Higg Index Learning Board Game
Development of the Lean Game comprising the three pillars of sustainability: society, environment and economy

Master thesis to the acquisition of the academic degree of Master of Science in Applied Textile Management

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Abstract

The background of this project is the need of a better understanding of what sustainable development is and what tools can be used in the fashion supply chain to decrease its ecological footprint. For that purpose the researchers have endeavored to create a new learning board game for fashion industry students that could teach them the basic principles of sustainability and Higg Index. The developed Higg Index Board Game is part of the collaborative work of Swedish School of Textiles and Sustainable Apparel Coalition. The study about the teaching effect of the new game was carried out with a quasi-experimental design and comprised two workshops with the master students from the Swedish School of Textiles as participants. The first workshop was conducted to analyze the principles and environment of the Lean Game that served as a basis for the new game. After that the researchers elaborated the structure and rules for the new game with help of the game-theory and conducted a trial testing of the game to exclude possible basic errors. The Higg Index modules were integrated in the structure of the game in the form of facilities and product-choices that could affect the economy of the game. The second workshop was devoted to playing the new Higg Index Game and evaluating its sustainability teaching effect. The participants were tested with pre- and post-test questionnaires and also observed by the researchers under their discussions during the game. The tests analysis showed that the Higg Index Game teaches lean philosophy, fashion supply chain’s entity and hot spots, and to some extent sustainability and the Higg Index’ function. After playing the game the participants increased their knowledge about sustainability by 10,1%. The researchers concluded that the game can become a teaching module in the sustainability education programs for fashion and textile students and other stakeholders - academics, managers, consultants etc., but needs some further development. Thus, in this study the Higg Index Game is presented as a prototype for future improvements.

Key words: sustainability, fashion supply chain, Higg Index, learning, board game
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1. Introduction

The current social model consists of consumers and producers - the operators in the industrial society. Without such model there would be no jobs, and without jobs we wouldn’t have money to consume. The dark side of this industry model is that it is based on cheap energy, “free” resources from nature and an endless disposal of waste (Halt and Milstein, 1999). The economic model of current fashion industry model excludes the value of the natural resources it consumes (Thorpe, 2007). With uncontrolled natural resource consumption the planet is suffering from such consequences as rise of water level, decrease of biological diversity, pollutions and overflow of materials into the wrong spheres. This industrial model that emerged in the early 1900 is now threatening the prosperity of human life (Rockström et al., 2009). However, during the last decades we can see increasing concern about sustainable development in business and society (European Union, 2011). This concern emerged to prevent environment from harm and save natural resources for the future generations (Brundtland, 1987).

Sustainable development in industry comprises improvements in the supply chain, which is especially important for the fashion market, one of the most resource-consuming markets in the world (Thorpe, 2007). Enhancements in the fashion supply chain mean primarily improving water-use efficiency and/or its re-use in cultivation or production of raw materials and the manufacturing of apparel products. Moreover, it means minimization of the volume and chemical constituents of water discharges and elimination of impacts to local communities. In the garment manufacturing the water use can be reduced by challenging conventional washing practices and developing alternative approaches. Additionally, apparel industry should think how to minimize direct and embedded energy use and carbon in its products. The industry has to develop effective use for textile waste, to minimize waste in the operations of supply chain and end-of-life of apparel products; furthermore, to reduce the use of chemicals and potentially hazardous materials which pose health or environmental risks (Sustainable Apparel Coalition, 2012).

The sustainability concept of reduced and more effective resource-consumption echoes the famous concept of Toyota Production System, also known as “lean production philosophy” that implies the key principle of removing all forms of waste from business operations (Liker, 2004). Waste in regard to the environment means unnecessary usage of resources and pollutions to air, water and land that cause harm to the planet. Thereby, along with cost reduction, elimination of waste across the supply chain enhances its environmental performance. One can’t deny that lean initiatives can contribute to a better sustainable development. Thus, to gain a better sustainable performance in the supply chain, there is a challenge to integrate sustainability principles with lean techniques (Vinodh et al., 2011).

Moreover, not only by eliminating wastes but also by implementation of new sustainable choices and technologies in the business processes, companies can gain better profitability (Demetrakakes, 2011). However, it is not easy to reveal and evaluate wastes and environmental impacts in the supply chain to find sustainable improvements’ opportunities. The focus of the industrial model is based on economical measurements, while human and nature have zero value, they are invisible in the business. Yvon Chouinard, the founder of Patagonia and a pioneer in sustainable business, stressed the importance of using a measurement system to engage the industry to see its environmental impacts in black and white (Miller, 2013; Chouinard, 2006).
It was estimated that each ton of carbon dioxide causes a damage for 85$, yet this environmental impact is not reflected in the shipping prices (Christopher, 2011). The Sustainable Apparel Coalition challenged to create a common self-assessment tool for the apparel industry that could help companies to reveal their sustainability hot spots and find improvement opportunities across the supply chain. This tool, called Higg Index, is suggested as a learning tool for both small and large companies to identify sustainable challenges and capture on-going improvement (Sustainable Apparel Coalition, 2012). The interest for becoming more “green consciousness” and the growing popularity of the concept of sustainability, still many have not really understood the meaning of sustainability (United Nations, 2002). Since business directly or indirectly causes most ecological and social changes and threats, they can also turn the situation in another direction. New business and management solutions could help restore a balance between the rising level of consumption and threats to natural resources and lead to a healthier planet where there is a win-win-win situation for companies, the environment and society (Willard, 2004).

There are a lot of trainings, programs and games that focuses solely on profits and shareholder value of business activities, not on their environmental and social impacts. Since 1999 the education sector has integrated sustainability learning both in secondary and in university education programs. Issues of sustainable environmental and social development have become a significant part of teaching process (Scheunpflug & Asbrand, 2006). To take better and more conscious decisions of investments in the supply chain, for future fashion business it is important to learn the meaning and the profit of sustainability.

Games are widely used in the learning process because they facilitate simulation of the real conditions where the players can practice theory against reality and test scenarios and strategies in a safe environment. The basics of learning through games is the balance between fun and learning, where the players have to be challenged by learning new things or they will lose interest in the process (Fabricatore & López, 2012). There are a variety of learning board games used in the University and management education, some of the most popular are Beer Game, Supply Chain Game and Lean Game. The Lean Game is an effective method to get knowledge and motivation for Lean strategies in production process. The Lean production philosophy, spread all over the world in the business practice, has been adapting lean tools and principles beyond manufacturing - to logistics, distribution, services, retail, healthcare, and even government (Liker, 2004). The Lean game is a board game where the players have the chance to simulate the conditions of reality and strategically use the Lean tools and philosophy to solve such problems within the supply chain as: overproduction, wrong lead-time, unnecessary transportation, over-processing, excess inventory etc (Liker, 2004).

