. First it should be mentioned that the group of respondents is not a complete representation of the people working in the construction sector. There were relatively more people of a younger age and with an higher level of education, which is likely caused by the network of this research. There were relatively more people with a management position and technical employees at the expense of the construction laborers. In general it is of course a limitation that a large part of the respondents comes from the network of the researcher, creating a limited reach of the questionnaire and increasing the danger the respondents might be prejudiced. In addition, the possible bias of the researcher should be taken into consideration, since people could interpreted results more positive if that could strengthen their own idea.

Additionally, some of the respondents declared in the final comments that the use of the stated choice was confusing for them and not a type of research they were used to. People that did not understand the stated choice questions were not included in the final data, but it is possible that there are people that did not mention this in the research and they were still included. Another disadvantage of the use of a stated choice experiment is the fact that the choices people make are virtual and not real life choices. There could of course be a difference in how willing people then are to choose for certain options. People might give socially desirable answers in a survey that does not reflect their actual behavior, This should be taken into consideration when implementing the serious game.

Another important limitation to the results of this research is the high level of multicollinearity in the variables used for the regression analyses. A lot of independent variables correlated with each other, making the results a little less clear. Additionally the Cronbach's alpha test shows a value that is just lower than 0.7 making the internal consistency of the data set questionable. Furthermore, not all R-values of the different analyses were that high, meaning that the variables used in the analyses cannot decisively predict the preferences of people. There might still be a lot of variation among the people and other variables that were not included in this research might have an effect as well.

5.4 Recommendations

An important part of a research is the recommendations that it makes. These are split into two types: first the recommendations for the implementation of a serious game of a lean construction training and secondly the recommendations for further research will be given.

5.4.1 Implementation

Despite the limitations of this research, there are still some recommendations that can be made regarding the implementation of the serious game. A large number of people were interested in the use of the serious game, especially when a clear target group was defined. This target group consists of people that are relatively young and consider themselves to be innovative. Additionally, they should be interested to learn more about the topic but do not want the training to be too long.

The training provided by the serious game should be a basic study. More in depth training should be given by means of workshops for people that are interested in becoming experts in lean construction. However, for the basic training of LC the serious game would definitely be recommended to use. Furthermore, there should be a standardization of the certificate system of lean construction and this should be a reward for finishing the training. Finally, the training should mainly consist of videos and animations, however text and images as an alternative way of training should be considered.

5.4.2 Further research

Of course the scoop of this research is limited and there is still room for more research on this topic. This study only showed the possibilities of a lean construction training in a serious game, however this is mostly theoretical and respondents did not have the opportunity to really try out the serious game. Further research with, for example a prototype or the mock-up as future reference, should be done to make it more tangible for people and let them make more well-considered choices.

More research can also be done on how to implement the serious game. Are there for example other factors that should be taken into account and how should companies motivate their employees to use the serious game? A feasibility study could give more concrete insights in the implementation of the serious game.

Furthermore, a lot of people did not finish the survey. Most of them stopped when they had to fill in the stated choice part. This type of research might limit the amount of data that is retrieved at the end. This should be taken into consideration when doing further research. Also a lot of people mentioned in the comment section at the end of the survey that they were annoyed that they had no place to fill in their preferable combination of attribute levels. This is not included because it is not necessary for a stated choice research, but might for respondents be nice to include in the survey as well. Or create adaption discrete choice model that makes a choice set per respondent depending on their favorite attribute levels.

Further research can also be done regarding the use of achievement systems in the serious game. Although the literature research showed that it was an important aspect of serious games, this analysis showed that the respondents did not care that much about this characteristic. Possibly people find it not that important when they choose to use the serious game but is it important for keeping them attached to it. This could be further analyzed.

Finally, further research can be done regarding other serious games for the construction sector. The amount of serious games in this sector is still very limited, while there are a lot of other trainings that would be possible by means of a serious game. Possible examples could be a training in BIM, H&S and drawing programs.

6

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APPENDIX

Appendix A – Experimental design in SAS

Input

CODE LOG RESULTS

```
/* Suggesting design size*/
/* ex) two-level = 1, three-level = 4 */
%mktruns(3 ** 4 2 ** 1)

/* Generating Efficient Design */
/* As the result of mktruns: n=18 */
%mktex(3 ** 4 2 ** 1, n=18, seed=1008)

/* Output (Print) */
proc print; run;

/* Evaluation of design */
%mkteval(data=randomized)

/* Generating Efficient Design - blocking */
%mktblock(data=randomized, nblocks=2, seed=1008)

/* Output (Print) */
proc print; run;
```

Output

```
      Design Summary
  Number of
  Levels        Frequency
       2             1
       3             4
```

```
       Saturated      = 10
       Full Factorial = 162
       Some Reasonable                          Cannot Be
          Design Sizes         Violations       Divided By
                    18 *                0
                    36 *                0
                    27                  5       2 6
                    12                  6       9
                    24                  6       9
                    30                  6       9
                    15                 11       2 6 9
                    21                 11       2 6 9
                    33                 11       2 6 9
                    10 S               14       3 6 9
 * - 100% Efficient design can be made with the MktEx macro.
 S - Saturated Design - The smallest design that can be made.
     Note that the saturated design is not one of the
     recommended designs for this problem.  It is shown
     to provide some context for the recommended sizes.
```

Obs	x1	x2	x3	x4	x5
1	3	1	3	2	1
2	1	2	3	1	2
3	3	3	1	1	2
4	1	1	2	2	2
5	1	3	2	3	1
6	1	2	1	3	1
7	2	1	1	3	2
8	2	3	1	2	2
9	3	1	2	3	2
10	2	2	3	3	2
11	2	1	3	1	1
12	3	2	1	2	1
13	1	1	1	1	1
14	1	3	3	2	2
15	2	2	2	2	1
16	3	3	3	3	1
17	3	2	2	1	2
18	2	3	2	1	1

Obs	Block	Run	x1	x2	x3	x4	x5
1	1	1	1	2	3	1	2
2	1	2	1	1	2	2	2
3	1	3	1	3	2	3	1
4	1	4	2	1	1	3	2
5	1	5	2	3	1	2	2
6	1	6	2	1	3	1	1
7	1	7	3	2	1	2	1
8	1	8	3	3	3	3	1
9	1	9	3	2	2	1	2
10	2	1	3	1	3	2	1
11	2	2	3	3	1	1	2
12	2	3	1	2	1	3	1
13	2	4	3	1	2	3	2
14	2	5	2	2	3	3	2
15	2	6	1	1	1	1	1
16	2	7	1	3	3	2	2
17	2	8	2	2	2	2	1
18	2	9	2	3	2	1	1

Appendix B – Questionnaire

Page 1 - Introduction

Introduction

Dear respondent,

Thank you for participating in this survey. This study is part of a graduation project at Eindhoven University of Technology. The purpose of this research is to get more insight in the training in lean construction by means of a serious game to make the construction process more efficient (an explanation of lean construction and serious games will be given in the survey). This survey is specifically designed for people in the construction and/or infrastructure sector. The survey is more readable on a pc than on a smartphone.

Participation of this survey is voluntarily and you can stop or pause the survey at any time. To pause the survey press 'resume later' at the right top of the page. The survey is anonymous and the data will be used for research and not shared with third parties.

There are 31 questions in the survey and participating will approximately take 10 minutes.

Next

Page 2 – Socio-demographic questions (1/2)

General questions

*What is your age?

Your answer must be at least 18

Only an integer value may be entered in this field.

What is your gender?

Female | Male | No answer

*What is the highest level of education you have completed?

Choose one of the following answers

- Primary school
- Pre-vocational secondary education
- High school or vocational training
- Bachelor's degree, Master's degree or PhD
- Other:

Socio-demographic questions (2/2)

*What is your working situation?

Choose one of the following answers

- Working (paid) more than 30 hours a week
- Working (paid) 12-30 hours a week
- Working (paid) less than 12 hours a week
- Student or intern
- Unemployed/looking for a job
- Retired
- No answer
- Other:

*What type of job do you have (or which option descibes your profession best)?

Choose one of the following answers

- Contractor
- Architect/Urban designer
- Building physicist
- Draughtsman
- Construction laborer/execution
- Structural designer
- MEP engineer
- Project manager
- Real estate developer
- Other:

*Is the complexity of the projects you are working on in general normal (dwellings, roads, etc.) or extra complex (train stations, area development plans, etc., where a lot of different stakeholders are involved)?

	Normal	Mostly normal	Neutral	Mostly complex	Complex	Not applicable
	○	○	○	○	○	○

Previous Next

Page 3 – Lean construction questions (1/2)

Lean construction

Lean construction

Lean construction consists of a large number of practical techniques and tools that can be used in different parts of the construction process and for different groups. Lean is a concept that was originally used in the car industry to make the manufacturing process more efficient. Later an adjusted version for the construction industry was made named lean construction. In general the concept focusses on more value-added activities while getting rid of activities that do not add value (waste). Additionally, the concept simulates a better process flow and constant improvements of the process. Many studies show that projects that actively implement lean construction stay more often within their budget and time limit while improving their working climate and health and safety. Research also shows that proper training of the entire team is necessary to implement lean well.

*Did you have any training in lean in the past?

Yes | No

*How well did you already know the concept of lean construction before this survey?

	Not at all	A little	Reasonable	Rather well	Very well
	○	○	○	○	○

Which of the following lean construction techniques have you already heard of?

Check all that apply

- ☐ Last Planner System
- ☐ Just-In-Time
- ☐ Pull Planning
- ☐ Daily clustering/huddle meeting
- ☐ 5S
- ☐ Kaizen
- ☐ Total Quality Management
- ☐ Virtual Design Construction
- ☐ Error Proofing (Poko-yoke)
- ☐ Kanban System
- ☐ Standardization
- ☐ First Run Study
- ☐ Target Value Design
- ☐ Gemba Walk
- ☐ Design Workshop/Big Room
- ☐ Knotworking
- ☐ Benchmarking
- ☐ Fail Safe for Quality and Safety
- ☐ Design Structure Matrix (DSM)
- ☐ Location-Based Management System
- ☐ Other: ______

Lean construction questions 2/2)

Which of the following lean construction techniques have you applied in your work?

Check all that apply

- [ ] Last Planner System
- [ ] Just-In-Time
- [ ] Pull Planning
- [ ] Daily Clustering/Huddle Meeting
- [ ] 5S
- [ ] Kaizen
- [ ] Total Quality Management
- [ ] Virtual Design Construction
- [ ] Error Proofing (Poko-yoke)
- [ ] Kanban System
- [ ] Standardization
- [ ] First Run Study
- [ ] Target Value Design
- [ ] Gemba Walk
- [ ] Design Workshop/Big Room
- [ ] Knotworking
- [ ] Benchmarking
- [ ] Fail Safe for Quality and Safety
- [ ] Design Structure matrix (DSM)
- [ ] Location-Based Management System

*Do you agree with the following statements?

	Definitely not	Probably not	Neutral	Probably yes	Definitely yes
I am interested to learn more about lean construction	○	○	○	○	○
I am willing to participate in a lean construction workshop of 16 hours	○	○	○	○	○
I am willing to participate in a lean construction workshop of 40 hours	○	○	○	○	○

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Page 4 – Serious game question

Serious game

Serious game

To improve the training in lean construction we propose the use of a serious game. Serious games are games (often apps) designed for serious matters and are, for example, often used for educational purposes. The fun aspects of games are combined with a learning environment so users are more motivated to continue learning. Famous examples are the apps Duolingo, where you can learn another language, and Khan Academy, where you can learn different school courses.

How a serious game of a lean construction training could look like

*How much do you agree with the following statement?

	Definitly not	Probably not	Neutral	Probably yes	Definitly yes
I am willing to follow a lean construction training by means of a serious game	○	○	○	○	○

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Page 5 – Explanation stated choice

Set Up

In the next 9 questions you will get a choice between two alternative ways the serious game could be made and you are asked to pick the alternative you would use. You can also choose neither of the options if you think you would not use these alternatives.

Each option has 5 characteristics, as shown in the example below.

Choice 1/9

*What serious game for lean construction would you use?

Choose one of the following answers

	Option 1	Option 2	Neither
1. Presentation of information	Text and images	Videos and animations	Neither
2. Assessment system	Example exercises	A combination	
3. Depth of training	Customized	Advanced (ca. 40h)	
4. Achievement system	No additional achievement system	No additional achievement system	
5. Certificate	No certificate	Certificate	

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Page 6 – Explanation serious game attributes

Explanation Stated Choice

The characteristics of the serious game have the following options:

The **presentation of information** is about how the knowledge of lean construction is presented in the serious game. The options are text and images, videos and animations and a combination.

The **assessment** characteristic regards how progress is tracked. This could be done with multiple choice test in between the lessons, but also with example exercises that give scenarios and asks the user to apply a specific lean construction techniques to improve the process. As a third option a combination of the two assessment types is given.

The training could also have a different **depth**. Users could have a more basic training of 16 hours, a more advanced training of 40 hours or a customized training that lets the user choose what he/she wants to include in the training. In each option the hours do not have to be sequential and can be split into timeslots the users prefers.

The fourth category is the **achievement system**. This is an important part of a serious game to motivate users and make it more fun. Therefore, there will always be some achievement system included like badges for achievements. However, two of these systems could be included on top of that: points for an online economy, where you could receive a virtual currency when finishing lessons that they could spend on buying things in a virtual marketplace, and points for an anonymous competition where finishing a lesson gives you experience that could increase your place in a leaderboard.

The final category regards an official **certificate** that the user could receive after finishing the training. They will either get a certificate or no certificate.

You will not receive an official certificate at the end of the training

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Page 7 to 15 – Stated choice questions

Choice 1/9

*What serious game for lean construction would you use?

Choose one of the following answers

	○	○	○
1. Presentation of information	Text and images	Videos and animations	Neither
2. Assessment system	Example exercises	A combination	
3. Depth of training	Customized	Advanced (ca. 40h)	
4. Achievement system	No additional achievement system	No additional achievement system	
5. Certificate	No certificate	Certificate	

Page 16 – Innovation statements

Innovation

*How much do you agree with the following statements?

	Absolutely disagree	Disagree	Neutral	Agree	Absolutely agree	Not applicable
I am interested in new innovations	○	○	○	○	○	○
I think the construction sector should be more innovative	○	○	○	○	○	○
I often try to improve the way I work	○	○	○	○	○	○
I like to learn new things	○	○	○	○	○	○
I often invest money in new innovations	○	○	○	○	○	○
I have used other types of serious games to learn new things	○	○	○	○	○	○

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Page 17 - Final comments

Do you have any questions and/or remarks regarding this survey?