In this thesis project the Lean game is in focus as a suitable structure for eliminating waste and the Higg Index as a unique assessment tool for improving the supply chain’s sustainability.
1.1 Problem description

It is discussed that sustainable development requires “a new understanding of the path from statistics to policy, where sustainability assessment is redefined from a technical process to a deliberative process of learning, participation and involvement” (Granåsjordet et al., 2012, p. 332). Sustainable development indicator sets “should be evaluated according to how they contribute to deliberation of sustainability in learning processes involving participants beyond the science–policy interface” (Granåsjordet et al., 2012, p. 334).

Despite of the growing “green consciousness” and popularity of the concept of sustainability, “many people have still not grasped its meaning” (United Nations, 2002, n.p.) and thereby the need of learning and thinking of sustainability has increased. Therefore, it has been popular to use different games to educate people about sustainability (Fabricatore and López, 2012).

The recently suggested tool for sustainability assessment, Higg Index, can be the starting point for the apparel industry to learn sustainability opportunities and effectively communicate across the supply chain. Though, not many people to date know what Higg Index is and which possibilities it has for sustainable development in the fashion industry. To educate academics and stakeholders in the fashion industry to take better and more conscious decisions of investments in the supply chain the special teaching module or tool is needed. It is important for future fashion business to learn the meaning and the profit of sustainability. Thereby, the research area of this thesis work is the development of teaching tools for learning sustainability and Higg Index.

1.2 Purpose and aim of the study

The purpose of this study is to develop and test a learning board game with the starting point at lean production philosophy and social and environmental aspects of the fashion supply chain. The game should give the player an understanding of what sustainability is and how the ecological footprint of a fashion supply chain can be reduced. This game is planned to be used as a teaching module in sustainability education and learning the Higg Index.

The aim of the project - designing a learning board game with focus on sustainability - is part of the Swedish School of Textiles’ sustainability work and its commitment to the Sustainable Apparel Coalition.

1.3 Research questions

1.3.1 Motivation and questions

In this thesis work the researchers are intending to analyze how the learning board game can facilitate stakeholders with grasping the significance of sustainable development in the fashion supply chain. To explore if the Higg Index Game can educate the players in the two main areas - sustainability in the fashion supply chain and the function of Higg Index - the research questions are formulated as follows:

1. How can the game help players to understand how sustainability in a fashion supply chain can be increased?
2. How can the game explain the function of the Higg Index?
1.3.2 Expected results and answers

As result of this thesis work authors expect to develop and test the new learning game of sustainability and Higg Index and get the feedback from the players if this game could help them to understand how to make profitable sustainable improvements in the fashion supply chain.

1.4 Delimitations

This research will focus on sustainable development of the fashion industry and integrating human and environmental values into the Lean Game. The game will be tested on students at the Swedish school of Textiles in Borås, who have been chosen owing to the short timeframe and suitability of involvement of students within the research region – Västra Götaland in Sweden. In this report the customer’s environmental impact is excluded since the focus is on improving the processes within the supply chain.

The customer’s impact is relevant to the questions of sustainability and should be considered regarding this issue. However, to follow the structure of the Lean Game where the Customer is just a trigger for a production process and to avoid an exceeding complexity in the new game, the customer’s impact is simplified to ordering of conventional or eco-products (special orders). Therefore, the customer’s impact on the sustainable development of the fashion supply chain will be left for the later versions of the game. Because of the time limit of the thesis work this game will be only a prototype and the researchers will explore its possibilities for further development.
2. Methodological framework

In this thesis work a qualitative research strategy with a quasi-experimental design will be applied. The learning game will be created on the basis of the existing Lean Board Game with a help of the game design theory and practical tests from the workshops. Then, to evaluate the effect of the learning through the new game, authors will conduct the experiment with pre- and post-test questionnaires and researcher’s observations under the treatment, i.e. playing the new game.

The study will consist of two workshops and a game trial testing. The first workshop will be dedicated to the Lean game, where researchers will analyze the game structure, behavior of the players and the way the game influences the participants. After that the researchers will elaborate and integrate new elements into the Lean Game structure and make other essential transformation in it to create the test version of the new game. Thus, before the second workshop the new game will be pre-tested by the developers and textile students to reveal its hot spots for further improvements and to exclude basic errors. The output of the trial game will be related to the theories and learning subjects and researchers will make needful corrections. The second Higg Index Game workshop will be crucial for our study since it will reveal if the developed new game serves its purpose. In this workshop after the playing the game the textile students will answer a questionnaire with a simple written exam to test and evaluate the new knowledge they gained from the game. The results of the exam will be analyzed regarding the involved theories and the subjects that the players should learn during the game. The outcomes of the last workshop are considered to be the basis for the answers to the research questions of this study (see Figure 1).
Figure 1. The structure of the thesis work
2.1 Game design

Games are known as an integral part of human cultures. Classic games and new digital ones in all their various formats and genres are just a new expression of the ancient method of social interaction. Creating a good game is a challenging task that requires a playful approach but a systematic structure. The game designer should be part engineer, part entertainer, part mathematician, and part a social researcher where his role is to create a set of rules within which there are means and motivations to play (Fullerton, et al., 2008). Whether we consider folk games, board games, or massively multiplayer online games, says Fullerton, “the art of game design has always been to create that elusive combination of challenge, competition, and interaction that players just call “fun” (Fullerton et al., 2008 n.p).

To design the game one should set the experience goals up front, as a part of brainstorming process. Features can be brainstormed later to meet these goals, and then they have to be play tested to see if the players experience that goals are being met. To play and perfect the simplistic model and to get an instant feedback if it helps to meet the expected goals, a physical prototype for a play test has to be built. It is important to test the game. The process of iteration is crucial in the game design and implying testing and evaluation of the results over and over again throughout the development of the game (Fullerton et al., 2008).

The interactive process that a game designer should go through when designing the game, consists of following steps according to Fullerton et al. (2008): to set the goals for player experience, to conceive an idea or a system, to formalize an idea or system (to write it down or prototype), to test an idea or system against player experience goals (to get feedback) and to evaluate and prioritize results. If results are negative and the idea or system appears to be fundamentally flawed, go back to the first step. If results point to improvements - modify and test again. If results are positive and the idea or system appears to be successful, the iterative process has been completed (see Figure 2).

![Iterative process diagram](image)

Figure 2. Iterative process diagram (reconstructed from Fullerton et al., 2008)
Within the game players should get Objectives, something to strive for applying rules of the game. The Procedure and Rules should be described in the rule sheet. Rules can also close up loopholes in the game system – “do not pass Go”, “do not collect X” etc. The game will need Resources - units, inventory, time, currency etc. and Boundaries - physical or conceptual. Game designer should plan and consider possible Conflicts and Outcome of the game. Conflict usually emerges when players are trying to accomplish the goals of the game within its rules and boundaries. Conflict can be designed into the game by creating rules, procedures, and situations that do not allow players to accomplish their goals directly. This means to challenge the players by forcing them to employ a particular knowledge and make a decision. In the game, like in real life, compromising is sometimes necessary and it can be an important source of effective collaboration (Fullerton et al., 2008).