Previous Submit

Appendix C – Data modifications

DemEducation

Respondent 2
Field: Other
Filled in: university diploma
Changed to: Bachelor's degree, Master's degree or PhD

Respondent 157
Field: Other
Filled in: post-hbo
Changed to: High school or vocational training

Respondent 162
Field: Other
Filled in: als je een architect dit stuurt dan weet je zijn opleidingsniveau
Changed to: Bachelor's degree, Master's degree or PhD

Respondent 172
Field: Other
Filled in: akademie voor bouwkunst tilburg
Changed to: Bachelor's degree, Master's degree or PhD

Respondent 193
Field: Other
Filled in: Academie
Changed to: Bachelor's degree, Master's degree or PhD

Respondent 200
Field: Other
Filled in: Gym beta
Changed to: High school or vocational training

Respondent 225
Field: Other
Filled in: Academy van Bouwkunst
Changed to: Bachelor's degree, Master's degree or PhD

Respondent 265
Field: Other
Filled in: university diploma
Changed to: WO

DemWorkSitu

Respondent 162
Field: Other
Filled in: zelfstandig ondernemer
Changed to: Working (paid) more than 30 hours a week

DemJobType

Respondent 13
Field: Other
Filled in: Werkvoorbereider
Changed to: Project manager

Respondent 17
Field: Other
Filled in: werkvoorbereiding
Changed to: Project manager

Respondent 23
Field: Other
Filled in: assistent uitvoerder
Changed to: Contractor

Respondent 32
Field: Other
Filled in: Student in Vastgoed
Changed to: Real estate developer

Respondent 39
Field: Other
Filled in: Werkvoorbereider
Changed to: Project manager

Respondent 45
Field: Other
Filled in: Bouwkunde opleiding in architectuur richting
Changed to: Architect/Urban Designer

Respondent 79
Field: Other
Filled in: Timmerman tv
Changed to: Construction laborer/execution

Respondent 80
Field: Other
Filled in: Timmerman
Changed to: Construction laborer/execution

Respondent 81
Field: Other
Filled in: Carpenter
Changed to: Construction laborer/execution

Respondent 82
Field: Other
Filled in: Beton boorder
Changed to: Construction laborer/execution

Respondent 88
Field: Other
Filled in: Gevel montage
Changed to: Construction laborer/execution

Respondent 96
Field: Other
Filled in: Bouwkundige werkvoorbeereider
Changed to: Project manager

Respondent 98
Field: Other
Filled in: Werkvoorbereider
Changed to: Project manager

Respondent 101
Field: Other
Filled in: Betontimmerman
Changed to: Construction laborer/execution

Respondent 111
Field: Other
Filled in: Zzp'er adviseur BREEAM en WELL en vastgoedbeheer
Changed to: Real estate developer

Respondent 113
Field: Other
Filled in: Plafoneur
Changed to: Construction laborer/execution

Respondent 131
Field: Other
Filled in: Constructief tekenaar
Changed to: Draughtsman

Respondent 165
Field: Other
Filled in: Construction manager
Changed to: Project manager

Respondent 179
Field: Other
Filled in: projectleider
Changed to: Project manager

Respondent 206
Field: Other
Filled in: Werkvoorbereiding
Changed to: Project manager

Respondent 212
Field: Other
Filled in: werkvoorbereider
Changed to: Project manager

Respondent 222
Field: Other
Filled in: manager
Changed to: Project manager

Respondent 248
Field: Other
Filled in: Landschapsarchitect
Changed to: Architect/Urban designer

LCTechnique

Respondent 29, 76, 77, 88, 89, 90, 96, 112, 153, 162, 170, 203, 213, 244, 255, 257 and 272
Field: Other
Filled in: geen
Changed to: <blank>

Appendix D – Cronbach's alpha test

All variables included

Cronbach's Alpha	N of Items
0.589	15

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Age	27.2095	45.594	-0.148	0.645
Gender	28.8872	44.800	-0.045	0.596
Level of Education	28.3046	43.251	0.244	0.579
Working Situation	28.8500	45.327	-0.125	0.604
Job type	27.8170	45.189	-0.127	0.641
Project scale	28.0525	42.540	0.137	0.584
LC training	29.8790	42.433	0.392	0.570
Prior knowledge LC	27.5938	35.965	0.515	0.516
LC techniques known	27.6104	20.808	0.599	0.459
LC techniques used	29.0525	30.415	0.683	0.451
Innovation level	26.1818	42.813	0.289	0.575
LC Learn More	27.7137	40.105	0.412	0.552
LC 16h workshop	27.9657	39.882	0.375	0.553
LC 40h workshop	28.4823	41.325	0.259	0.569
Willingness SG in LC	27.7715	41.058	0.285	0.566

Scenario 1

After removing Age

Cronbach's Alpha	N of Items
0.645	14

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Gender	25.9988	45.356	0.013	0.650
Level of Education	25.4162	44.047	0.257	0.637
Working Situation	25.9616	45.825	-0.071	0.657
Job type	24.9286	45.894	-0.117	0.695
Project scale	25.1641	43.085	0.167	0.641
LC training	26.9905	43.473	0.357	0.632
Prior knowledge LC	24.7054	37.334	0.471	0.593
LC techniques known	24.7219	21.792	0.582	0.583
LC techniques used	26.1641	31.814	0.638	0.544
Innovation level	23.2934	43.453	0.326	0.632
LC Learn More	24.8252	40.393	0.470	0.609
LC 16h workshop	25.0773	40.073	0.437	0.609
LC 40h workshop	25.5938	41.715	0.304	0.626
Willingness SG in LC	24.8831	41.168	0.358	0.619

After removing Job type

Cronbach's Alpha	N of Items
0.695	13

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Gender	23.7178	45.712	0.003	0.702
Level of Education	23.1352	44.181	0.287	0.689
Working Situation	23.6806	46.101	-0.068	0.708
Project scale	22.8831	43.218	0.182	0.693
LC training	24.7095	43.699	0.369	0.685
Prior knowledge LC	22.4244	37.242	0.499	0.650
LC techniques known	22.4410	21.427	0.612	0.672
LC techniques used	23.8831	31.823	0.655	0.612
Innovation level	21.0124	43.539	0.362	0.684
LC Learn More	22.5443	40.700	0.467	0.666
LC 16h workshop	22.7963	40.373	0.435	0.667
LC 40h workshop	23.3129	41.933	0.311	0.680
Willingness SG in LC	22.6021	41.333	0.370	0.674

After removing Working situation

Cronbach's Alpha	N of Items
0.708	12

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Gender	1.2107	0.40868	242	1.2107
Level of Education	1.7934	0.40571	242	1.7934
Project scale	2.0455	0.83119	242	2.0455
LC training	0.2190	0.41443	242	0.2190
Prior knowledge LC	2.5041	1.18863	242	2.5041
LC techniques known	2.4876	2.86810	242	2.4876
LC techniques used	1.0455	1.57061	242	1.0455
Innovation level	3.9162	0.45037	242	3.9162
LC Learn More	2.3843	0.77100	242	2.3843
LC 16h workshop	2.1322	0.86367	242	2.1322
LC 40h workshop	1.6157	0.81800	242	1.6157
Willingness SG in LC	2.3264	0.81788	242	2.3264

Scenario 2

After removing Job type

Cronbach's Alpha	N of Items
0.641	14

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Age	2.8884	1.36340	242	2.8884
Gender	1.2107	0.40868	242	1.2107
Level of Education	1.7934	0.40571	242	1.7934
Working situation	1.2479	0.51983	242	1.2479
Project scale	2.0455	0.83119	242	2.0455
LC training	0.2190	0.41443	242	0.2190
Prior knowledge LC	2.5041	1.18863	242	2.5041
LC techniques known	2.4876	2.86810	242	2.4876
LC techniques used	1.0455	1.57061	242	1.0455
Innovation level	3.9162	0.45037	242	3.9162
LC Learn More	2.3843	0.77100	242	2.3843
LC 16h workshop	2.1322	0.86367	242	2.1322
LC 40h workshop	1.6157	0.81800	242	1.6157
Willingness SG in LC	2.3264	0.81788	242	2.3264

After removing Working situation

Cronbach's Alpha	N of Items
0.656	13

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Age	23.6806	46.101	-0.118	0.708
Gender	25.3583	45.969	-0.066	0.667
Level of Education	24.7757	44.176	0.266	0.649
Project scale	24.5236	43.437	0.150	0.655
LC training	26.3500	43.320	0.418	0.641
Prior knowledge LC	24.0649	36.300	0.563	0.591
LC techniques known	24.0814	20.887	0.635	0.578
LC techniques used	25.5236	31.013	0.703	0.543
Innovation level	22.6529	43.721	0.310	0.646
LC Learn More	24.1848	41.231	0.399	0.629
LC 16h workshop	24.4368	40.986	0.365	0.631
LC 40h workshop	24.9533	42.338	0.260	0.643
Willingness SG in LC	24.2426	42.055	0.287	0.640

After removing Gender

Cronbach's Alpha	N of Items
0.668	12

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Age	2.8765	1.34933	251	2.8765
Level of Education	1.7888	0.40894	251	1.7888
Project scale	2.0518	0.83025	251	2.0518
LC training	0.2151	0.41174	251	0.2151
Prior knowledge LC	2.5100	1.18444	251	2.5100
LC techniques known	2.4622	2.84984	251	2.4622
LC techniques used	1.0239	1.55674	251	1.0239
Innovation level	3.9262	0.45462	251	3.9262
LC Learn More	2.3745	0.77665	251	2.3745
LC 16h workshop	2.1355	0.86578	251	2.1355
LC 40h workshop	1.6215	0.82230	251	1.6215
Willingness SG in LC	2.3227	0.82185	251	2.3227

Appendix E – Stepwise regressions analysis

LC Learn more - forwards stepwise regression analysis

Model	Variables Entered	Variables Removed	Method
1	Innovation level		Forward (Criterion: Probability-of-F-to-enter <= .050)
2	Age		Forward (Criterion: Probability-of-F-to-enter <= .050)
3	Prior knowledge LC		Forward (Criterion: Probability-of-F-to-enter <= .050)
4	Level of Education		Forward (Criterion: Probability-of-F-to-enter <= .050)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.317	0.101	0.097	0.733	0.101	26.901	1	240	0.000
2	0.387	0.150	0.143	0.714	0.049	13.879	1	239	0.000
3	0.428	0.183	0.173	0.701	0.033	9.586	1	238	0.002
4	0.450	0.203	0.189	0.694	0.020	5.873	1	237	0.016

Model		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	0.256	0.413		0.619	0.536		
	Innovation level	0.543	0.105	0.317	5.187	0.000	1.000	1.000
2	(Constant)	0.916	0.440		2.083	0.038		
	Innovation level	0.469	0.104	0.274	4.513	0.000	0.963	1.038
	Age	-0.128	0.034	-0.226	-3.725	0.000	0.963	1.038
3	(Constant)	0.871	0.432		2.015	0.045		
	Innovation level	0.418	0.104	0.244	4.037	0.000	0.939	1.065
	Age	-0.147	0.034	-0.260	-4.291	0.000	0.932	1.073
	Prior knowledge LC	0.121	0.039	0.186	3.096	0.002	0.952	1.051
4	(Constant)	0.601	0.442		1.360	0.175		
	Innovation level	0.362	0.105	0.211	3.442	0.001	0.893	1.120
	Age	-0.144	0.034	-0.255	-4.242	0.000	0.930	1.075
	LC Prior knowledge	0.115	0.039	0.178	2.986	0.003	0.948	1.054
	Level of Education	0.276	0.114	0.145	2.424	0.016	0.938	1.066

LC Learn more - backwards stepwise regression analysis

Model	Variables Entered	Variables Removed	Method
1	Innovation level, Gender, LC training, Job type, Project scale, Working Situation, Level of Education, Age, Prior knowledge LC, LC techniques used, LC techniques known		Enter
2		Project scale	Backward (criterion: Probability of F-to-remove >= .100).
3		LC training	Backward (criterion: Probability of F-to-remove >= .100).
4		LC techniques used	Backward (criterion: Probability of F-to-remove >= .100).
5		Working Situation	Backward (criterion: Probability of F-to-remove >= .100).
6		LC techniques known	Backward (criterion: Probability of F-to-remove >= .100).
7		Job type	Backward (criterion: Probability of F-to-remove >= .100).

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.469	0.220	0.183	0.697	0.220	5.907	11	230	0.000
2	0.469	0.220	0.187	0.695	0.000	0.000	1	230	0.986
3	0.469	0.220	0.190	0.694	0.000	0.006	1	231	0.936
4	0.469	0.220	0.193	0.693	0.000	0.074	1	232	0.786
5	0.469	0.220	0.196	0.691	0.000	0.100	1	233	0.752
6	0.466	0.217	0.197	0.691	-0.002	0.714	1	234	0.399
7	0.461	0.213	0.196	0.691	-0.005	1.437	1	235	0.232

Model		Unstandardized Coefficients B	Std. Error	Standardized Coefficients Beta	t	Sig.	Collinearity Statistics Tolerance	VIF
1	(Constant)	0.223	0.525		0.424	0.672		
	Age	-0.124	0.037	-0.220	-3.350	0.001	0.785	1.274
	Gender	0.194	0.119	0.103	1.630	0.104	0.853	1.172
	Level of Education	0.234	0.121	0.123	1.938	0.054	0.838	1.194
	Working Situation	0.027	0.095	0.018	0.283	0.777	0.835	1.198
	Job type	0.040	0.034	0.070	1.160	0.247	0.937	1.067
	Project scale	0.001	0.057	0.001	0.018	0.986	0.898	1.114
	LC training	-0.010	0.127	-0.005	-0.080	0.936	0.723	1.383
	Prior knowledge LC	0.107	0.049	0.166	2.185	0.030	0.591	1.693
	LC techniques known	0.012	0.027	0.044	0.428	0.669	0.326	3.063
	LC techniques used	0.014	0.049	0.028	0.278	0.781	0.337	2.966
	Innovation level	0.365	0.110	0.213	3.309	0.001	0.815	1.227
2	(Constant)	0.223	0.522		0.428	0.669		
	Age	-0.125	0.037	-0.220	-3.404	0.001	0.806	1.241
	Gender	0.194	0.118	0.103	1.642	0.102	0.865	1.157
	Level of Education	0.234	0.120	0.123	1.949	0.052	0.843	1.186
	Working Situation	0.027	0.094	0.018	0.284	0.777	0.835	1.197
	Job type	0.040	0.034	0.070	1.163	0.246	0.937	1.067
	LC training	-0.010	0.127	-0.005	-0.080	0.936	0.724	1.382
	Prior knowledge LC	0.107	0.049	0.166	2.198	0.029	0.595	1.682
	LC techniques known	0.012	0.027	0.044	0.429	0.668	0.328	3.050
	LC techniques used	0.014	0.049	0.028	0.280	0.780	0.338	2.958
	Innovation level	0.366	0.108	0.214	3.374	0.001	0.842	1.188

3	(Constant)	0.221	0.520		0.425	0.671		
	Age	-0.125	0.036	-0.221	-3.425	0.001	0.810	1.235
	Gender	0.194	0.118	0.103	1.649	0.101	0.865	1.156
	Level of Education	0.236	0.119	0.124	1.978	0.049	0.856	1.169
	Working Situation	0.028	0.093	0.019	0.298	0.766	0.852	1.174
	Job type	0.040	0.034	0.070	1.169	0.244	0.938	1.066
	Prior knowledge LC	0.107	0.049	0.165	2.202	0.029	0.596	1.679
	LC techniques known	0.011	0.027	0.042	0.423	0.673	0.337	2.968
	LC techniques used	0.013	0.048	0.027	0.271	0.786	0.346	2.890
	Innovation level	0.365	0.108	0.213	3.381	0.001	0.843	1.186
4	(Constant)	0.201	0.513		0.391	0.696		
	Age	-0.123	0.036	-0.218	-3.436	0.001	0.834	1.199
	Gender	0.195	0.117	0.103	1.665	0.097	0.867	1.154
	Level of Education	0.234	0.119	0.123	1.972	0.050	0.857	1.167
	Working Situation	0.029	0.093	0.020	0.316	0.752	0.855	1.170
	Job type	0.040	0.034	0.070	1.181	0.239	0.939	1.064
	Prior knowledge LC	0.110	0.047	0.170	2.321	0.021	0.625	1.599
	LC techniques known	0.016	0.019	0.061	0.843	0.400	0.642	1.559
	Innovation level	0.367	0.108	0.215	3.414	0.001	0.847	1.180
5	(Constant)	0.231	0.503		0.459	0.646		
	Age	-0.125	0.035	-0.221	-3.567	0.000	0.865	1.156
	Gender	0.196	0.117	0.104	1.680	0.094	0.868	1.152
	Level of Education	0.236	0.118	0.124	1.995	0.047	0.860	1.163
	Job type	0.040	0.034	0.070	1.174	0.242	0.940	1.063
	Prior knowledge LC	0.107	0.046	0.165	2.312	0.022	0.656	1.524