In this thesis work we will build the new learning board game on the basis of the existing Lean board game, therefore we will use existing structure and rules of the Lean game but will change and adopt them according the purpose of the new game – sustainability and Higg Index learning effect.

### 2.2 Quasi-experimental research design

Quasi-experimental design is a form of experimental design. Experimental design can have different forms but the most common is the classical experiment. In a classic experiment subjects are usually randomly assigned to one or more experimental group, which represents different types of the independent variable. When using two groups, one, called experimental group, is treated with the dependent variables and the other one, called control group, is not treated. Then a manipulation is applied on the experimental group and its impact on subjects is being determined (Bryman, 2012). Thus, a classic experiment includes pre-post testing, a treatment group and a control group, and random assignment of participants. In case when the study has certain characteristics of an experimental design but studies lacks one or more of these elements it becomes a quasi-experimental design (NCTI, 2013). The aim of the experiment is to see if playing the learning game has provided the outcome in form of new or better sustainability knowledge. That will point to the effectiveness of the game. In this study a control group will be missing owing to a limited number of participants of the experiment, hence the study has a quasi-experimental design. A quasi-experimental design starts from identifying the variables. The quasi-independent variable will be the x-variable, in case of this thesis - the game, that is manipulated in order to affect a dependent variable - the students.

In this project the researchers will conduct pre-post testing quasi-experiment. A pre-post testing means collecting data from the experiment participants before the treatment took place (pre-), and then collecting the same data after the treatment took place (post-). Thus, researchers only look at one group of individuals who receive the treatment. The pre-post testing allows to make inferences on the effect of the treatment by looking at the difference in the pre-test and post-test results. However, interpreting the pre-test and post-test difference should be done with caution since it is not sure that the differences in the pre-test and the post-test are causally related to the treatment (NCTI, 2013).
2.2.1 Purposive sampling

In qualitative research purposive sampling can be used when the population is chosen based on the goal of the research. The sampling represents a specific type of characters that fits to the aim of the study. The directives of the participants are set in the beginning of the research but units are added under the process to fit the research goal (Bryman, 2012). In this case the purpose is to develop a game that teaches sustainability in fashion supply chain that can be used in academic studies and training programs. Thereby the population is chosen in relation to their studies and their interest in fashion and sustainability. The students selected for the testing were studying at two master programs at The Swedish School of Textiles in Borås: Applied Textile Management and Fashion Management. The students had under their program studied sustainability and fashion and textile supply chain and had a good knowledge about the subjects treated in the game from the start. In both workshops there were equal numbers of students participating from each program. The students were invited via social media, mail and flyers.

2.3 Evaluation of learning process

The evaluation system chosen for this thesis project is developed by The Swedish National Agency for Education. There the student can be tested with two different approaches - formal, informal or with both. The formal test can apply an exam, a presentation or a questionnaire. The informal test is based on observations by the researchers when the student gets questions under the process of practicing their new knowledge. It is important for the researchers to set up a goal of what the students should learn from the practice, or the game in this case, especially when the formal test is used. The evaluation of the learning process has to give a holistic view of the knowledge that participant has retrieved from the game (The Swedish National Agency for Education, 2011). It is important that the education, goal and evaluation are logically linked together and have a clear structure.

Therefore, in this research the evaluation is a combination of a questionnaires and participant observations of the players’ discussions. For catching the discussion part of the game which is an important part of the learning process, the researchers will observe and write down the participants’ decisions and discussion patterns.

According to Elizabeth et al. (2012) students that are engaged in academic discussion are more effective in group problem solving and show signs of improved reasoning skills. They also experience a higher level of individual achievement. The discussions and disagreements in the groups help the student to make more informed and careful choices and decisions. By implementing practical discussion in the classroom the student can practice the background knowledge and relate that to reality (Elizabeth et al, 2012). It is hereby an important part of the research process to observe the groups analytic discussions after every round of the game. This must be balanced so that the researcher does not influence the participants to feel that they cannot say what they really think. It is important in observations that the participants are free to speak their mind and openly discuss with each other.

When conducting observations different methods can be applied such as, for example, a participant observation. There the researchers can act as two different observers: the active observer and the constrained observer (Ely et al., 1991).
The active observer acts as the game leader and as the person of trust that could be asked questions and lead the players in the right direction, whereas the constrained observer acts as a researcher and does not take part in the discussions. The advantage of using participant observations is that unexpected subjects and behaviors are more likely to arise here than in interviews (Bryman, 2012). The observation will be complemented with pre- and post-test questionnaires that evaluate players’ knowledge of the game’s subjects and if it has increased after playing the game.

The process of learning through the practice of the new board game of sustainability is presented in Table 1. The questionnaire will contain the questions related to the purpose of the game, such as about the three pillars of sustainability, Higg Index and fashion supply chain (see Annex 4 and 5).

<table>
<thead>
<tr>
<th>Form</th>
<th>Learning task</th>
<th>Evaluation</th>
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| The participants are playing the game of the fashion supply chain that involves economic, ecological and social aspects. After every round the participants discuss and analyze its results and choose the possible changes for the next round. | The participants should learn the dynamics of the fashion supply chain and where and how the three pillars of sustainability are comprised. Also they should get understanding where and how in the fashion supply chain sustainability performance can be measured and related to economy. | **Formal test**: A post-test questionnaire about the learning effect of the game: understanding the fashion supply chain function and sustainable choices.  
**Informal test**: Researchers observe and analyze the discussion and choices made by participants in each round of the game. |

Table 1. Learning through the practice of the sustainability board game

### 2.4 Conducted tests

#### 2.4.1 Workshop: The Lean Game

In this workshop six students and two researchers were playing the Lean Game. The layout of the Lean Game consisted of 8-9 activities and 6 stations - tables. Each station was placed in a specific order. The game was led by the thesis project supervisor (see Annex 1). The purpose of the workshop was to observe what the participants can learn from the playing the Lean Game and how do they gain it.

Before and after the workshop the participants conducted a questionnaire. The pre-test questionnaire showed that most of the participants had knowledge about the supply chain before starting the game.
However, most of them did not know the Lean Game previously but thought that playing games is a good way of learning process and thereby had a positive attitude before the start (see Annex 2).

After the game the participants answered a post-test questionnaire about the game layout and time, the knowledge they perceived and what facets of the game they think are the most important.

### 2.4.2 Trial Higg Index Game testing
While developing the new game researches decided closely to follow the Lean Game layout and lead times to minimize possible structure and economy scoring mistakes. However, according to the game design theory the developed game was tested for preventing unnecessary interruptions under the later workshops. The testing was conducted by 4 participants that handled several stations. The purpose was to detect the flow complexities in form of wrong layout, lead-time and new sustainability scoring system. Game testing revealed mostly minor errors and they were fixed during the further game development process.

### 2.4.3 Workshop: Higg Index Game
The purpose of this experiment was to determine if the game teaches the players sustainability in harmony with economy. The workshop engaged 6 participants that answered questionnaires and were observed under the treatment (see Annex 3).

Because of a limited amount of students that participated in the experiment the researchers had to be a part of the game. In the game the researchers chose to operate on the stations that had a low influence on the round’s discussions as stations with low or without alternative options – Customer and Material Handler. Under the discussions one of the researchers took notes and the other one acted as the game leader. The game leader engaged the participants into the possible choices and gave explanations if something was unclear. The textile manufacturing stations looked like as in Figure 3 and in Figure 4 the participants have moved all the tables together which was possible in the last round.

![Figure 3 and 4. The Higg Index Game Workshop](image)

Before and after the game the participants were tested with questionnaires to see if the knowledge of the subjects of sustainability had increased after playing the game (see Annex 4).
Pre-test detected the current knowledge about sustainability in the fashion supply chain. After the introduction the workshop begun where the game’s subjects and aims were outlined. Thereon the students played the game in six rounds, where each round lasted 12 minutes. Between the rounds the players got to make some changes for next round under the discussion part of 10-15 minutes. After playing the game the participants had to fill in a post-test questionnaire with the same questions as in the pre-test questionnaire (see Annex 5).

2.5 Data analysis method

To fulfill the research design of the project in the both planned workshops the questionnaires with closed and open questions will be used. The answer imply a multiple choice in order to simplify data processing and avoid the bias of the result since in the case of closed questions the result is less influenced of the researchers interpretations than if it would be open answers. Therewith, during the workshop the researchers will conduct active observations. Students’ answers to closed questions in the questionnaires will be analyzed by building a bar chart diagram, which is the most frequently used method of displaying quantitative data. For that the average of answers for each question from all participants will be found like the sum of all answers divided for number of participants (Olsson and Sörensen, 2007). Right answers will be counted as 1 and wrong answers will be counted as 0. Open questions from the questionnaires and the data from researchers observations will be processed with a qualitative data analysis method such as thematic analysis. Thematic analysis helps to search for themes - categories identified by the researchers through their data and related to their research focus and research questions. Themes will be built on codes identified in transcripts and field notes (Bryman, 2012).
3. Literature Review

The concept of sustainability is used worldwide regarding different aspects. In this report the researchers refer to the classic definition of sustainability coined in 1987: “Sustainable development stands for meeting the needs for present generations without compromising the ability for future generations to meet their own needs” (Brundtland, 1987, n.p). It is a long-term vision that includes global and local actions in the areas of environmental, economic and social issues (European Union, 2011). These areas are often stated as the three pillars of sustainability that form the foundation of the literature review of this study. The theory will be built around the fashion supply chain, that is the focus of the future game, and its environmental, economic and social aspects where sustainable improvements can be implemented. Teaching sustainability, Higg Index and learning through the games are other significant research areas for this thesis work.

The “Fashion supply chain” chapter comprises the sub-chapters “Textile fibers and biodiversity” and “Textile manufacturing and chemical pollutions” that are presented as a part of the foundation for applying the environmental aspects in the game. Social aspects of the fashion supply chain are represented in sub-chapters “Garment manufacturing and human rights” and “Local production and its advantages”. The chapter “Economy and sustainability will describe the economy and lean philosophy in relation to sustainability.

3.1 Higgs index

The purpose of this study is to explain and teach stakeholders the Higg Index function and its relation to sustainability performance of the fashion supply chain. In this chapter authors present a short overview of what Higg Index is to date.

3.1.1 Sustainable Apparel Coalition

With growing of green consciousness and CSR activity’s significance in the business strategies the need of the common highly integrated index for evaluation of sustainable development has arisen (Bell and Morse, 2012). During the last five years the leading apparel companies have been collaborating to identify the environmental and social impacts of their products in order to improve a supply chain process. They need a tool that would provide the functionality for making sourcing choices that reduce environmental impact. For that purpose companies have joined into the Sustainable Apparel Coalition (SAC) that works to reduce the environmental and social impacts of apparel and footwear products around the world. Today the Sustainable Apparel Coalition is an industry-wide group of over 80 leading apparel and footwear brands, retailers, suppliers and also of non-profits governmental organizations, trade associations and academic institutions. The Swedish School of Textiles is one of them. Together they represent more than 30% of the global market share of apparel and footwear industries. The concept of collaboration in SAC is addressing the industry’s current social and environmental challenges that is a business imperative and an opportunity. The Coalition seeks to lead the industry toward a shared vision of sustainability that will spotlight priorities for action and opportunities for efficiency and technological innovation. The companies having positive impact on the people and communities and not producing unnecessary environmental harm can be regarded to that sort of vision (Sustainable Apparel Coalition, 2012).
3.1.2 Higgs index version 1.0

The focus of Sustainable apparel coalition is the development of the Higg Index and its support. The Higg Index is designed to be a self-assessment tool for measuring sustainability impacts of apparel and footwear products.

The index, first launched in July 2012, was elaborated on the basis of several established evaluation tools, such as the Outdoor Industry Association's (OIA) Eco Index, Nike's Environmental Apparel Design Tool and Global Social Compliance Program (GSCP) Environmental Facilities Assessment (Sustainable Apparel Coalition, 2012).

The Higg Index 1.0 is an open source internal-facing tool that can help fashion business to identify sustainability hot spots and improvement opportunities within the companies. With this tool they can understand and measure environmental impacts and create a starting point of engagement, education, and collaboration among stakeholders (Sustainable Apparel Coalition, 2012).

Thus, the usage of the Higgs index is planned to benefit companies with: understanding and quantifying sustainability impacts; reducing redundancy in measuring sustainability; reducing risk and uncover efficiency and be a common means to communicate with stakeholders.

Sustainable Apparel Coalition considers different impacts of the product throughout its life cycle, such as: materials, packaging, manufacturing, transportation, use, service and end of life. Accordingly, it is suggested to measure impacts through three modules: Brand module, Product module and Facility module. All modules are scored independently of one another. Within each module, there are major groups of content called sections (e.g. materials, manufacturing, and packaging) and each section includes qualitative indicator questions. Companies can measure impacts through these modules in ways that are best suitable for their organizations (Sustainable Apparel Coalition, 2012).

The Brand module is constructed for internal use for brands and retailers and identifies opportunities in the overall sustainability strategy. The Product module as well measures and compares the sustainability performance of specific products internally, where users are brands and retailers. The Facility module is designed for brands, retailers and suppliers to measure and improve sustainability performance of facilities externally and internally. Though, retail activities are not yet included in The Higg Index 1.0 and will be considered for future releases (Sustainable Apparel Coalition, 2013).