	LC techniques known	0.016	0.019	0.061	0.845	0.399	0.642	1.559
	Innovation level	0.371	0.107	0.217	3.485	0.001	0.860	1.163
6	(Constant)	0.149	0.493		0.301	0.764		
	Age	-0.127	0.035	-0.224	-3.619	0.000	0.868	1.153
	Gender	0.192	0.117	0.102	1.643	0.102	0.870	1.150
	Level of Education	0.255	0.116	0.134	2.199	0.029	0.892	1.121
	Job type	0.040	0.034	0.071	1.199	0.232	0.941	1.063
	Prior knowledge LC	0.128	0.039	0.197	3.288	0.001	0.925	1.081
	Innovation level	0.383	0.106	0.224	3.622	0.000	0.874	1.144
7	(Constant)	0.349	0.465		0.751	0.454		
	Age	-0.129	0.035	-0.228	-3.685	0.000	0.870	1.149
	Gender	0.199	0.117	0.105	1.706	0.089	0.872	1.147
	Level of Education	0.239	0.115	0.126	2.069	0.040	0.905	1.105
	Prior knowledge LC	0.124	0.039	0.192	3.204	0.002	0.930	1.075
	Innovation level	0.365	0.105	0.213	3.483	0.001	0.893	1.120

Willingness SG in LC - forwards stepwise regression analysis

Model	Variables Entered	Variables Removed	Method
1	LC Learn More		Forward (Criterion: Probability-of-F-to-enter <= .050)
2	Age		Forward (Criterion: Probability-of-F-to-enter <= .050)
3	LC 16h workshop		Forward (Criterion: Probability-of-F-to-enter <= .050)
4	LC 40h workshop		Forward (Criterion: Probability-of-F-to-enter <= .050)
5	Level of Education		Forward (Criterion: Probability-of-F-to-enter <= .050)

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.629	0.396	0.394	0.637	0.396	157.392	1	240	0.000
2	0.653	0.427	0.422	0.622	0.030	12.691	1	239	0.000
3	0.668	0.446	0.439	0.613	0.019	8.352	1	238	0.004
4	0.677	0.458	0.449	0.607	0.013	5.476	1	237	0.020
5	0.684	0.468	0.456	0.603	0.009	4.051	1	236	0.045

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	0.735	0.133		5.511	0.000		
	LC Learn More	0.668	0.053	0.629	12.546	0.000	1.000	1.000
2	(Constant)	1.178	0.180		6.542	0.000		
	LC Learn More	0.614	0.054	0.579	11.345	0.000	0.922	1.084
	Age	-0.109	0.031	-0.182	-3.562	0.000	0.922	1.084
3	(Constant)	1.053	0.183		5.767	0.000		
	LC Learn More	0.494	0.068	0.465	7.304	0.000	0.573	1.744
	Age	-0.096	0.030	-0.160	-3.141	0.002	0.901	1.109
	LC 16h workshop	0.175	0.061	0.185	2.890	0.004	0.569	1.757
4	(Constant)	1.110	0.182		6.082	0.000		
	LC Learn More	0.508	0.067	0.479	7.559	0.000	0.568	1.760
	Age	-0.099	0.030	-0.165	-3.282	0.001	0.899	1.112
	LC 16h workshop	0.241	0.066	0.255	3.638	0.000	0.465	2.150
	LC 40h workshop	-0.139	0.059	-0.139	-2.340	0.020	0.652	1.535

5	(Constant)	0.810	0.235		3.456	0.001		
	LC Learn More	0.489	0.068	0.461	7.250	0.000	0.557	1.795
	Age	-0.099	0.030	-0.165	-3.299	0.001	0.899	1.112
	LC 16h workshop	0.230	0.066	0.243	3.469	0.001	0.462	2.167
	LC 40h workshop	-0.130	0.059	-0.131	-2.213	0.028	0.649	1.542
	Level of Education	0.199	0.099	0.099	2.013	0.045	0.939	1.065

Willingness SG in LC - backwards stepwise regression analysis

Model	Variables Entered	Variables Removed	Method
1	LC 40h workshop, Gender, Job type, LC training, Project scale, Working Situation, Level of Education, Innovation level, Prior knowledge LC, Age, LC Learn More, LC techniques used, LC 16h workshop, LC techniques known		Enter
2		Prior knowledge LC	Backward (criterion: Probability of F-to-remove >= .100).
3		Working Situation	Backward (criterion: Probability of F-to-remove >= .100).
4		Innovation level	Backward (criterion: Probability of F-to-remove >= .100).
5		LC training	Backward (criterion: Probability of F-to-remove >= .100).
6		Project scale	Backward (criterion: Probability of F-to-remove >= .100).
7		LC techniques used	Backward (criterion: Probability of F-to-remove >= .100).
8		LC techniques known	Backward (criterion: Probability of F-to-remove >= .100).
9		Gender	Backward (criterion: Probability of F-to-remove >= .100).
10		Job type	Backward (criterion: Probability of F-to-remove >= .100).

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	0.689	0.475	0.443	0.611	0.475	14.672	14	227	0.000
2	0.689	0.475	0.445	0.609	0.000	0.001	1	227	0.974
3	0.689	0.475	0.447	0.608	0.000	0.033	1	228	0.855
4	0.689	0.475	0.450	0.607	0.000	0.042	1	229	0.837
5	0.689	0.474	0.452	0.606	0.000	0.173	1	230	0.678
6	0.689	0.474	0.454	0.605	0.000	0.184	1	231	0.669
7	0.688	0.473	0.455	0.604	-0.001	0.384	1	232	0.536
8	0.687	0.472	0.456	0.603	-0.001	0.413	1	233	0.521
9	0.686	0.471	0.458	0.602	-0.001	0.431	1	234	0.512
10	0.684	0.468	0.456	0.603	-0.004	1.629	1	235	0.203

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	0.766	0.463		1.656	0.099		
	Age	-0.090	0.034	-0.151	-2.680	0.008	0.732	1.366
	Gender	0.082	0.106	0.041	0.776	0.439	0.824	1.214
	Level of Education	0.141	0.107	0.070	1.315	0.190	0.819	1.221
	Working Situation	-0.014	0.083	-0.009	-0.171	0.864	0.834	1.199
	Job type	-0.036	0.030	-0.060	-1.201	0.231	0.929	1.077
	Project scale	0.020	0.050	0.020	0.391	0.696	0.891	1.122
	LC training	-0.049	0.112	-0.025	-0.441	0.660	0.722	1.385
	Prior knowledge LC	0.001	0.044	0.002	0.032	0.974	0.572	1.748
	LC techniques known	0.022	0.024	0.076	0.906	0.366	0.326	3.067
	LC techniques used	-0.025	0.043	-0.047	-0.568	0.571	0.336	2.975
	Innovation level	0.022	0.099	0.012	0.225	0.822	0.774	1.292
	LC Learn More	0.484	0.070	0.456	6.909	0.000	0.531	1.884
	LC 16h workshop	0.224	0.068	0.237	3.296	0.001	0.447	2.236
	LC 40h workshop	-0.131	0.061	-0.131	-2.159	0.032	0.627	1.596

2	(Constant)	0.769	0.451		1.708	0.089		
	Age	-0.090	0.033	-0.150	-2.695	0.008	0.739	1.353
	Gender	0.082	0.105	0.041	0.778	0.437	0.832	1.202
	Level of Education	0.141	0.107	0.070	1.318	0.189	0.821	1.218
	Working Situation	-0.015	0.081	-0.009	-0.183	0.855	0.873	1.145
	Job type	-0.036	0.030	-0.060	-1.213	0.226	0.938	1.066
	Project scale	0.020	0.050	0.020	0.396	0.693	0.896	1.116
	LC training	-0.049	0.111	-0.025	-0.441	0.660	0.723	1.383
	LC techniques known	0.022	0.023	0.077	0.935	0.351	0.341	2.931
	LC techniques used	-0.024	0.042	-0.047	-0.575	0.566	0.350	2.854
	Innovation level	0.022	0.099	0.012	0.225	0.822	0.774	1.292
	LC Learn More	0.484	0.070	0.456	6.953	0.000	0.535	1.870
	LC 16h workshop	0.225	0.068	0.237	3.322	0.001	0.451	2.215
	LC 40h workshop	-0.131	0.060	-0.131	-2.173	0.031	0.630	1.586
3	(Constant)	0.756	0.444		1.704	0.090		
	Age	-0.089	0.033	-0.148	-2.721	0.007	0.771	1.297
	Gender	0.081	0.105	0.041	0.773	0.440	0.834	1.199
	Level of Education	0.140	0.106	0.069	1.314	0.190	0.823	1.216
	Job type	-0.036	0.030	-0.060	-1.213	0.227	0.938	1.066
	Project scale	0.020	0.050	0.020	0.403	0.687	0.898	1.114
	LC training	-0.046	0.110	-0.023	-0.419	0.676	0.740	1.352
	LC techniques known	0.022	0.023	0.078	0.952	0.342	0.343	2.918
	LC techniques used	-0.025	0.042	-0.047	-0.584	0.560	0.351	2.849
	Innovation level	0.020	0.098	0.011	0.205	0.837	0.786	1.273
	LC Learn More	0.484	0.069	0.456	6.966	0.000	0.535	1.870
	LC 16h workshop	0.225	0.067	0.238	3.338	0.001	0.452	2.212
	LC 40h workshop	-0.131	0.060	-0.131	-2.179	0.030	0.630	1.586

4	(Constant)	0.823	0.299		2.756	0.006		
	Age	-0.090	0.032	-0.150	-2.766	0.006	0.780	1.282
	Gender	0.081	0.105	0.041	0.774	0.440	0.834	1.199
	Level of Education	0.143	0.105	0.071	1.353	0.177	0.836	1.196
	Job type	-0.037	0.029	-0.061	-1.260	0.209	0.960	1.042
	Project scale	0.022	0.049	0.022	0.445	0.657	0.923	1.083
	LC training	-0.046	0.110	-0.023	-0.416	0.678	0.740	1.351
	LC techniques known	0.022	0.023	0.078	0.961	0.338	0.343	2.915
	LC techniques used	-0.024	0.042	-0.046	-0.575	0.566	0.352	2.842
	LC Learn More	0.486	0.069	0.458	7.087	0.000	0.547	1.830
	LC 16h workshop	0.225	0.067	0.238	3.349	0.001	0.452	2.211
	LC 40h workshop	-0.131	0.060	-0.131	-2.176	0.031	0.632	1.582
5	(Constant)	0.814	0.297		2.737	0.007		
	Age	-0.091	0.032	-0.152	-2.830	0.005	0.789	1.268
	Gender	0.083	0.104	0.041	0.793	0.429	0.835	1.197
	Level of Education	0.148	0.104	0.074	1.424	0.156	0.851	1.175
	Job type	-0.036	0.029	-0.061	-1.246	0.214	0.962	1.040
	Project scale	0.021	0.049	0.021	0.428	0.669	0.925	1.081
	LC techniques known	0.020	0.023	0.072	0.899	0.369	0.356	2.808
	LC techniques used	-0.027	0.041	-0.052	-0.651	0.516	0.361	2.770
	LC Learn More	0.486	0.068	0.458	7.102	0.000	0.547	1.830
	LC 16h workshop	0.224	0.067	0.237	3.342	0.001	0.453	2.208
	LC 40h workshop	-0.130	0.060	-0.130	-2.167	0.031	0.633	1.580
6	(Constant)	0.859	0.277		3.097	0.002		
	Age	-0.093	0.032	-0.155	-2.933	0.004	0.807	1.239
	Gender	0.077	0.103	0.038	0.744	0.458	0.850	1.176
	Level of Education	0.152	0.104	0.076	1.471	0.143	0.858	1.166
	Job type	-0.037	0.029	-0.062	-1.275	0.203	0.965	1.037

	LC techniques known	0.020	0.023	0.071	0.886	0.377	0.357	2.804
	LC techniques used	-0.025	0.041	-0.049	-0.620	0.536	0.363	2.752
	LC Learn More	0.486	0.068	0.458	7.108	0.000	0.547	1.829
	LC 16h workshop	0.227	0.067	0.240	3.399	0.001	0.456	2.191
	LC 40h workshop	-0.130	0.060	-0.130	-2.167	0.031	0.633	1.580
7	(Constant)	0.874	0.276		3.165	0.002		
	Age	-0.097	0.031	-0.162	-3.117	0.002	0.839	1.192
	Gender	0.076	0.103	0.038	0.732	0.465	0.851	1.176
	Level of Education	0.155	0.103	0.077	1.502	0.135	0.859	1.163
	Job type	-0.037	0.029	-0.062	-1.277	0.203	0.965	1.037
	LC techniques known	0.009	0.014	0.032	0.643	0.521	0.894	1.118
	LC Learn More	0.484	0.068	0.456	7.102	0.000	0.547	1.827
	LC 16h workshop	0.226	0.067	0.239	3.395	0.001	0.456	2.191
	LC 40h workshop	-0.131	0.060	-0.131	-2.194	0.029	0.634	1.578
8	(Constant)	0.864	0.275		3.140	0.002		
	Age	-0.096	0.031	-0.160	-3.091	0.002	0.841	1.189
	Gender	0.067	0.102	0.034	0.657	0.512	0.864	1.157
	Level of Education	0.168	0.101	0.083	1.662	0.098	0.894	1.119
	Job type	-0.038	0.029	-0.063	-1.311	0.191	0.967	1.034
	LC Learn More	0.490	0.068	0.462	7.245	0.000	0.556	1.800
	LC 16h workshop	0.228	0.067	0.240	3.422	0.001	0.457	2.189
	LC 40h workshop	-0.130	0.060	-0.130	-2.176	0.031	0.634	1.576
9	(Constant)	0.934	0.254		3.685	0.000		
	Age	-0.101	0.030	-0.168	-3.364	0.001	0.897	1.115
	Level of Education	0.179	0.100	0.089	1.787	0.075	0.916	1.092
	Job type	-0.037	0.029	-0.061	-1.276	0.203	0.970	1.031
	LC Learn More	0.492	0.067	0.463	7.290	0.000	0.557	1.796

	LC 16h workshop	0.232	0.066	0.245	3.506	0.001	0.461	2.168
	LC 40h workshop	-0.135	0.059	-0.135	-2.289	0.023	0.646	1.547
10	(Constant)	0.810	0.235		3.456	0.001		
	Age	-0.099	0.030	-0.165	-3.299	0.001	0.899	1.112
	Level of Education	0.199	0.099	0.099	2.013	0.045	0.939	1.065
	LC Learn More	0.489	0.068	0.461	7.250	0.000	0.557	1.795
	LC 16h workshop	0.230	0.066	0.243	3.469	0.001	0.462	2.167
	LC 40h workshop	-0.130	0.059	-0.131	-2.213	0.028	0.649	1.542

Appendix F – Multicollinearity

Chi square tests – categorical with categorical

Age

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Age * Gender	261	96.3%	10	3.7%	271	100.0%
Age * Level of Education	270	99.6%	1	0.4%	271	100.0%
Age * Working Situation	271	100.0%	0	0.0%	271	100.0%
Age * Job type	271	100.0%	0	0.0%	271	100.0%
Age * Project scale	252	93.0%	19	7.0%	271	100.0%
Age * LC training	271	100.0%	0	0.0%	271	100.0%
Age * Prior knowledge LC	271	100.0%	0	0.0%	271	100.0%
Age * LC Learn More	271	100.0%	0	0.0%	271	100.0%
Age * LC 16h workshop	271	100.0%	0	0.0%	271	100.0%
Age * LC 40h workshop	271	100.0%	0	0.0%	271	100.0%

			Gender		Total
			Male	Female	
Age	18-24	Count	29	22	51
		% within Age	56.9%	43.1%	100.0%
	25-34	Count	64	24	88
		% within Age	72.7%	27.3%	100.0%
	35-44	Count	31	3	34
		% within Age	91.2%	8.8%	100.0%
	45-54	Count	37	8	45
		% within Age	82.2%	17.8%	100.0%
	>55	Count	42	1	43
		% within Age	97.7%	2.3%	100.0%
Total		Count	203	58	261
		% within Age	77.8%	22.2%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	28.101	4	0.000
Likelihood Ratio	31.729	4	0.000
Linear-by-Linear Association	23.430	1	0.000
N of Valid Cases	261		

			Level of education		Total
			Low or middle	High	
Age	18-24	Count	12	38	50
		% within Age	24.0%	76.0%	100.0%
	25-34	Count	14	80	94
		% within Age	14.9%	85.1%	100.0%
	35-44	Count	8	28	36
		% within Age	22.2%	77.8%	100.0%
	45-54	Count	11	36	47
		% within Age	23.4%	76.6%	100.0%
	>55	Count	12	31	43
		% within Age	27.9%	72.1%	100.0%
Total		Count	57	213	270
		% within Age	21.1%	78.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.800	4	0.434
Likelihood Ratio	3.896	4	0.420
Linear-by-Linear Association	1.169	1	0.280
N of Valid Cases	270		

			Working situation			Total
			Working	Student	Unemployed/ retired	
Age	18-24	Count	11	40	0	51
		% within Age	21.6%	78.4%	0.0%	100.0%
	25-34	Count	73	15	6	94
		% within Age	77.7%	16.0%	6.4%	100.0%
	35-44	Count	36	0	0	36
		% within Age	100.0%	0.0%	0.0%	100.0%
	45-54	Count	47	0	0	47
		% within Age	100.0%	0.0%	0.0%	100.0%
	>55	Count	37	0	6	43
		% within Age	86.0%	0.0%	14.0%	100.0%
Total		Count	204	55	12	271
		% within Age	75.3%	20.3%	4.4%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	153.947	8	0.000
Likelihood Ratio	153.185	8	0.000
Linear-by-Linear Association	28.077	1	0.000
N of Valid Cases	271		

			Job type					Total
			Manager	Architect/ Urban Designer	Technical engineer	Construc-tion Laborer	Other	
Age	18-24	Count	17	14	8	1	11	51
		% within Age	33.3%	27.5%	15.7%	2.0%	21.6%	100.0%
	25-34	Count	35	21	18	6	14	94
		% within Age	37.2%	22.3%	19.1%	6.4%	14.9%	100.0%
	35-44	Count	16	9	2	6	3	36
		% within Age	44.4%	25.0%	5.6%	16.7%	8.3%	100.0%
	45-54	Count	23	14	4	2	4	47
		% within Age	48.9%	29.8%	8.5%	4.3%	8.5%	100.0%
	>55	Count	10	20	2	8	3	43
		% within Age	23.3%	46.5%	4.7%	18.6%	7.0%	100.0%
Total		Count	101	78	34	23	35	271
		% within Age	37.3%	28.8%	12.5%	8.5%	12.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	36.559	16	0.002
Likelihood Ratio	36.146	16	0.003
Linear-by-Linear Association	1.542	1	0.214
N of Valid Cases	271		

			Project scale			Total
			Normal	Neutral	Complex	
Age	18-24	Count	6	18	14	38
		% within Age	15.8%	47.4%	36.8%	100.0%
	25-34	Count	25	30	33	88
		% within Age	28.4%	34.1%	37.5%	100.0%
	35-44	Count	9	8	19	36
		% within Age	25.0%	22.2%	52.8%	100.0%
	45-54	Count	22	13	12	47
		% within Age	46.8%	27.7%	25.5%	100.0%
	>55	Count	18	10	15	43
		% within Age	41.9%	23.3%	34.9%	100.0%
Total		Count	80	79	93	252
		% within Age	31.7%	31.3%	36.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	18.159	8	0.020
Likelihood Ratio	18.035	8	0.021
Linear-by-Linear Association	4.719	1	0.030
N of Valid Cases	252		

			LC training		Total
			No	Yes	
Age	18-24	Count	49	2	51
		% within Age	96.1%	3.9%	100.0%
	25-34	Count	80	14	94
		% within Age	85.1%	14.9%	100.0%
	35-44	Count	20	16	36
		% within Age	55.6%	44.4%	100.0%
	45-54	Count	34	13	47
		% within Age	72.3%	27.7%	100.0%
	>55	Count	34	9	43
		% within Age	79.1%	20.9%	100.0%
Total		Count	217	54	271
		% within Age	80.1%	19.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.032	4	0.000
Likelihood Ratio	25.651	4	0.000
Linear-by-Linear Association	8.117	1	0.004
N of Valid Cases	271		

			Prior knowledge LC					Total
			Not at all	A little	Reason-able	Rather well	Very well	
Age	18-24	Count	18	17	9	6	1	51
		% within Age	35.3%	33.3%	17.6%	11.8%	2.0%	100.0%
	25-34	Count	24	39	18	8	5	94
		% within Age	25.5%	41.5%	19.1%	8.5%	5.3%	100.0%
	35-44	Count	4	9	10	6	7	36
		% within Age	11.1%	25.0%	27.8%	16.7%	19.4%	100.0%
	45-54	Count	4	17	12	7	7	47
		% within Age	8.5%	36.2%	25.5%	14.9%	14.9%	100.0%
	>55	Count	7	18	12	4	2	43
		% within Age	16.3%	41.9%	27.9%	9.3%	4.7%	100.0%
Total		Count	57	100	61	31	22	271
		% within Age	21.0%	36.9%	22.5%	11.4%	8.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	30.577	16	0.015
Likelihood Ratio	30.323	16	0.016
Linear-by-Linear Association	7.980	1	0.005
N of Valid Cases	271		

			LC learn more			Total
			No	Neutral	Yes	
Age	18-24	Count	1	14	36	51
		% within Age	2.0%	27.5%	70.6%	100.0%
	25-34	Count	14	20	60	94
		% within Age	14.9%	21.3%	63.8%	100.0%
	35-44	Count	3	9	24	36
		% within Age	8.3%	25.0%	66.7%	100.0%
	45-54	Count	16	11	20	47
		% within Age	34.0%	23.4%	42.6%	100.0%
	>55	Count	13	15	15	43
		% within Age	30.2%	34.9%	34.9%	100.0%
Total		Count	47	69	155	271
		% within Age	17.3%	25.5%	57.2%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	31.343	8	0.000
Likelihood Ratio	34.207	8	0.000
Linear-by-Linear Association	23.233	1	0.000
N of Valid Cases	271		

			LC 16h workshop			Total
			No	Neutral	Yes	
Age	18-24	Count	8	13	30	51
		% within Age	15.7%	25.5%	58.8%	100.0%
	25-34	Count	25	20	49	94
		% within Age	26.6%	21.3%	52.1%	100.0%
	35-44	Count	6	8	22	36
		% within Age	16.7%	22.2%	61.1%	100.0%
	45-54	Count	20	13	14	47
		% within Age	42.6%	27.7%	29.8%	100.0%
	>55	Count	24	10	9	43
		% within Age	55.8%	23.3%	20.9%	100.0%
Total		Count	83	64	124	271
		% within Age	30.6%	23.6%	45.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	31.251	8	0.000
Likelihood Ratio	32.019	8	0.000
Linear-by-Linear Association	23.888	1	0.000
N of Valid Cases	271		

			LC 40h workshop			Total
			No	Neutral	Yes	
Age	18-24	Count	20	18	13	51
		% within Age	39.2%	35.3%	25.5%	100.0%
	25-34	Count	54	11	29	94
		% within Age	57.4%	11.7%	30.9%	100.0%
	35-44	Count	18	9	9	36
		% within Age	50.0%	25.0%	25.0%	100.0%
	45-54	Count	33	7	7	47
		% within Age	70.2%	14.9%	14.9%	100.0%
	>55	Count	32	9	2	43
		% within Age	74.4%	20.9%	4.7%	100.0%
Total		Count	157	54	60	271
		% within Age	57.9%	19.9%	22.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	27.707	8	0.001
Likelihood Ratio	29.956	8	0.000
Linear-by-Linear Association	14.263	1	0.000
N of Valid Cases	271		

Gender

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Gender * Level of Education	260	95.9%	11	4.1%	271	100.0%
Gender * Working Situation	261	96.3%	10	3.7%	271	100.0%
Gender * Job type	261	96.3%	10	3.7%	271	100.0%
Gender * Project scale	242	89.3%	29	10.7%	271	100.0%
Gender * LC training	261	96.3%	10	3.7%	271	100.0%
Gender * Prior knowledge LC	261	96.3%	10	3.7%	271	100.0%
Gender * LC Learn More	261	96.3%	10	3.7%	271	100.0%
Gender * LC 16h workshop	261	96.3%	10	3.7%	271	100.0%
Gender * LC 40h workshop	261	96.3%	10	3.7%	271	100.0%

			Level of education		Total
			Low or middle	High	
Gender	Male	Count	48	154	202
		% within Age	23.8%	76.2%	100.0%
	Female	Count	5	53	58
		% within Age	8.6%	91.4%	100.0%
Total		Count	53	207	260
		% within Age	20.4%	79.6%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	6.366	1	0.012
Likelihood Ratio	5.467	1	0.019
Linear-by-Linear Association	7.368	1	0.007
N of Valid Cases	260		

			Working situation			Total
			Working	Student	Unemployed/ retired	
Gender	Male	Count	163	30	10	203
		% within Age	80.3%	14.8%	4.9%	100.0%
	Female	Count	32	25	1	58
		% within Age	55.2%	43.1%	1.7%	100.0%
Total		Count	195	55	11	261
		% within Age	74.7%	21.1%	4.2%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	22.084	2	0.000
Likelihood Ratio	19.913	2	0.000
Linear-by-Linear Association	7.388	1	0.007
N of Valid Cases	261		

			Job type					Total
			Manager	Architect / Urban Designer	Technical engineer	Construc - tion Laborer	Other	
Gender	Male	Count	79	55	23	23	23	203
		% within Age	38.9%	27.1%	11.3%	11.3%	11.3 %	100.0 %
	Female	Count	16	22	9	0	11	58
		% within Age	27.6%	37.9%	15.5%	0.0%	19.0 %	100.0 %
Total		Count	95	77	32	23	34	261
		% within Age	36.4%	29.5%	12.3%	8.8%	13.0 %	100.0 %

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.622	4	0.013
Likelihood Ratio	17.402	4	0.002
Linear-by-Linear Association	0.586	1	0.444
N of Valid Cases	261		

			Project scale			Total
			Normal	Neutral	Complex	
Gender	Male	Count	60	57	74	191
		% within Age	31.4%	29.8%	38.7%	100.0%
	Female	Count	18	18	15	51
		% within Age	35.3%	35.3%	29.4%	100.0%
Total		Count	78	75	89	242
		% within Age	32.2%	31.0%	36.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.527	2	0.466
Likelihood Ratio	1.563	2	0.458
Linear-by-Linear Association	1.017	1	0.313
N of Valid Cases	242		

			LC training		Total
			No	Yes	
Gender	Male	156	47	203	156
		76.8%	23.2%	100.0%	76.8%
	Female	52	6	58	52
		89.7%	10.3%	100.0%	89.7%
Total		208	53	261	208
		79.7%	20.3%	100.0%	79.7%

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	4.573[a]	1	0.032		
Continuity Correction	3.816	1	0.051		
Likelihood Ratio	5.139	1	0.023		
Fisher's Exact Test				0.041	0.021
Linear-by-Linear Association	4.555	1	0.033		

			Prior knowledge LC					Total
			Not at all	A little	Reason-able	Rather well	Very well	
Gender	Male	Count	35	76	51	22	19	203
		% within Age	17.2%	37.4%	25.1%	10.8%	9.4%	100.0%
	Female	Count	20	23	6	6	3	58
		% within Age	34.5%	39.7%	10.3%	10.3%	5.2%	100.0%
Total		Count	55	99	57	28	22	261
		% within Age	21.1%	37.9%	21.8%	10.7%	8.4%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.882	4	0.018
Likelihood Ratio	12.092	4	0.017
Linear-by-Linear Association	6.707	1	0.010
N of Valid Cases	261		

			LC learn more			Total
			No	Neutral	Yes	
Gender	Male	Count	41	53	109	203
		% within Age	20.2%	26.1%	53.7%	100.0%
	Female	Count	3	13	42	58
		% within Age	5.2%	22.4%	72.4%	100.0%
Total		Count	44	66	151	261
		% within Age	16.9%	25.3%	57.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	9.016	2	0.011
Likelihood Ratio	10.567	2	0.005
Linear-by-Linear Association	8.837	1	0.003
N of Valid Cases	261		

			LC 16h workshop			Total
			No	Neutral	Yes	
Gender	Male	Count	71	45	87	203
		% within Age	35.0%	22.2%	42.9%	100.0%
	Female	Count	9	17	32	58
		% within Age	15.5%	29.3%	55.2%	100.0%
Total		Count	80	62	119	261
		% within Age	30.7%	23.8%	45.6%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	8.042	2	0.018
Likelihood Ratio	8.841	2	0.012
Linear-by-Linear Association	6.130	1	0.013
N of Valid Cases	261		

			LC 40h workshop			Total
			No	Neutral	Yes	
Gender	Male	Count	120	37	46	203
		% within Age	59.1%	18.2%	22.7%	100.0%
	Female	Count	32	15	11	58
		% within Age	55.2%	25.9%	19.0%	100.0%
Total		Count	152	52	57	261
		% within Age	58.2%	19.9%	21.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.722	2	0.423
Likelihood Ratio	1.653	2	0.438
Linear-by-Linear Association	0.000	1	0.984
N of Valid Cases	261		