Higg Index 1.0 consists of qualitative questions, Excel-tables and focuses on apparel and environment. Upcoming in the fall 2013 is version 2.0 that will be web based and include footwear, social/labor issues and other improvements. The scoring system of the Higg Index 1.0 was developed to drive behavior change and it will be improved in future releases with more data, information and methodologies. In addition to asking “yes/no” questions, it is planned to ask for data to support quantitative metrics that will help provide a more accurate picture of environmental performance, e.g., energy use data (Sustainable Apparel Coalition, 2012).

There is a problem in measuring sustainability how to weigh different parameters against each other. The Higg Index assessment software converts each metric into a points score to enable comparison where high scores are being better than low scores. This scoring system might be not perfect but does help to simplify matters and start the process of measuring of sustainability on the common base (Sustainable Apparel Coalition, 2013).
In the Product Module the Higg Index measures the impacts of different textiles in terms of greenhouse gases, energy, water, land use, toxicity and waste. The Product Module includes scoring system of Material Sustainability Index (MSI) originally developed by Nike. With its help product development teams can select materials based on available data. Each material has own impact which has a metric defined in single sustainability score of 50, where the higher numbers shows better sustainability performance (see Table 2). The present version of Higg Index has 14 different metrics to measure. Today the analysts consider that the index is not yet easy to use (Bodey, 2013).

<table>
<thead>
<tr>
<th>Material</th>
<th>Toxicity Total</th>
<th>Energy/GHG Total</th>
<th>Water/Land Total</th>
<th>Waste Total</th>
<th>Total score 50pt scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>3,4</td>
<td>6,3</td>
<td>3,4</td>
<td>13,7</td>
<td>26,8</td>
</tr>
<tr>
<td>Hemp</td>
<td>5,9</td>
<td>3,4</td>
<td>3,8</td>
<td>11,9</td>
<td>26,1</td>
</tr>
<tr>
<td>Lyocell</td>
<td>4,7</td>
<td>5,0</td>
<td>5,6</td>
<td>10,0</td>
<td>25,3</td>
</tr>
</tbody>
</table>

Table 2. Simplified version of Material Sustainability Index’ Scoring (Reconstructed from the Higg Index 1.0 training materials, 2013)

The Brand and Product Modules embrace sections about materials, packaging, manufacturing, transportation, use & service and end of life of the product whereas the Facility Module deals with the environmental management system, energy use and greenhouse gas, water use and waste, emissions to air, waste management and hazardous substances. The Facility module is complete and scored once per facility and contains facility-level practices not specific to a particular product/garment (see Table 3). In this project authors will make an attempt to integrate all these modules into the simulated for the game fashion supply chain.

<table>
<thead>
<tr>
<th>Higg Index Modules</th>
<th>Brand Module</th>
<th>Product Module</th>
<th>Facility Module</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higg Index metrics</td>
<td>•General</td>
<td>•Materials</td>
<td>Environmental mgt program</td>
</tr>
<tr>
<td></td>
<td>•Materials</td>
<td>•Packaging</td>
<td>•energy use and GHG emissions</td>
</tr>
<tr>
<td></td>
<td>•Packaging</td>
<td>•Manufacturing</td>
<td>•Water use</td>
</tr>
<tr>
<td></td>
<td>•Manufacturing</td>
<td>•Transportation</td>
<td>•Wastewater / effluent</td>
</tr>
<tr>
<td></td>
<td>•Transportation</td>
<td>•Product care &amp; repair service</td>
<td>•Emissions to air</td>
</tr>
<tr>
<td></td>
<td>•Product care &amp; repair service</td>
<td>•End of life</td>
<td>•Waste management</td>
</tr>
<tr>
<td></td>
<td>•End of life</td>
<td></td>
<td>•Pollution prevention</td>
</tr>
</tbody>
</table>

Table 3. Higg Index Modules (Sustainable Apparel Coalition, 2013)
3.2 Teaching sustainability

Sustainable development requires “a new understanding of the path from statistics to policy, where sustainability assessment is redefined from a technical process to a deliberative process of learning, participation and involvement” (Garnåsjordet et al., 2012, p. 334).

The sustainability indicators should be evaluated according to their contribution to sustainability learning processes, where participants are involved beyond the science interface (Garnåsjordet et al., 2012).

Despite of the growing “green consciousness” and popularity of the concept of sustainability, “many people have still not grasped its meaning” (United Nations, 2002, n.p.) and thereby the need of learning and thinking of sustainability have increased. Therefore, it has been popular to use different games to educate people about sustainability (Fabricatore and López, 2012).

Since business directly or indirectly causes most ecological and social changes and threats, it can, as well, turn the situation in another direction. New business and management solutions could help restore a balance between the rising level of consumption and threats and natural resources. There are a lot of trainings, programs and games that focused solely on profits and shareholder value of business activities, not on their environmental and social impacts. To make implementation of social and environmental improvements attractive for business, their benefits should be quantified and expressed in business language, i.e. language of money. Better sustainability education for the corporate leaders, managers and students will lead to a healthier planet where is a win-win-win situation for companies, environment and society (Willard, 2004).

Today some Master of business Administration (MBA) programs already offer core courses that include business ethic and address sustainability and corporate responsibility issues (Bhattacharya, 2012). Nevertheless, the creation of effective and easy tools for learning sustainability is a need of a modern society.

3.3 Board games: learning in a game

Different games are widely used with education purpose since they make it possible to simulate real conditions and explore new ideas or strategies in a safe, interactive environment. The key principle of motivating and engaging people in the games is the intrinsic connection between fun and learning. Moreover, the meaningful learning in games is a determinant of motivation - when players do not get anything new to learn, discover, develop or improve they will not feel challenged (Fabricatore and López, 2012, p. 213). The possibility to explore new scenarios, to test alternative strategies and to reflect over results motivate player to continue the game and improve its performance. Learning games are designed for use by consultants, in house company trainers and academics.

Nowadays games are splitted into 2 classes – board games and computer games. Board games have a simple model to be played with tokens or pieces that are placed on, removed from or moved across a board. Computers games can imply more sophisticated interface and involve much more participants (Fabricatore and López, 2012).

There is a variety of learning board games in University teaching and management education, where some of the most popular are Beer Game, Supply Chain Game and Lean Game. The Beer
Game is a widely used board game in MBA courses to demonstrate the bullwhip effect along the supply chain. The role-played simulation game lets students experience typical coordination problems of traditional supply chains, in which information sharing and collaboration does not exist. Four players in this game act as manufacturer, distributor, wholesaler and retailer. Tokens and chips are used as cans of beer to be delivered from one player to another. The target of the game is to reduce back-orders and inventory and thus to minimize the total cost of the supply chain (Riemer, 2012).

The Supply Chain Game is developed from the Beer Game. Through the Supply Chain Game participants follow the flow of products through several stages from raw material to end customer. The players see waste in the form of stocks, poor information, demand amplification, etc. Supply chain in the game represents discoordinated system where problems are the result of not holistic view over the chain (Revere, 2009).