Level of education

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Level of Education * Working Situation	270	99.6%	1	0.4%	271	100.0%
Level of Education * Job type	270	99.6%	1	0.4%	271	100.0%
Level of Education * Project scale	252	93.0%	19	7.0%	271	100.0%
Level of Education * LC training	270	99.6%	1	0.4%	271	100.0%
Level of Education * Prior knowledge LC	270	99.6%	1	0.4%	271	100.0%
Level of Education * LC Learn More	270	99.6%	1	0.4%	271	100.0%
Level of Education * LC 16h workshop	270	99.6%	1	0.4%	271	100.0%
Level of Education * LC 40h workshop	270	99.6%	1	0.4%	271	100.0%

			Working situation			Total
			Working	Student	Unemployed/ retired	
Level of education	Low or middle	Count	47	9	1	57
		% within Age	82.5%	15.8%	1.8%	100.0%
	High	Count	156	46	11	213
		% within Age	73.2%	21.6%	5.2%	100.0%
Total		Count	203	55	12	270
		% within Age	75.2%	20.4%	4.4%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.429	2	0.297
Likelihood Ratio	2.731	2	0.255
Linear-by-Linear Association	2.414	1	0.120
N of Valid Cases	270		

			Job type					Total
			Manager	Architect / Urban Designer	Technical engineer	Construc- tion Laborer	Other	
Level of education	Low or middle	Count	22	5	7	20	3	57
		% within Age	38.6%	8.8%	12.3%	35.1%	5.3%	100.0%
	High	Count	79	73	27	3	31	213
		% within Age	37.1%	34.3%	12.7%	1.4%	14.6%	100.0%
Total		Count	101	78	34	23	34	270
		% within Age	37.4%	28.9%	12.6%	8.5%	12.6%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	73.113	4	0.000
Likelihood Ratio	62.629	4	0.000
Linear-by-Linear Association	3.359	1	0.067
N of Valid Cases	270		

			Project scale			Total
			Normal	Neutral	Complex	
Level of education	Low or middle	Count	19	22	13	54
		% within Age	35.2%	40.7%	24.1%	100.0%
	High	Count	61	57	80	198
		% within Age	30.8%	28.8%	40.4%	100.0%
Total		Count	80	79	93	252
		% within Age	31.7%	31.3%	36.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.256	2	0.072
Likelihood Ratio	5.450	2	0.066
Linear-by-Linear Association	2.650	1	0.104
N of Valid Cases	252		

			LC training		Total
			No	Yes	
Level of education	Low or middle	Count	45	12	57
		% within Age	78.9%	21.1%	100.0%
	High	Count	171	42	213
		% within Age	80.3%	19.7%	100.0%
Total		Count	216	54	270
		% within Age	80.0%	20.0%	100.0%

	Value	df	Asymptotic Significance (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	0.050	1	0.823		
Continuity Correction	0.001	1	0.970		
Likelihood Ratio	0.050	1	0.824		
Fisher's Exact Test				0.853	0.476
Linear-by-Linear Association	0.050	1	0.823		

			Prior knowledge LC					Total
			Not at all	A little	Reason-able	Rather well	Very well	
Level of education	Low or middle	Count	14	21	16	1	5	57
		% within Age	24.6%	36.8%	28.1%	1.8%	8.8%	100.0%
	High	Count	43	79	45	29	17	213
		% within Age	20.2%	37.1%	21.1%	13.6%	8.0%	100.0%
Total		Count	57	100	61	30	22	270
		% within Age	21.1%	37.0%	22.6%	11.1%	8.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.095	4	0.131
Likelihood Ratio	9.432	4	0.051
Linear-by-Linear Association	1.142	1	0.285
N of Valid Cases	270		

			LC learn more			Total
			No	Neutral	Yes	
Level of education	Low or middle	Count	18	16	23	57
		% within Age	31.6%	28.1%	40.4%	100.0%
	High	Count	29	52	132	213
		% within Age	13.6%	24.4%	62.0%	100.0%
Total		Count	47	68	155	270
		% within Age	17.4%	25.2%	57.4%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	12.236	2	0.002
Likelihood Ratio	11.402	2	0.003
Linear-by-Linear Association	11.936	1	0.001
N of Valid Cases	270		

			LC 16h workshop			Total
			No	Neutral	Yes	
Level of education	Low or middle	Count	26	14	17	57
		% within Age	45.6%	24.6%	29.8%	100.0%
	High	Count	57	49	107	213
		% within Age	26.8%	23.0%	50.2%	100.0%
Total		Count	83	63	124	270
		% within Age	30.7%	23.3%	45.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	9.325	2	0.009
Likelihood Ratio	9.273	2	0.010
Linear-by-Linear Association	9.288	1	0.002
N of Valid Cases	270		

			LC 40h workshop			Total
			No	Neutral	Yes	
Level of education	Low or middle	Count	35	13	9	57
		% within Age	61.4%	22.8%	15.8%	100.0%
	High	Count	122	40	51	213
		% within Age	57.3%	18.8%	23.9%	100.0%
Total		Count	157	53	60	270
		% within Age	58.1%	19.6%	22.2%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.849	2	0.397
Likelihood Ratio	1.947	2	0.378
Linear-by-Linear Association	1.002	1	0.317
N of Valid Cases	270		

Working situation

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Working Situation * Job type	271	100.0%	0	0.0%	271	100.0%
Working Situation * Project scale	252	93.0%	19	7.0%	271	100.0%
Working Situation * LC training	271	100.0%	0	0.0%	271	100.0%
Working Situation * Prior knowledge LC	271	100.0%	0	0.0%	271	100.0%
Working Situation * LC Learn More	271	100.0%	0	0.0%	271	100.0%
Working Situation * LC 16h workshop	271	100.0%	0	0.0%	271	100.0%
Working Situation * LC 40h workshop	271	100.0%	0	0.0%	271	100.0%

			Job type					**Total**
			Manager	Architect / Urban Designer	Technical engineer	Constr-uction Laborer	Other	
Working situation	Work-ing	Count	81	58	19	23	23	204
		% within Age	39.7%	28.4%	9.3%	11.3%	11.3 %	100.0 %
	Student	Count	16	16	13	0	10	55
		% within Age	29.1%	29.1%	23.6%	0.0%	18.2 %	100.0 %
	Unem-ployed/ retired	Count	4	4	2	0	2	12
		% within Age	33.3%	33.3%	16.7%	0.0%	16.7 %	100.0 %
Total		Count	101	78	34	23	35	271
		% within Age	37.3%	28.8%	12.5%	8.5%	12.9 %	100.0 %

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	18.003	8	0.021
Likelihood Ratio	22.489	8	0.004
Linear-by-Linear Association	0.723	1	0.395
N of Valid Cases	271		

			Project scale			Total
			Normal	Neutral	Complex	
Working situation	Working	Count	68	56	77	201
		% within Age	33.8%	27.9%	38.3%	100.0%
	Student	Count	7	20	13	40
		% within Age	17.5%	50.0%	32.5%	100.0%
	Unem-ployed/ retired	Count	5	3	3	11
		% within Age	45.5%	27.3%	27.3%	100.0%
		% within Age	68	56	77	201
Total		Count	80	79	93	252
		% within Age	31.7%	31.3%	36.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	9.355	4	0.053
Likelihood Ratio	9.156	4	0.057
Linear-by-Linear Association	0.030	1	0.862
N of Valid Cases	252		

			LC training		Total
			No	Yes	
Working situation	Working	151	53	204	151
		74.0%	26.0%	100.0%	74.0%
	Student	55	0	55	55
		100.0%	0.0%	100.0%	100.0%
	Unemployed/ retired	11	1	12	11
		91.7%	8.3%	100.0%	91.7%
		151	53	204	151
Total		Count	217	54	271
		% within Age	80.1%	19.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	19.384	2	0.000
Likelihood Ratio	30.055	2	0.000
Linear-by-Linear Association	14.745	1	0.000
N of Valid Cases	271		

			Prior knowledge LC					Total
			Not at all	A little	Reason-able	Rather well	Very well	
Working situation	Working	Count	30	73	53	27	21	204
		% within Age	14.7%	35.8%	26.0%	13.2%	10.3%	100.0%
	Student	Count	22	22	7	3	1	55
		% within Age	40.0%	40.0%	12.7%	5.5%	1.8%	100.0%
	Unem-ployed/ retired	Count	5	5	1	1	0	12
		% within Age	41.7%	41.7%	8.3%	8.3%	0.0%	100.0%
Total		Count	57	100	61	31	22	271
		% within Age	21.0%	36.9%	22.5%	11.4%	8.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	27.758	8	0.001
Likelihood Ratio	28.939	8	0.000
Linear-by-Linear Association	21.121	1	0.000
N of Valid Cases	271		

			LC learn more			Total
			No	Neutral	Yes	
Working situation	Working	Count	42	56	106	204
		% within Age	20.6%	27.5%	52.0%	100.0%
	Student	Count	1	10	44	55
		% within Age	1.8%	18.2%	80.0%	100.0%
	Unem-ployed/ retired	Count	4	3	5	12
		% within Age	33.3%	25.0%	41.7%	100.0%
Total		Count	47	69	155	271
		% within Age	17.3%	25.5%	57.2%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	18.598	4	0.001
Likelihood Ratio	22.718	4	0.000
Linear-by-Linear Association	3.880	1	0.049
N of Valid Cases	271		

			LC 16h workshop			Total
			No	Neutral	Yes	
Working situation	Working	Count	71	46	87	204
		% within Age	34.8%	22.5%	42.6%	100.0%
	Student	Count	7	15	33	55
		% within Age	12.7%	27.3%	60.0%	100.0%
	Unem-ployed/ retired	Count	5	3	4	12
		% within Age	41.7%	25.0%	33.3%	100.0%
Total		Count	83	64	124	271
		% within Age	30.6%	23.6%	45.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.087	4	0.026
Likelihood Ratio	12.450	4	0.014
Linear-by-Linear Association	2.441	1	0.118
N of Valid Cases	271		

			LC 40h workshop			Total
			No	Neutral	Yes	
Working situation	Working	Count	127	36	41	204
		% within Age	62.3%	17.6%	20.1%	100.0%
	Student	Count	22	18	15	55
		% within Age	40.0%	32.7%	27.3%	100.0%
	Unem-ployed/ retired	Count	8	0	4	12
		% within Age	66.7%	0.0%	33.3%	100.0%
Total		Count	157	54	60	271
		% within Age	57.9%	19.9%	22.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	13.033	4	0.011
Likelihood Ratio	14.930	4	0.005
Linear-by-Linear Association	3.265	1	0.071
N of Valid Cases	271		

Job type

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Job type * Project scale	252	93.0%	19	7.0%	271	100.0%
Job type * LC training	271	100.0%	0	0.0%	271	100.0%
Job type * Prior knowledge LC	271	100.0%	0	0.0%	271	100.0%
Job type * LC Learn More	271	100.0%	0	0.0%	271	100.0%
Job type * LC 16h workshop	271	100.0%	0	0.0%	271	100.0%
Job type * LC 40h workshop	271	100.0%	0	0.0%	271	100.0%

			Project scale			Total
			Normal	Neutral	Complex	
Job type	Manager	Count	26	27	44	97
		% within Age	26.8%	27.8%	45.4%	100.0%
	Arch/urb design	Count	27	25	20	72
		% within Age	37.5%	34.7%	27.8%	100.0%
	Tech empl	Count	7	8	16	31
		% within Age	22.6%	25.8%	51.6%	100.0%
	Constr labor	Count	11	9	3	23
		% within Age	47.8%	39.1%	13.0%	100.0%
	Other	Count	9	10	10	29
		% within Age	31.0%	34.5%	34.5%	100.0%
Total		Count	80	79	93	252
		% within Age	31.7%	31.3%	36.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	14.594	8	0.068
Likelihood Ratio	15.433	8	0.051
Linear-by-Linear Association	2.038	1	0.153
N of Valid Cases	252		

			LC training		Total
			No	Yes	
Job type	Manager	Count	68	33	101
		% within Age	67.3%	32.7%	100.0%
	Arch/urb design	Count	74	4	78
		% within Age	94.9%	5.1%	100.0%
	Tech empl	Count	31	3	34
		% within Age	91.2%	8.8%	100.0%
	Constr labor	Count	16	7	23
		% within Age	69.6%	30.4%	100.0%
	Other	Count	28	7	35
		% within Age	80.0%	20.0%	100.0%
Total		Count	217	54	271
		% within Age	80.1%	19.9%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.209	4	0.000
Likelihood Ratio	27.887	4	0.000
Linear-by-Linear Association	1.667	1	0.197
N of Valid Cases	271		

			Prior knowledge LC					Total
			Not at all	A little	Reason-able	Rather well	Very well	
Job type	Manager	Count	10	34	28	18	11	101
		% within Age	9.9%	33.7%	27.7%	17.8%	10.9%	100.0%
	Arch/urb design	Count	24	28	16	5	5	78
		% within Age	30.8%	35.9%	20.5%	6.4%	6.4%	100.0%
	Tech empl	Count	12	14	4	3	1	34
		% within Age	35.3%	41.2%	11.8%	8.8%	2.9%	100.0%
	Constr labor	Count	8	10	4	0	1	23
		% within Age	34.8%	43.5%	17.4%	0.0%	4.3%	100.0%
	Other	Count	3	14	9	5	4	35

		% within Age	8.6%	40.0%	25.7%	14.3%	11.4%	100.0%
Total		Count	57	100	61	31	22	271
		% within Age	21.0%	36.9%	22.5%	11.4%	8.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	33.409	16	0.007
Likelihood Ratio	37.329	16	0.002
Linear-by-Linear Association	2.810	1	0.094
N of Valid Cases	271		

			LC learn more			Total
			No	Neutral	Yes	
Job type	Manager	Count	18	17	66	101
		% within Age	17.8%	16.8%	65.3%	100.0%
	Arch/urb design	Count	16	25	37	78
		% within Age	20.5%	32.1%	47.4%	100.0%
	Tech empl	Count	5	7	22	34
		% within Age	14.7%	20.6%	64.7%	100.0%
	Constr labor	Count	7	11	5	23
		% within Age	30.4%	47.8%	21.7%	100.0%
	Other	Count	1	9	25	35
		% within Age	2.9%	25.7%	71.4%	100.0%
Total		Count	47	69	155	271
		% within Age	17.3%	25.5%	57.2%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	25.333	8	0.001
Likelihood Ratio	28.085	8	0.000
Linear-by-Linear Association	0.041	1	0.840
N of Valid Cases	271		

			LC 16h workshop			Total
			No	Neutral	Yes	
Job type	Manager	Count	29	15	57	101
		% within Age	28.7%	14.9%	56.4%	100.0%
	Arch/urb design	Count	31	22	25	78
		% within Age	39.7%	28.2%	32.1%	100.0%
	Tech empl	Count	10	8	16	34
		% within Age	29.4%	23.5%	47.1%	100.0%
	Constr labor	Count	9	8	6	23
		% within Age	39.1%	34.8%	26.1%	100.0%
	Other	Count	4	11	20	35
		% within Age	11.4%	31.4%	57.1%	100.0%
Total		Count	83	64	124	271
		% within Age	30.6%	23.6%	45.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	21.777	8	0.005
Likelihood Ratio	23.604	8	0.003
Linear-by-Linear Association	0.139	1	0.710
N of Valid Cases	271		

			LC 40h workshop			Total
			No	Neutral	Yes	
Job type	Manager	Count	55	14	32	101
		% within Age	54.5%	13.9%	31.7%	100.0%
	Arch/urb design	Count	52	17	9	78
		% within Age	66.7%	21.8%	11.5%	100.0%
	Tech empl	Count	22	7	5	34
		% within Age	64.7%	20.6%	14.7%	100.0%
	Constr labor	Count	13	7	3	23
		% within Age	56.5%	30.4%	13.0%	100.0%
	Other	Count	15	9	11	35
		% within Age	42.9%	25.7%	31.4%	100.0%
Total		Count	157	54	60	271
		% within Age	57.9%	19.9%	22.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	17.946	8	0.022
Likelihood Ratio	18.482	8	0.018
Linear-by-Linear Association	0.047	1	0.828
N of Valid Cases	271		

Project scale

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Project scale * LC training	252	93.0%	19	7.0%	271	100.0%
Project scale * Prior knowledge LC	252	93.0%	19	7.0%	271	100.0%
Project scale * LC Learn More	252	93.0%	19	7.0%	271	100.0%
Project scale * LC 16h workshop	252	93.0%	19	7.0%	271	100.0%
Project scale * LC 40h workshop	252	93.0%	19	7.0%	271	100.0%

			LC training		Total
			No	Yes	
Project scale	Normal	Count	62	18	80
		% within Age	77.5%	22.5%	100.0%
	Neutral	Count	68	11	79
		% within Age	86.1%	13.9%	100.0%
	Complex	Count	68	25	93
		% within Age	73.1%	26.9%	100.0%
		% within Age	62	18	80
Total		Count	198	54	252
		% within Age	78.6%	21.4%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	4.340	2	0.114
Likelihood Ratio	4.529	2	0.104
Linear-by-Linear Association	0.610	1	0.435
N of Valid Cases	252		

			Prior knowledge LC					Total
			Not at all	A little	Reason-able	Rather well	Very well	
Project scale	Normal	Count	13	35	22	6	4	80
		% within Age	16.3%	43.8%	27.5%	7.5%	5.0%	100.0%
	Neutral	Count	25	23	18	7	6	79
		% within Age	31.6%	29.1%	22.8%	8.9%	7.6%	100.0%
	Complex	Count	13	34	19	15	12	93
		% within Age	14.0%	36.6%	20.4%	16.1%	12.9%	100.0%
Total		Count	51	92	59	28	22	252
		% within Age	20.2%	36.5%	23.4%	11.1%	8.7%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	17.432	8	0.026
Likelihood Ratio	16.841	8	0.032
Linear-by-Linear Association	4.304	1	0.038
N of Valid Cases	252		

			LC learn more			Total
			No	Neutral	Yes	
Project scale	Normal	Count	19	21	40	80
		% within Age	23.8%	26.3%	50.0%	100.0%
	Neutral	Count	16	17	46	79
		% within Age	20.3%	21.5%	58.2%	100.0%
	Complex	Count	11	28	54	93
		% within Age	11.8%	30.1%	58.1%	100.0%
Total		Count	46	66	140	252
		% within Age	18.3%	26.2%	55.6%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.455	4	0.244
Likelihood Ratio	5.666	4	0.226
Linear-by-Linear Association	2.838	1	0.092
N of Valid Cases	252		

			LC 16h workshop			Total
			No	Neutral	Yes	
Project scale	Normal	Count	31	23	26	80
		% within Age	38.8%	28.8%	32.5%	100.0%
	Neutral	Count	22	19	38	79
		% within Age	27.8%	24.1%	48.1%	100.0%
	Complex	Count	26	18	49	93
		% within Age	28.0%	19.4%	52.7%	100.0%
Total		Count	79	60	113	252
		% within Age	31.3%	23.8%	44.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.827	4	0.098
Likelihood Ratio	7.973	4	0.093
Linear-by-Linear Association	5.354	1	0.021
N of Valid Cases	252		

			LC 40h workshop			Total
			No	Neutral	Yes	
Project scale	Normal	Count	56	12	12	80
		% within Age	70.0%	15.0%	15.0%	100.0%
	Neutral	Count	42	17	20	79
		% within Age	53.2%	21.5%	25.3%	100.0%
	Complex	Count	52	18	23	93
		% within Age	55.9%	19.4%	24.7%	100.0%
Total		Count	150	47	55	252
		% within Age	59.5%	18.7%	21.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.669	4	0.225
Likelihood Ratio	5.814	4	0.213
Linear-by-Linear Association	3.409	1	0.065
N of Valid Cases	252		

LC training

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
LC training * Prior knowledge LC	271	100.0%	0	0.0%	271	100.0%
LC training * LC Learn More	271	100.0%	0	0.0%	271	100.0%
LC training * LC 16h workshop	271	100.0%	0	0.0%	271	100.0%
LC training * LC 40h workshop	271	100.0%	0	0.0%	271	100.0%
LC training * Prior knowledge LC	271	100.0%	0	0.0%	271	100.0%

			Prior knowledge LC					Total
			Not at all	A little	Reason-able	Rather well	Very well	
LC training	No	Count	55	86	46	19	11	217
		% within Age	25.3%	39.6%	21.2%	8.8%	5.1%	100.0%
	Yes	Count	2	14	15	12	11	54
		% within Age	3.7%	25.9%	27.8%	22.2%	20.4%	100.0%
Total		Count	57	100	61	31	22	271
		% within Age	21.0%	36.9%	22.5%	11.4%	8.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	31.987	4	0.000
Likelihood Ratio	32.412	4	0.000
Linear-by-Linear Association	31.735	1	0.000
N of Valid Cases	271		

			LC learn more			Total
			No	Neutral	Yes	
LC training	No	Count	41	52	124	217
		% within Age	18.9%	24.0%	57.1%	100.0%
	Yes	Count	6	17	31	54
		% within Age	11.1%	31.5%	57.4%	100.0%
Total		Count	47	69	155	271
		% within Age	17.3%	25.5%	57.2%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.471	2	0.291
Likelihood Ratio	2.590	2	0.274
Linear-by-Linear Association	0.476	1	0.490
N of Valid Cases	271		

			LC 16h workshop			Total
			No	Neutral	Yes	
LC training	No	Count	70	48	99	217
		% within Age	32.3%	22.1%	45.6%	100.0%
	Yes	Count	13	16	25	54
		% within Age	24.1%	29.6%	46.3%	100.0%
Total		Count	83	64	124	271
		% within Age	30.6%	23.6%	45.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	1.982	2	0.371
Likelihood Ratio	1.982	2	0.371
Linear-by-Linear Association	0.456	1	0.499
N of Valid Cases	271		

			LC 40h workshop			Total
			No	Neutral	Yes	
LC training	No	Count	128	39	50	217
		% within Age	59.0%	18.0%	23.0%	100.0%
	Yes	Count	29	15	10	54
		% within Age	53.7%	27.8%	18.5%	100.0%
Total		Count	157	54	60	271
		% within Age	57.9%	19.9%	22.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	2.694	2	0.260
Likelihood Ratio	2.546	2	0.280
Linear-by-Linear Association	0.004	1	0.952
N of Valid Cases	271		

Prior knowledge LC

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
Prior knowledge LC * LC Learn More	271	100.0%	0	0.0%	271	100.0%
Prior knowledge LC * LC 16h workshop	271	100.0%	0	0.0%	271	100.0%
Prior knowledge LC * LC 40h workshop	271	100.0%	0	0.0%	271	100.0%

			LC learn more			Total
			No	Neutral	Yes	
Prior know-ledge LC	Not at all	Count	14	15	28	57
		% within Age	24.6%	26.3%	49.1%	100.0%
	A little	Count	21	25	54	100
		% within Age	21.0%	25.0%	54.0%	100.0%
	Reasonable	Count	9	15	37	61
		% within Age	14.8%	24.6%	60.7%	100.0%
	Rather well	Count	2	9	20	31
		% within Age	6.5%	29.0%	64.5%	100.0%
	Very well	Count	1	5	16	22
		% within Age	4.5%	22.7%	72.7%	100.0%
Total		Count	47	69	155	271
		% within Age	17.3%	25.5%	57.2%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	9.354	8	0.313
Likelihood Ratio	10.616	8	0.224
Linear-by-Linear Association	8.126	1	0.004
N of Valid Cases	271		

			LC 16h workshop			Total
			No	Neutral	Yes	
Prior know-ledge LC	Not at all	Count	23	13	21	57
		% within Age	40.4%	22.8%	36.8%	100.0%
	A little	Count	36	23	41	100
		% within Age	36.0%	23.0%	41.0%	100.0%
	Reasonable	Count	13	15	33	61
		% within Age	21.3%	24.6%	54.1%	100.0%
	Rather well	Count	6	6	19	31
		% within Age	19.4%	19.4%	61.3%	100.0%
	Very well	Count	5	7	10	22
		% within Age	22.7%	31.8%	45.5%	100.0%
Total		Count	83	64	124	271
		% within Age	30.6%	23.6%	45.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	11.134	8	0.194
Likelihood Ratio	11.202	8	0.191
Linear-by-Linear Association	6.627	1	0.010
N of Valid Cases	271		

			LC 40h workshop			Total
			No	Neutral	Yes	
Prior know-ledge LC	Not at all	Count	37	9	11	57
		% within Age	64.9%	15.8%	19.3%	100.0%
	A little	Count	62	17	21	100
		% within Age	62.0%	17.0%	21.0%	100.0%
	Reasonable	Count	34	13	14	61
		% within Age	55.7%	21.3%	23.0%	100.0%
	Rather well	Count	12	10	9	31
		% within Age	38.7%	32.3%	29.0%	100.0%
	Very well	Count	12	5	5	22
		% within Age	54.5%	22.7%	22.7%	100.0%
Total		Count	157	54	60	271
		% within Age	57.9%	19.9%	22.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	7.220	8	0.513
Likelihood Ratio	7.090	8	0.527
Linear-by-Linear Association	2.716	1	0.099
N of Valid Cases	271		

LC Learn more

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
LC Learn More * LC 16h workshop	271	100.0%	0	0.0%	271	100.0%
LC Learn More * LC 40h workshop	271	100.0%	0	0.0%	271	100.0%

			LC 16h workshop			Total
			No	Neutral	Yes	
LC learn more	No	Count	40	7	0	47
		% within Age	85.1%	14.9%	0.0%	100.0%
	Neutral	Count	26	29	14	69
		% within Age	37.7%	42.0%	20.3%	100.0%
	Yes	Count	17	28	110	155
		% within Age	11.0%	18.1%	71.0%	100.0%
Total		Count	83	64	124	271
		% within Age	30.6%	23.6%	45.8%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	132.486	4	0.000
Likelihood Ratio	143.381	4	0.000
Linear-by-Linear Association	115.125	1	0.000
N of Valid Cases	271		

			LC 40h workshop			Total
			No	Neutral	Yes	
LC learn more	No	Count	46	1	0	47
		% within Age	97.9%	2.1%	0.0%	100.0%
	Neutral	Count	45	21	3	69
		% within Age	65.2%	30.4%	4.3%	100.0%
	Yes	Count	66	32	57	155
		% within Age	42.6%	20.6%	36.8%	100.0%
Total		Count	157	54	60	271
		% within Age	57.9%	19.9%	22.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	66.480	4	0.000
Likelihood Ratio	81.919	4	0.000
Linear-by-Linear Association	53.338	1	0.000
N of Valid Cases	271		

LC 16h workshop

	Cases					
	Valid		Missing		Total	
	N	Percent	N	Percent	N	Percent
LC 16h workshop * LC 40h workshop	271	100.0%	0	0.0%	271	100.0%

			LC 40h workshop			Total
			No	Neutral	Yes	
LC 16h workshop	No	Count	82	1	0	83
		% within Age	98.8%	1.2%	0.0%	100.0%
	Neutral	Count	35	27	2	64
		% within Age	54.7%	42.2%	3.1%	100.0%
	Yes	Count	40	26	58	124
		% within Age	32.3%	21.0%	46.8%	100.0%
Total		Count	157	54	60	271
		% within Age	57.9%	19.9%	22.1%	100.0%

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	131.546	4	0.000
Likelihood Ratio	153.128	4	0.000
Linear-by-Linear Association	97.008	1	0.000
N of Valid Cases	271		

ANOVA tests

LC Techniques known

		Sum of Squares	df	Mean Square	F	Sig.
Age	Between Groups	40.220	13	3.094	1.721	0.057
	Within Groups	462.134	257	1.798		
	Total	502.354	270			
Gender	Between Groups	2.149	13	0.165	0.951	0.501
	Within Groups	42.962	247	0.174		
	Total	45.111	260			
Level of Education	Between Groups	3.897	13	0.300	1.869	0.034
	Within Groups	41.069	256	0.160		
	Total	44.967	269			
Working Situation	Between Groups	6.273	13	0.483	1.683	0.065
	Within Groups	73.698	257	0.287		
	Total	79.970	270			
Job type	Between Groups	41.234	13	3.172	1.717	0.058
	Within Groups	474.729	257	1.847		
	Total	515.963	270			
Project scale	Between Groups	11.018	13	0.848	1.250	0.245
	Within Groups	161.312	238	0.678		
	Total	172.329	251			
LC training	Between Groups	9.955	13	0.766	5.912	0.000
	Within Groups	33.285	257	0.130		
	Total	43.240	270			
Prior knowledge LC	Between Groups	147.713	13	11.363	12.808	0.000
	Within Groups	227.992	257	0.887		
	Total	375.705	270			
LC Learn More	Between Groups	13.405	13	1.031	1.821	0.040
	Within Groups	145.554	257	0.566		
	Total	158.959	270			
LC 16h workshop	Between Groups	15.835	13	1.218	1.692	0.063
	Within Groups	184.962	257	0.720		
	Total	200.797	270			
LC 40h workshop	Between Groups	9.660	13	0.743	1.106	0.354
	Within Groups	172.620	257	0.672		
	Total	182.280	270			

LC Techniques used

		Sum of Squares	df	Mean Square	F	Sig.
Age	Between Groups	24.522	8	3.065	1.681	0.103
	Within Groups	477.832	262	1.824		
	Total	502.354	270			
Gender	Between Groups	1.766	8	0.221	1.284	0.252
	Within Groups	43.345	252	0.172		
	Total	45.111	260			
Level of Education	Between Groups	1.608	8	0.201	1.210	0.293
	Within Groups	43.359	261	0.166		
	Total	44.967	269			
Working Situation	Between Groups	3.912	8	0.489	1.684	0.102
	Within Groups	76.059	262	0.290		
	Total	79.970	270			
Job type	Between Groups	32.619	8	4.077	2.210	0.027
	Within Groups	483.345	262	1.845		
	Total	515.963	270			
Project scale	Between Groups	3.442	8	0.430	0.619	0.762
	Within Groups	168.887	243	0.695		
	Total	172.329	251			
LC training	Between Groups	9.717	8	1.215	9.493	0.000
	Within Groups	33.523	262	0.128		
	Total	43.240	270			
Prior knowledge LC	Between Groups	124.142	8	15.518	16.162	0.000
	Within Groups	251.563	262	0.960		
	Total	375.705	270			
LC Learn More	Between Groups	4.320	8	0.540	0.915	0.505
	Within Groups	154.640	262	0.590		
	Total	158.959	270			
LC 16h workshop	Between Groups	10.008	8	1.251	1.718	0.094
	Within Groups	190.789	262	0.728		
	Total	200.797	270			
LC 40h workshop	Between Groups	3.372	8	0.421	0.617	0.763
	Within Groups	178.909	262	0.683		
	Total	182.280	270			