The Lean Game is an effective method to get knowledge and motivation for lean strategies in production process. The game involves players in decision making and teach such concepts as JIT, set-up time reduction, flexible equipment, one-piece flow, Kaizen etc. (Revere, 2009).

While participants play this game, they have to make numerous choices and take wise decisions as, for example, where to produce the goods? To choose low production costs and long delivery routes or spend more on production but establish it closer to home? Which distribution chains to choose? Above mentioned games do not include environmental and social issues, therefore, there is an opportunity to create a more integrated versions of such games that will include human and ecological tasks with the purpose to foster sustainability thinking.

From all these games the Lean Game is the most promising for the purpose of this thesis, because of its waste reduction and therefore more possible positive environmental issues which will be observed in later chapters. However, the sustainability game should be as well designed in entertaining way, when players feel motivated to play it even outside formal educational settings (Fabricatore and López, 2012).

3.4 Economy and Sustainability

In this Chapter authors present a short overview of basic economic principles in production process and their relation to environmental issues and society.

3.4.1 Ecological economy

The development of industrial revolution is depended on the free resources of water, fresh air and biological diversity that in their turn are depended on a balanced biosphere, hydrosphere, atmosphere and cryosphere. For a safe and sustainable future it is necessary to understand the limits and what is uncertain and risky. The development of human growth is seen as external to the planet’s growth and that perspective of human development needs a change. The welfare of human life is measured in GNP which is based on money transactions. In the industry where the human and natural capitals have a zero value, the actual cost of human growth is not captured. The economy grows at the expense of both natural and social capital where the natural capital is not balanced and equally shared. Every nation and financial sector acts by their own when the common ecological space is not a part of the collective responsibility of the actors on the market (Klum and Rockström, 2012). An example of a company that takes its environmental impact
seriously is Patagonia. Since 1991 the company has started to clean up their supply chain when
the founder Yvon Chouinard under his climbing trip realized the threat industry is against nature.
He states that the problem is that the customer prioritizes quality and price before environment
and thereby it is hard to argue for the business to make a more conscious decision about their
supply chain. Taking nature into account demands hard work and a lot of time. Companies can
consider this as additional problems to the business and to make it more complicated than it is
(Chouinard, 2006). In the book *Let my people go surfing* he states “to pay more now for organic
rather than pay the hidden environmental cost down the road...” (Chouinard, 2006, p. 217).
Chouinard claims that for companies to value the hidden cost of environment a special
measurement system would make a difference because the customer has the power and by
informing the customer under the purchase he or she can make a better decision. The customer
should easily see the benefits from choosing organic cotton garment against an industrial cotton
garment (Miller, 2013).

In ecological economy the social and natural capital have larger value, which is based on safety
and quality of human development. The industry does not need to put solely an economic value
on natural resources to capture the actual cost of human prosperity, but rather make the profit of
the sustainable methods in a long-term perspective visible (Klum and Rockström, 2012).

To start the process of change, Rockström and Klum suggest five alternatives such as: to set
economic value of carbon, ecosystem services and water; to double the farming production
without using more water and land; to stop the deforestation; to halve the CO-emission to 2050
year, compared to 2005, by shifting to the carbon-efficient energy system and to reduce the
demand of energy through the carbon-efficient transportation (Klum and Rockström, 2012).

### 3.4.2 Lean production philosophy

*Lean production* or *lean manufacturing* or just simply, *Lean*, is a production concept that is
associated with production at Toyota Motors Company - Toyota Production System (TPS).

This is the next notable efficient step in production process after the mass production system
invented by Henry Ford in the beginning of 20th century (Liker, 2004).

The basic principle in TPS is eliminating wastes. At Toyota seven major wastes were defined to
work on them in order to improve manufacturing process. These wastes are: *Overproduction,
Waiting, Unnecessary transport or conveyance, Over-processing or incorrect processing, Excess
inventory, Unnecessary movement, Defects* (Liker, 2004). Liker himself adds the eight wastes -
*Unused employee creativity*. Moreover, today the *Environmental waste* is regarded as the ninth
waste (Vinodh et al. 2011). According to Toyota’s philosophy, there is no limitation in the
improvements of manufacturing. The process of continuous improvements is called *Kaizen*
(Convis and Liker, 2012).

This production philosophy, spread all over the world in the business practice, has been adapting
lean tools and principles beyond manufacturing - to logistics, distribution, services, retail,
healthcare, and even government.

### 3.4.3 Sustainability meets economy

The sustainability concept of reduced and more effective resource consumption echoes *Lean
production philosophy* by Toyota Production System (TPS), where the key principle is removing
all forms of wastes from business operations (Liker, 2004). Environmental wastes refer to
unnecessary usage of resources or pollutions to air, water and land that cause harm to the
environment, whereas lean initiatives focus on the elimination of non-value-added activities. Along with cost reduction, elimination of wastes across the supply chain can enhance its environmental performance. Lean initiatives can contribute with better sustainable development.

Wastes and environmental impacts go together with each other. Vinodh et al. (2011) describe the environmental impact that each of Seven Wastes has. For example, overproduction leads to excessive consumption of raw materials and energy resources; excessive hazardous materials resulting in extra emissions and waste disposal. Over-processing brings to additional consumption of parts and raw materials per unit of production, increased waste, energy usage and emissions. Waiting damages potential materials components and causes energy waste from heating, cooling, and other processes during production time. Transportation means energy usage for transport, carbon emissions, extra packaging and damages during movement. Defects imply consumption of raw materials and energy in making defective parts, recycling for defective components, space for rework etc (Vinodh et al., 2011).

Additionally, not only by eliminating wastes with lean philosophy but also by implementation of new sustainable choices and technologies in the business processes, companies can gain better profitability. For example, Zumbiel Packaging company uses sustainable packages based on Treehugger (TM) technology, that facilitates achieving sustainability goals and exploring multiple cost savings through the use of scientifically engineered recycled paperboard and lighter weight virgin paperboard. Whether recycled or virgin lighter weight carrier board assist in reducing the carbon footprint. By maximizing pallet loads and getting more physical goods on a truck the transportation costs can be significantly reduced. Further down the supply chain the truck loaders will handle fewer pallets as more physical empty packages fit on a single pallet (Demetrakakes, 2011). Thus, to gain a better sustainable performance in supply chain, there is a challenge to integrate sustainability principles with lean techniques (Vinodh et al., 2011; Johnson, 2006). This challenge the authors will face in their attempt to create the sustainability board game.

3.5 Fashion supply chain

There are many different stages in fashion supply chain from raw materials to ready-made garment where all the actors add value to the product. Supply chain drives a product from the cotton plant to the hands of the customer. The product goes through a refinement process that can encounter advanced series of activities, operations and distribution. All the players in the supply chain are a part of the product’s value and every player is independent to each other (Hedén and McAndrew, 2006).

Supply chain management leads, handles and develops the processes and activities that happen across the supply chain from producer to customer. Supply chain management models come and go, and former managers main focus was to cut out costs in the chain. Today the main purpose is to create cooperative relationships between the actors in the supply chain. Collaborative handling and planning the material, product and information flows throughout the supply chain bring shorter lead times and less communication errors between the actors, which helps creating long and respectable business relationships (Hedén and McAndrew, 2006).

Here the short description of actors and principles of the traditional fashion supply chain is given. The fashion industry consists of four segments: Manufactures, Wholesalers, Retailers and Customers. Manufacturer often stands for raw materials, fiber, yarn and textile production of the products. Subcontractors deliver materials to manufacturer that produces end products of the
quantity ordered by Wholesaler, or Brand. Wholesaler, or Brand, is responsible for the product development processes - design of collections, advertisement, orders to manufactures, as well as for distribution to Retailers or Customers and Customer service. Fashion products can be sold through a variety of retail channels, for example, physical stores as department stores and specialty stores, online stores or post order companies. The Retailers can have different business concepts but their common purpose is to reach the end customer with their offers (Sen, 2008).

The actors can integrate forward and backward in the supply chain, for example, the Wholesale can integrate into Retail with their own stores and the Retail can integrate backward into the Wholesale by creating their own Brand. Every actor of the chain has their own processes and operations that require time, cost and human assets. The crucial aspect of the production process is lead-time, the time taken for the whole production process from start to end. Here, investments in materials and orders are often made on speculations. Long lead-times can result in uncertainty in getting the products to the market in time and difficulties with liquidity when payments must be done before the products are sold. Short lead-times create flexibility and increase chances of making bigger profit by the competitive advantage of getting products to the market before competitors. To reduce the lead-time means to use it more efficient and not to exclude processes altogether. Often being fast can result in high price for the fast transportation and errors in order’s volume; it needs to be balanced depending on the customer demand (Hedén and McAndrew, 2006).

The fashion supply chain causes greenhouse gases arise from such its activities as manufacturing and transportation. Greenhouse gases, that for example include carbon dioxide, methane, nitrous oxide, bring potential harm to the environment. There is 40-60 percent of the total carbon footprint lies upstream to the operation, whereas for retailers it can reach up to 80 percent. Hence, outsourcing manufacturing processes and moving products on greater distances largely increases the ecological footprint of the supply chain. In the supply chain even product design and its material choice can affect the transportation through the physical characteristics of the product and ease of its recycling and reuse (Christopher, 2011).

3.5.1 Textile Fibers and biodiversity

The environmental impact of the fashion industry is often related to textile production. From the beginning of the 20th century the choice of alternative textiles in fashion industry has increased with such variations as recycled fibers, organic and fair trade fabrics etc. Textile is often the starting point of the change in the fashion production and the key component connecting farmers, manufacturers, designers and customers. Kate Fletcher (2008) argues that the textile choice is often the key of social and environmental responsibility. It is the textiles that are most evident for the customer - the cloth, fabrics and textile products. The fiber production is an essential part of the fashion supply chain resource consumption, energy use, pollution and impacts on the society and environment. For more conscious choices textiles should be linked to the fibers life-cycle (Fletcher, 2008).

According to Kate Fletcher sustainability of fiber production is linked to the ecological system and biodiversity. In the fashion industry polyester and cotton fibers dominate and stand for 80 percent of the produced fibers. The limited possibilities of cotton fiber cultivation increase the concentrated impact of the manufactures, the ecological risks, business and sector less resilient to changing conditions in the environment and market. Thus, the main message is not to replace all cotton but to spread out production with hemp, lyocell, flax, organic- and low chemical cotton.
Thereby, the supply chain reduces not only the pesticides and water use but also spreads the risk, maximizing long-term environmental-, ecological- and social effectiveness and stability (Fletcher, 2008).

Fletcher states that the fiber productions highest impacts on environment and society are: large use of water and pesticides when growing cotton, cellulose and synthetic fibers high emission to air and water, natural fibers negative impact on water and high energy use and the non-renewable resources in production of synthetic fibers (Fletcher, 2008). Ann Thorpe agrees that the fashion industry is disturbing nature’s ecological system by spreading materials. The pace that the industry uses up resources is faster than the nature can recreate. The range of waste the industry creates is larger than the environment can dispose of and it affects the natural cycle. The industry’s extract from one sphere and release into another one hurts the living beings of that sphere (Thorpe, 2007). The diversity of minority fiber reduces resource consumption and promotes varied and local agricultures, more local jobs and higher use of regional fibers (Fletcher, 2008).

3.5.2 Textile manufacturing and chemical pollutions

Here we present the overview of the fiber and fabric production stages and their environmental impacts. The finishing process of fabric is the most resource consuming process in the fabric production (Fletcher, 2008).

The textile manufacturing consists of such production processes as: ginning, spinning, sizing, dyeing, bleaching, knitting or weaving, embroidery, cutting and sewing etc. After every process the product can be consumed or exported as an input to the next process (Khan and Ghani, 2004).

Other altering finishing processes can be used to change the properties or aesthetics of the textile, but the common steps that most textiles go through are described below.

The cotton fiber needs to be ginned for preparing and cleaning it for the yarn process. The yarn can be knitted or weaved into a fabric for future cloth or textile product. For the yarn to be made into fabric it needs to go through sizing, where the small cones are de-seized on cylinders. The yarn here is wound up on beams and stretched before being threaded with hot starch and then steamed. After that they are unwound on to a large beam that could be inserted in a loom. The latest decades the weaving and knitting machines have become more automated which leads to decrease in staff. On the other hand the staff’s skills become more important when managing the machines, thereby also the cost for the personal is increased. The simplest of produced textiles called greige fabric (Khan and Ghani, 2004). It can be printed, dyed or embroidered and sent to the garment manufacturing or to customer. The finishing process converts the greige fabric into merchandise. Different types of finishing process can be applied: chemical-, mechanical- or thermal finishing, printing or dyeing. The chemical finishing process alters textile’s properties by flame resistance, softening compounds, resins, gums, anti-microbial or water repellents. The mechanical process alters the structure of the yarn by flattening, compacting and embossing. In thermal treatment, heat is used to alter the fabric properties with shrink, increased bulk or resins (Hatch, 1993).

To change the appearance of the fabric the printing and dyeing processes are often applied. In the dyeing process colorant penetrates into the fiber whereas in the printing process it stays on the surface of the fiber. The dyeing process can happen in different stages and in various ways. Before dyeing the fabric is treated with a chemical compound that lets the dye to penetrate the
fibers. This process is called *desizing*. Natural fibers consist of different impurities that need to be removed before the dyeing process. Scouring, carbonizing and degumming are processes that remove plant’s parts, waxes, gums, oil and soil. A manufactured fiber as nylon, polyester and acetate only needs to remove machine oils. The impurities are removed in a wet process with a chemical compound. Carbonizing and degumming is often used on materials as wool and silk, this are also wet processes that remove impurities. Moreover, *decatizing* is a process for silk and rayon fibers when heating and cooling rolls or water force the material soften or reduce shine. The natural fibers usually go through a bleaching process - a wet process with a chemical compound that breaks down the fiber’s natural color and makes it white before the dyeing process (Hatch, 1993).