Innovation level

		Sum of Squares	df	Mean Square	F	Sig.
Age	Between Groups	69.320	24	2.888	1.634	0.035
	Within Groups	432.980	245	1.767		
	Total	502.300	269			
Gender	Between Groups	3.436	24	0.143	0.811	0.722
	Within Groups	41.675	236	0.177		
	Total	45.111	260			
Level of Education	Between Groups	10.079	24	0.420	2.991	0.000
	Within Groups	34.263	244	0.140		
	Total	44.342	268			
Working Situation	Between Groups	15.890	24	0.662	2.535	0.000
	Within Groups	63.995	245	0.261		
	Total	79.885	269			
Job type	Between Groups	44.470	24	1.853	0.964	0.515
	Within Groups	471.015	245	1.923		
	Total	515.485	269			
Project scale	Between Groups	19.204	22	0.873	1.300	0.172
	Within Groups	153.123	228	0.672		
	Total	172.327	250			
LC training	Between Groups	3.815	24	0.159	0.989	0.482
	Within Groups	39.385	245	0.161		
	Total	43.200	269			
Prior knowledge LC	Between Groups	49.084	24	2.045	1.545	0.054
	Within Groups	324.324	245	1.324		
	Total	373.407	269			
LC Learn More	Between Groups	37.726	24	1.572	3.181	0.000
	Within Groups	121.074	245	0.494		
	Total	158.800	269			
LC 16h workshop	Between Groups	41.237	24	1.718	2.639	0.000
	Within Groups	159.537	245	0.651		
	Total	200.774	269			
LC 40h workshop	Between Groups	27.402	24	1.142	1.808	0.014
	Within Groups	154.750	245	0.632		
	Total	182.152	269			

Correlation matrix

		LC techniques known	LC techniques used	Innovation level
LC techniques known	Between Groups	1	0.787	0.209
	Within Groups		0.000	0.001
	Total	271	271	270
LC techniques used	Between Groups	0.787	1	0.162
	Within Groups	0.000		0.008
	Total	271	271	270
Innovation level	Between Groups	0.209	0.162	1
	Within Groups	0.001	0.008	
	Total	270	270	270

Appendix G – Regression analyses

Ordinal regression 1

Model fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	491.053			
Final	433.980	57.073	15	0.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	482.295	475	0.399
Deviance	429.822	475	0.932

Pseudo R-square

Cox and Snell	0.203
Nagelkerke	0.236
McFadden	0.115

Parameter estimates

		Estimate	Std. Error	Wald	df	Sig.	95% Confidence Interval Lower Bound	Upper Bound
Thres-hold	[LCLearnMore = 1]	3.042	1.550	3.848	1	0.050	0.003	6.081
	[LCLearnMore = 2]	4.569	1.566	8.508	1	0.004	1.499	7.639
Location	LCTechnKnown	0.023	0.086	0.074	1	0.786	-0.145	0.191
	LCTechnUsed	0.122	0.153	0.641	1	0.424	-0.177	0.422
	InnovationLvl	1.086	0.326	11.086	1	0.001	0.447	1.725
	[Age=1]	1.350	0.482	7.840	1	0.005	0.405	2.295
	[Age=2]	1.089	0.378	8.291	1	0.004	0.348	1.831
	[Age=3]	1.300	0.496	6.871	1	0.009	0.328	2.272
	[Age=4]	-0.129	0.412	0.098	1	0.754	-0.937	0.679
	[Age=5]	0[a]			0			
	[EducationLvl=1]	-0.583	0.335	3.031	1	0.082	-1.239	0.073
	[EducationLvl=2]	0[a]			0			
	[ProjectScale=1]	0.249	0.333	0.562	1	0.454	-0.403	0.901
	[ProjectScale=2]	0.096	0.331	0.084	1	0.772	-0.553	0.746
	[ProjectScale=3]	0[a]			0			
	[LCTraining=0]	0.197	0.381	0.268	1	0.605	-0.550	0.945
	[LCTraining=1]	0[a]			0			
	[PriorKnowledge-LC=1]	-1.006	0.686	2.149	1	0.143	-2.351	0.339
	[PriorKnowledge-LC=2]	-0.633	0.624	1.027	1	0.311	-1.857	0.591
	[PriorKnowledge-LC=3]	-0.242	0.619	0.153	1	0.696	-1.456	0.971
	[PriorKnowledge-LC=4]	-0.229	0.672	0.116	1	0.734	-1.546	1.089
	[PriorKnowledge-LC=5]	0[a]			0			

[a] Is set 0 because it is a reference variable

MNL regression 1

Model fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	491.053			
Final	418.145	72.909	30	0.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	477.073	460	0.282
Deviance	413.986	460	0.939

Pseudo R-square

Cox and Snell	0.252
Nagelkerke	0.293
McFadden	0.147

Parameter estimates

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
No	Intercept	2.871	2.416	1.412	1	0.235		
	LCTechnKnown	-0.089	0.152	0.344	1	0.558	0.915	0.680
	LCTechnUsed	-0.160	0.261	0.376	1	0.540	0.852	0.510
	InnovationLvl	-1.110	0.468	5.640	1	0.018	0.329	0.132
	[Age=1]	-3.302	1.142	8.353	1	0.004	0.037	0.004
	[Age=2]	-1.413	0.544	6.759	1	0.009	0.243	0.084
	[Age=3]	-1.724	0.799	4.659	1	0.031	0.178	0.037
	[Age=4]	0.232	0.568	0.166	1	0.683	1.261	0.414
	[Age=5]	0^b			0			
	[EducationLvl=1]	0.924	0.485	3.629	1	0.057	2.520	0.974
	[EducationLvl=2]	0^b			0			
	[ProjectScale=1]	-0.070	0.510	0.019	1	0.891	0.932	0.343
	[ProjectScale=2]	0.234	0.512	0.209	1	0.648	1.264	0.463
	[ProjectScale=3]	0^b			0			
	[LCTraining=0]	-0.056	0.615	0.008	1	0.927	0.945	0.283
	[LCTraining=1]	0^b			0			

	[PriorKnowledge-LC=1]	1.997	1.248	2.563	1	0.109	7.370	0.639
	[PriorKnowledge-LC=2]	1.456	1.184	1.513	1	0.219	4.289	0.421
	[PriorKnowledge-LC=3]	0.924	1.193	0.600	1	0.439	2.519	0.243
	[PriorKnowledge-LC=4]	0.733	1.364	0.289	1	0.591	2.082	0.144
	[PriorKnowledge-LC=5]	0[b]			0			
Neutral	Intercept	4.915	1.917	6.571	1	0.010		
	LCTechnKnown	-0.006	0.095	0.004	1	0.951	0.994	0.826
	LCTechnUsed	-0.058	0.172	0.113	1	0.736	0.944	0.674
	InnovationLvl	-1.125	0.408	7.600	1	0.006	0.325	0.146
	[Age=1]	-0.551	0.550	1.005	1	0.316	0.576	0.196
	[Age=2]	-1.055	0.478	4.877	1	0.027	0.348	0.136
	[Age=3]	-1.190	0.586	4.119	1	0.042	0.304	0.096
	[Age=4]	-0.491	0.554	0.785	1	0.375	0.612	0.207
	[Age=5]	0[b]			0			
	[EducationLvl=1]	0.225	0.437	0.266	1	0.606	1.252	0.532
	[EducationLvl=2]	0[b]			0			
	[ProjectScale=1]	-0.363	0.399	0.831	1	0.362	0.695	0.318
	[ProjectScale=2]	-0.559	0.405	1.911	1	0.167	0.572	0.259
	[ProjectScale=3]	0[b]			0			
	[LCTraining=0]	-0.610	0.442	1.901	1	0.168	0.543	0.228
	[LCTraining=1]	0[b]			0			
	[PriorKnowledge-LC=1]	0.619	0.792	0.611	1	0.434	1.857	0.394
	[PriorKnowledge-LC=2]	0.351	0.703	0.249	1	0.618	1.420	0.358
	[PriorKnowledge-LC=3]	0.048	0.691	0.005	1	0.945	1.049	0.271
	[PriorKnowledge-LC=4]	-0.034	0.735	0.002	1	0.963	0.967	0.229
	[PriorKnowledge-LC=5]	0[b]			0			

[a] Reference category is: yes [b] Is set 0 because it is a reference variable

Ordinal regression 2

Model fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	502.108			
Final	347.016	155.092	21	0.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	524.655	479	0.073
Deviance	347.016	479	1.000

Pseudo R-square

Cox and Snell	0.461
Nagelkerke	0.533
McFadden	0.309

Parameter estimates

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
Thres-hold	[WillingnessSGinLC = 1]	0.481	1.845	0.068	1	0.795	-3.136	4.097
	[WillingnessSGinLC = 2]	2.330	1.853	1.581	1	0.209	-1.302	5.962
Location	LCTechnKnown	0.041	0.093	0.193	1	0.661	-0.141	0.223
	LCTechnUsed	-0.006	0.163	0.001	1	0.970	-0.325	0.313
	InnovationLvl	0.331	0.375	0.779	1	0.378	-0.404	1.065
	[Age=1]	1.613	0.581	7.710	1	0.005	0.474	2.751
	[Age=2]	1.124	0.440	6.518	1	0.011	0.261	1.987
	[Age=3]	0.725	0.531	1.861	1	0.173	-0.317	1.766
	[Age=4]	0.442	0.478	0.854	1	0.355	-0.495	1.378
	[Age=5]	0[a]			0			
	[EducationLvl=1]	-0.715	0.390	3.358	1	0.067	-1.480	0.050
	[EducationLvl=2]	0[a]			0			
	[ProjectScale=1]	0.067	0.371	0.033	1	0.856	-0.660	0.794
	[ProjectScale=2]	0.377	0.384	0.962	1	0.327	-0.376	1.130
	[ProjectScale=3]	0[a]			0			
	[LCTraining=0]	0.107	0.422	0.064	1	0.800	-0.721	0.935
	[LCTraining=1]	0[a]			0			
	[PriorKnow-ledgeLC=1]	1.117	0.702	2.531	1	0.112	-0.259	2.494
	[PriorKnow-ledgeLC=2]	0.593	0.607	0.955	1	0.329	-0.597	1.783
	[PriorKnow-ledgeLC=3]	1.453	0.610	5.668	1	0.017	0.257	2.649
	[PriorKnow-ledgeLC=4]	1.540	0.693	4.935	1	0.026	0.181	2.899
	[PriorKnow-ledgeLC=5]	0[a]			0			
	[LCLearnMore=1]	-3.055	0.530	33.212	1	0.000	-4.094	-2.016
	[LCLearnMore=2]	-1.095	0.380	8.316	1	0.004	-1.839	-0.351
	[LCLearnMore=3]	0[a]			0			
	[LC16hWork-shop=1]	-1.701	0.519	10.721	1	0.001	-2.719	-0.683
	[LC16hWorkshop=2]	-0.533	0.462	1.327	1	0.249	-1.439	0.374
	[LC16hWorkshop=3]	0[a]			0			
	[LC40hWorkshop=1]	1.073	0.519	4.264	1	0.039	0.055	2.091
	[LC40hWorkshop=2]	0.275	0.541	0.258	1	0.612	-0.786	1.336
	[LC40hWorkshop=3]	0[a]			0			

[a] Is set 0 because it is a reference variable

MNL regression 2

Model fitting Information

Model	-2 Log Likelihood	Chi-Square	df	Sig.
Intercept Only	502.108			
Final	320.293	181.815	42	0.000

Goodness-of-Fit

	Chi-Square	df	Sig.
Pearson	642.867	458	0.000
Deviance	320.293	458	1.000

Pseudo R-square

Cox and Snell	0.515
Nagelkerke	0.596
McFadden	0.362

Parameter estimates

							95% Confidence Interval	
		Estimate	Std. Error	Wald	df	Sig.	Lower Bound	Upper Bound
No	Intercept	2.813	3.001	0.878	1	0.349		
	LCTechnKnown	-0.144	0.172	0.700	1	0.403	0.866	0.618
	LCTechnUsed	-0.005	0.289	0.000	1	0.988	0.995	0.565
	InnovationLvl	-0.301	0.600	0.251	1	0.616	0.740	0.228
	[Age=1]	-1.869	1.029	3.298	1	0.069	0.154	0.021
	[Age=2]	-1.732	0.742	5.446	1	0.020	0.177	0.041
	[Age=3]	-1.218	0.864	1.989	1	0.158	0.296	0.054
	[Age=4]	-0.850	0.798	1.135	1	0.287	0.427	0.089
	[Age=5]	0[b]			0			
	[EducationLvl=1]	0.764	0.670	1.299	1	0.254	2.147	0.577
	[EducationLvl=2]	0[b]			0			
	[ProjectScale=1]	-0.160	0.622	0.066	1	0.797	0.852	0.252
	[ProjectScale=2]	-1.015	0.700	2.102	1	0.147	0.362	0.092
	[ProjectScale=3]	0[b]			0			
	[LCTraining=0]	-0.642	0.730	0.774	1	0.379	0.526	0.126
	[LCTraining=1]	0[b]			0			
	[PriorKnowledge-LC=1]	-2.187	1.162	3.543	1	0.060	0.112	0.012
	[PriorKnowledge-LC=2]	-1.169	0.971	1.449	1	0.229	0.311	0.046
	[PriorKnowledge-LC=3]	-3.372	1.101	9.377	1	0.002	0.034	0.004
	[PriorKnowledge-LC=4]	-2.449	1.200	4.161	1	0.041	0.086	0.008
	[PriorKnowledge-LC=5]	0[b]			0			
	[LC Learn More=1]	4.641	0.918	25.545	1	0.000	103.615	17.134
	[LC Learn More=2]	1.808	0.680	7.061	1	0.008	6.098	1.607
	[LC Learn More=3]	0[b]			0			
	[LC 16h workshop=1]	2.558	0.985	6.738	1	0.009	12.907	1.871
	[LC 16h workshop=2]	0.189	0.921	0.042	1	0.838	1.208	0.198
	[LC 16h workshop=3]	0[b]			0			
	[LC 40h workshop=1]	-2.014	1.078	3.488	1	0.062	0.133	0.016
	[LC 40h workshop=2]	-0.992	1.056	0.883	1	0.347	0.371	0.047
	[LC 40h workshop=3]	0[b]			0			

Neutral	Intercept	0.876	2.369	0.137	1	0.712		
	LCTechnKnown	0.079	0.109	0.525	1	0.469	1.082	0.874
	LCTechnUsed	0.091	0.197	0.213	1	0.644	1.095	0.744
	InnovationLvl	-0.631	0.483	1.707	1	0.191	0.532	0.206
	[Age=1]	-1.874	0.712	6.924	1	0.009	0.153	0.038
	[Age=2]	-1.164	0.563	4.276	1	0.039	0.312	0.104
	[Age=3]	-0.798	0.679	1.380	1	0.240	0.450	0.119
	[Age=4]	-0.055	0.604	0.008	1	0.928	0.947	0.290
	[Age=5]	0[b]			0			
	[EducationLvl=1]	0.688	0.500	1.894	1	0.169	1.990	0.747
	[EducationLvl=2]	0[b]			0			
	[ProjectScale=1]	0.112	0.457	0.061	1	0.806	1.119	0.457
	[ProjectScale=2]	-0.247	0.469	0.277	1	0.598	0.781	0.312
	[ProjectScale=3]	0[b]			0			
	[LCTraining=0]	0.773	0.558	1.920	1	0.166	2.167	0.726
	[LCTraining=1]	0[b]			0			
	[PriorKnowledge-LC=1]	0.696	0.901	0.597	1	0.440	2.005	0.343
	[PriorKnowledge-LC=2]	0.183	0.796	0.053	1	0.819	1.200	0.252
	[PriorKnowledge-LC=3]	-0.050	0.772	0.004	1	0.948	0.951	0.209
	[PriorKnowledge-LC=4]	-0.726	0.862	0.710	1	0.399	0.484	0.089
	[PriorKnowledge-LC=5]	0[b]			0			
	[LC Learn More=1]	1.081	0.791	1.869	1	0.172	2.949	0.626
	[LC Learn More=2]	0.760	0.444	2.928	1	0.087	2.137	0.895
	[LC Learn More=3]	0[b]			0			
	[LC 16h workshop=1]	0.922	0.614	2.256	1	0.133	2.513	0.755
	[LC 16h workshop=2]	0.801	0.510	2.466	1	0.116	2.229	0.820
	[LC 16h workshop=3]	0[b]			0			
	[LC 40h workshop=1]	-0.631	0.578	1.193	1	0.275	0.532	0.171
	[LC 40h workshop=2]	0.085	0.617	0.019	1	0.890	1.089	0.325
	[LC 40h workshop=3]	0[b]			0			

[a] Reference category is: yes [b] Is set 0 because it is a reference variable

Appendix H – General stated choice model

```
NLOGIT
      ;LHS=CHOICE
      ;choices=1,2,3
      ;RHS=one,Pres1,Pres2,Assess1,Assess2,Dep1,Dep2,Achie1,Achie2,Cert1$
```

```
Iterative procedure has converged
Normal exit:   5 iterations. Status=0, F=    .2466185D+04

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable               Choice
Log likelihood function     -2466.18469
Estimation based on N =    2439, K =  11
Inf.Cr.AIC  =    4954.4 AIC/N =    2.031
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -2579.0862  .0438 .0416
Note: R-sqrd = 1 - logL/Logl(constants)
---------------------------------------
Chi-squared[ 9]             =    225.80308
Prob [ chi squared > value ] =     .00000
Response data are given as ind. choices
Number of obs.=  2439, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
  CHOICE|  Coefficient     Error       z    |z|>Z*         Interval
--------+--------------------------------------------------------------------
   PRES1|   -.18729***     .04311    -4.34  .0000     -.27178   -.10280
   PRES2|    .11929***     .04253     2.81  .0050      .03594    .20264
 ASSESS1|   -.03626        .04364     -.83  .4060     -.12179    .04927
 ASSESS2|   -.01757        .04268     -.41  .6805     -.10122    .06607
    DEP1|    .19110***     .04242     4.50  .0000      .10796    .27424
    DEP2|   -.47910***     .04486   -10.68  .0000     -.56702   -.39117
  ACHIE1|   -.04566        .04296    -1.06  .2878     -.12986    .03854
  ACHIE2|   -.04676        .04314    -1.08  .2784     -.13133    .03780
   CERT1|    .28371***     .03075     9.23  .0000      .22344    .34398
     A_1|    .59548***     .05696    10.45  .0000      .48384    .70713
     A_2|    .67363***     .05513    12.22  .0000      .56558    .78168
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Feb 12, 2020 at 09:19:31 AM
-----------------------------------------------------------------------------
```

Appendix I – Latent class model

```
|-> LCLOGIT
        ;Lhs=CHOICE
        ;Choices=1,2,3
        ;Rhs=one,Pres1,Pres2,Ass1,Ass2,Dep1,Dep2,Achie1,Achie2,Cert1
        ;Pds=9
        ;Lcm=Age1,Age2,Age3,Age4,Edu,PK1,PK2,PK3,PK4,Inn,LM1,LM2,L16h1,
         L16h2,L40h1,L40h2
        ;Pts=3
        ;Maxit=200
        ;Halton
        ;Tlg=20$
Iterative procedure has converged
Normal exit:   1 iterations. Status=0, F=    .2570815D+04

-----------------------------------------------------------------------------
Discrete choice (multinomial logit) model
Dependent variable                Choice
Log likelihood function      -2570.81488
Estimation based on N =    2430, K =  11
Inf.Cr.AIC  =   5163.6 AIC/N =    2.125
---------------------------------------
            Log likelihood R-sqrd R2Adj
Constants only  -2570.8149  .0000-.0140
Note: R-sqrd = 1 - logL/Logl(constants)
---------------------------------------
Chi-squared[ 9]            =      .00000
Prob [ chi squared > value ] =   1.00000
Response data are given as ind. choices
Number of obs.=  2430, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.      95% Confidence
  CHOICE|  Coefficient     Error       z     |z|>Z*         Interval
--------+--------------------------------------------------------------------
 PRES1|1|       0.0          .04117      .00 1.0000 -.80686D-01  .80686D-01
 PRES2|1|       0.0          .04164      .00 1.0000 -.81610D-01  .81610D-01
  ASS1|1|       0.0          .04186      .00 1.0000 -.82037D-01  .82037D-01
  ASS2|1|       0.0          .04125      .00 1.0000 -.80845D-01  .80845D-01
  DEP1|1|       0.0          .04156      .00 1.0000 -.81458D-01  .81458D-01
  DEP2|1|       0.0          .04145      .00 1.0000 -.81231D-01  .81231D-01
ACHIE1|1|       0.0          .04148      .00 1.0000 -.81299D-01  .81299D-01
ACHIE2|1|       0.0          .04152      .00 1.0000 -.81370D-01  .81370D-01
 CERT1|1|       0.0          .02956      .00 1.0000 -.57928D-01  .57928D-01
   A_1|1|     .60013***      .05570    10.78  .0000      .49097      .70929
   A_2|1|     .70702***      .05469    12.93  .0000      .59983      .81421
--------+--------------------------------------------------------------------
***, **, * ==>  Significance at 1%, 5%, 10% level.
Model was estimated on Apr 12, 2020 at 03:39:19 PM
-----------------------------------------------------------------------------
```

```
Iterative procedure has converged
Normal exit:  25 iterations. Status=0, F=    .2093842D+04

-----------------------------------------------------------------------------
Latent Class Logit Model
Dependent variable                CHOICE
Log likelihood function      -2093.84187
Restricted log likelihood    -2669.62786
Chi squared [ 67](P= .000)    1151.57197
Significance level                .00000
McFadden Pseudo R-squared       .2156802
Estimation based on N =    2430, K =  67
Inf.Cr.AIC  =    4321.7 AIC/N =    1.778
---------------------------------------
            Log likelihood R-sqrd R2Adj
No coefficients -2669.6279  .2157 .2047
Constants only  -2570.8149  .1855 .1741
At start values -2570.7958  .1855 .1741
Note: R-sqrd = 1 - logL/Logl(constants)
---------------------------------------
Response data are given as ind. choices
Number of latent classes =             3
Average Class Probabilities
     .022  .105  .873
LCM model with panel has      270 groups
Fixed number of obsrvs./group=         9
BHHH estimator used for asymp. variance
Number of obs.=  2430, skipped    0 obs
--------+--------------------------------------------------------------------
        |                Standard            Prob.       95% Confidence
  CHOICE|  Coefficient     Error       z    |z|>Z*          Interval
--------+--------------------------------------------------------------------
        |Random utility parameters in latent class -->> 1...................
 PRES1|1|    -12.3309      .7641D+11      .00 1.0000 ***********  ***********
 PRES2|1|    -3.07901      .1199D+12      .00 1.0000 ***********  ***********
  ASS1|1|     -.07279      .2008D+12      .00 1.0000 ***********  ***********
  ASS2|1|     2.32010      .3428D+12      .00 1.0000 ***********  ***********
  DEP1|1|      .11216      .2187D+12      .00 1.0000 ***********  ***********
  DEP2|1|    -7.94628      .5965D+12      .00 1.0000 ***********  ***********
ACHIE1|1|    -5.13085      .1184D+12      .00 1.0000 ***********  ***********
ACHIE2|1|     1.96219      .2568D+12      .00 1.0000 ***********  ***********
 CERT1|1|    -4.99385      .1996D+12      .00 1.0000 ***********  ***********
   A_1|1|     1.10828      .3333D+12      .00 1.0000 ***********  ***********
   A_2|1|     2.44502      .6160D+11      .00 1.0000 ***********  ***********
```

|Random utility parameters in latent class -->> 2....................						
PRES1|2|	-1.50071	5.12926	-.29	.7698	-11.55388	8.55245
PRES2|2|	.28578	10.62971	.03	.9786	-20.54807	21.11963
ASS1|2|	.66679	8.69598	.08	.9389	-16.37701	17.71059
ASS2|2|	.53382	8.24372	.06	.9484	-15.62358	16.69122
DEP1|2|	.59153	2.79154	.21	.8322	-4.87980	6.06286
DEP2|2|	-.89110	1.32578	-.67	.5015	-3.48958	1.70739
ACHIE1|2|	-.44438	7.30022	-.06	.9515	-14.75255	13.86380
ACHIE2|2|	-1.68397	7.11226	-.24	.8128	-15.62374	12.25580
CERT1|2|	1.43410	8.97518	.16	.8731	-16.15693	19.02514
A_1|2|	-5.24533	22.15922	-.24	.8129	-48.67660	38.18595
A_2|2|	-3.76177	6.62339	-.57	.5701	-16.74338	9.21984
|Random utility parameters in latent class -->> 3....................						
PRES1|3|	-.23619***	.04685	-5.04	.0000	-.32802	-.14436
PRES2|3|	.16248***	.04714	3.45	.0006	.07010	.25487
ASS1|3|	-.05568	.05482	-1.02	.3098	-.16312	.05176
ASS2|3|	.00581	.05373	.11	.9138	-.09950	.11113
DEP1|3|	.27799***	.04468	6.22	.0000	.19042	.36557
DEP2|3|	-.58521***	.04393	-13.32	.0000	-.67130	-.49912
ACHIE1|3|	.06080	.04884	1.24	.2132	-.03493	.15653
ACHIE2|3|	-.14225***	.05042	-2.82	.0048	-.24108	-.04343
CERT1|3|	.31585***	.03133	10.08	.0000	.25445	.37725
A_1|3|	1.55588***	.05912	26.32	.0000	1.44002	1.67175
A_2|3|	1.60634***	.05600	28.68	.0000	1.49657	1.71610
|This is THETA(01) in class probability model........................						
_ONE|1|	-5.59490	44.90810	-.12	.9009	-93.61315	82.42336
_AGE1|1|	.54876	4.94938	.11	.9117	-9.15185	10.24937
_AGE2|1|	-.38831	5.18910	-.07	.9403	-10.55876	9.78213
_AGE3|1|	-.59146	12.46405	-.05	.9622	-25.02056	23.83764
_AGE4|1|	-.38427	6.95292	-.06	.9559	-14.01174	13.24320
_EDU|1|	-.48516	4.11035	-.12	.9060	-8.54130	7.57098
_PK1|1|	.92058	22.51254	.04	.9674	-43.20318	45.04434
_PK2|1|	.77777	22.68578	.03	.9727	-43.68553	45.24108
_PK3|1|	.56023	22.56933	.02	.9802	-43.67483	44.79530
_PK4|1|	-1.57605	82.35311	-.02	.9847	-162.98518	159.83308
_INN|1|	.11643	2.61311	.04	.9645	-5.00517	5.23803
_LM1|1|	.04694	4.86913	.01	.9923	-9.49638	9.59027
_LM2|1|	.35366	3.04238	.12	.9075	-5.60929	6.31661
_L16H1|1|	-.17888	2.99547	-.06	.9524	-6.04990	5.69213
_L16H2|1|	.30510	2.84054	.11	.9145	-5.26226	5.87246
_L40H1|1|	1.33933	38.15988	.04	.9720	-73.45266	76.13132
_L40H2|1|	.54246	37.93137	.01	.9886	-73.80167	74.88659
|This is THETA(02) in class probability model........................						

```
        |This is THETA(02) in class probability model.......................
   _ONE|2|   -3.04178***      .45207     -6.73  .0000     -3.92782  -2.15573
  _AGE1|2|    -.67144         .68389      -.98  .3262     -2.01183    .66895
  _AGE2|2|   -1.09390**       .53163     -2.06  .0396     -2.13588   -.05192
  _AGE3|2|    2.69055***      .54953      4.90  .0000      1.61349   3.76760
  _AGE4|2|    -.14701         .59153      -.25  .8037     -1.30638   1.01237
   _EDU|2|   -1.10065***      .30916     -3.56  .0004     -1.70658   -.49471
   _PK1|2|   -1.94660***      .56865     -3.42  .0006     -3.06114   -.83206
   _PK2|2|   -1.75305***      .53297     -3.29  .0010     -2.79765   -.70845
   _PK3|2|   -1.39678**       .58973     -2.37  .0179     -2.55263   -.24094
   _PK4|2|     .20298         .65910       .31  .7581     -1.08883   1.49479
   _INN|2|     .08746         .29710       .29  .7685      -.49484    .66976
   _LM1|2|    6.87087***      .97621      7.04  .0000      4.95753   8.78421
   _LM2|2|    1.32581**       .53010      2.50  .0124       .28683   2.36478
 _L16H1|2|    4.45935***     1.34480      3.32  .0009      1.82359   7.09510
 _L16H2|2|    3.61032***      .96082      3.76  .0002      1.72715   5.49349
 _L40H1|2|   -7.09092***     1.57236     -4.51  .0000    -10.17268  -4.00916
 _L40H2|2|   -2.33312**      1.05598     -2.21  .0271     -4.40281   -.26344
        |This is THETA(03) in class probability model.......................
   _ONE|3|        0.0     .....(Fixed Parameter).....
  _AGE1|3|        0.0     .....(Fixed Parameter).....
  _AGE2|3|        0.0     .....(Fixed Parameter).....
  _AGE3|3|        0.0     .....(Fixed Parameter).....
  _AGE4|3|        0.0     .....(Fixed Parameter).....
   _EDU|3|        0.0     .....(Fixed Parameter).....
   _PK1|3|        0.0     .....(Fixed Parameter).....
   _PK2|3|        0.0     .....(Fixed Parameter).....
   _PK3|3|        0.0     .....(Fixed Parameter).....
   _PK4|3|        0.0     .....(Fixed Parameter).....
   _INN|3|        0.0     .....(Fixed Parameter).....
   _LM1|3|        0.0     .....(Fixed Parameter).....
   _LM2|3|        0.0     .....(Fixed Parameter).....
 _L16H1|3|        0.0     .....(Fixed Parameter).....
 _L16H2|3|        0.0     .....(Fixed Parameter).....
 _L40H1|3|        0.0     .....(Fixed Parameter).....
 _L40H2|3|        0.0     .....(Fixed Parameter).....
--------+--------------------------------------------------------------------
nnnnn.D-xx or D+xx => multiply by 10 to -xx or +xx.
***, **, * ==>  Significance at 1%, 5%, 10% level.
Fixed parameter ... is constrained to equal the value or
had a nonpositive st.error because of an earlier problem.
Model was estimated on Apr 12, 2020 at 03:39:23 PM
-----------------------------------------------------------------------------
```