In the dyeing process the most commonly used colorants are synthetic but natural dyes are also available. The natural dyes are extracted from plants, insects, minerals and fruits. The problem with natural dyes is in their low fastness and irregularity of the color. The synthetic dyes are chemical compounds, called dyestuffs that are divided into dyeing classes. For the synthetic fibers dyes as basic, disperse and acid are used (acid is also used on wool). Different dyes are used depending on the desired outcome (Hatch, 1993).

In order to the dyes to react with the fibers chemicals as salt and alkali are applied (Colorzen, 2013). From 2 to 80g dyes are needed for every textile kilo, depending on the depth of color requested. After the dyeing process extensive water consumption is happening for washing. Dyes are the major case to metal pollution because of the high use of heavy metals like copper, zinc and chromium. In countries with poor living conditions and few environmental protection mechanisms, the dyeing and washing processes can be serious threat to human and the environment they live in (Fletcher, 2008).

In conventional dyeing baths are filled and drained about six times with different water sources as local public water and groundwater. Then this water ends up in streams, rivers and lakes and pollutes water and soil in the local area which leads to decrease of biological diversity in aquatic life (Colorzen, 2013). After the washing the fabric is dried under the 150 degrees Celsius in five minutes and then rolled up and sent to the next stage (Hatch, 1993). The dyeing process is highly water, energy and chemically consuming where darker shades result in higher environmental impact (Fletcher, 2008). To reduce the environmental and social impacts of the dyeing, washing and drying processes, certain changes can be made. Along with introduction of automatic dosing systems that make the dyeing more efficient and exact and reduce the waste of dyes and dyestuff, the following alternatives are recommended:

*A lower temperature and a longer time of the dyeing process.* By lowering the temperature of the dyeing process of 10 degrees the energy use decreases by 10 per cent. Same alternative can be applied in both washing and drying processes (Fletcher, 2008).

*Reuse dyeing chemicals and water.* When processing big batches of fabrics the colorant from the last bath can be reused again in the first one. Thereby, both the chemical and water use is decreased. The same approach can be used in the washing, when the water from the last bath, that is the cleanest, can be reused in the first bath (Fletcher, 2008).

*Pad Batch dyeing.* For improving the whole dyeing processes, pad-batch dyeing can be used. Pad batch means that the fabric goes into a bath of dyes, then it rolls up on cylinders and wraps into plastic film where stores in 12 hours. After that the fabric is washed and dried. The process can
be used both on synthetic and cellulose fibers. This method saves energy, water and chemical use compared to the conventional dyeing processes (Fletcher, 2008).

During the all above described processes the employees are highly subjected to various chemical hazards and threats. It is very important to find more sustainable and less dangerous for people processes that can be alternative in fashion supply chain.

3.5.3 Garment manufacturing and human rights

The garment manufacturing stage of fashion supply chain implies the biggest human capital, asset and cost. It is the final process that the finished fabric goes through and it is mainly a manual process. Therefore, here the sustainability issues are connected to working environment and ethic attitude.

The fashion industry is highly price and cost competitive whereas the labor wages are low. The modern machinery is easy to move wherever on the globe to find the cheapest labor costs. There people often work in sweatshops conditions when the worker’s labor rights are neglected. The abuse of labor power has had high visibility the latest years when business advantages and reduced costs were gained at the expense of the unethical living and working conditions for the employees (Glock and Knuz, 2005). The main social challenge for the industry stated by Kate Fletcher (2008) is to protect and respect employees’ rights, pay living wages and provide secure working environment. To create well-being working conditions the supply chain management can chose to implement such policies as Corporate Social Responsibility (CSR) and Code of Conduct. The European Commission defines CSR as “actions by companies over and above their legal obligations towards society and the environment. Certain regulatory measures create an environment more conducive to enterprises voluntarily meeting their social responsibility” (Europian Commission, 2011, p. 2)

The Code of Conduct is a document of rules and procedures for suppliers that addressing human and labor rights to provide more safe and fair conditions for the workers. It forbids forced labor, child labor, discrimination, exceeding working hours, health and safety, for example, adequate lighting and ventilation, machine safeguarding etc. (United Nations, 2011). Today these policies are voluntary for the companies and following them can be the first step to more prosperous and healthy society. Additionally, the local production is a way to improve the living standards for the community and people.

3.5.4 Local production and its advantages

Today the fashion industry is broadly dispersed and the local production is significantly decreased. The small scale producers such as weavers, small dyeing houses, spinning specialists and tailors are disappearing. However, the global fashion market is pressured by the development of internet and other technologies to cut cost, decrease lead-times and provide a fast response to consumers’ demand. This requires the companies to cut down the transportation distance and to produce closer to the European market. This results in higher labor costs but is compensated by avoiding of stock build-ups and other delivery and inventory problems in the supply chain (Fletcher, 2008).

The global scale of apparel production contributes with the high carbon emission. It is calculated that a cotton t-shirt travels one circle around the planet and has its environmental cost 16 times higher than its production cost. Transportation as environmental cost, as it is argued by Rockström and Klum, is seen as external to the product and business (Klum and Rockström,
China and India as predicted will very soon be responsible for more than a half of the global textile production, whereas in the nature most of the ecological systems operate locally, using and disposing resources within the boundaries of the location (Fletcher, 2008).

Thereby, localism is seen as the antidote to unsustainability. As stated in the book by Kate Fletcher, the most ecologically friendly innovations are the ones linked with development of products sustaining a community. A locally produced product is contributing to more efficient, equal and safe society where people can enjoy the results of their work within the community. Fletcher argues that the best product creates jobs, welfare and prospers the farming, local esthetics, culture as well as is visible economically in the product production process costs (Fletcher, 2008). By moving production closer to the market the service becomes timelier and more cost efficient (Khan and Ghani, 2004).

Local production is not easy and is more complex than the mass “one size fits all” production. It includes networking with small scale producers of different materials, yarn and fabric manufacturers and local dyeing/printing houses. They must manage the diversity, traditions and closeness to customer. Technology has not only contributed to the pressure on the fashion market but also to the development of “niche” markets. It has helped to build the local producers’ network and to find their niche customer. With technologies like CAD, whole garment knitting machines garment production can be moved again back to the local market to satisfy own customers’ unique needs and at the same time to diverse resource consumption and prosper the local community (Fletcher, 2008).
4. Game development

In this chapter the primary study made by the researchers is presented. For the purpose of the thesis to start, the Lean Game workshop was conducted to understand and analyze the principals of the game as the basis for the new game of sustainable fashion supply chain. The analysis is based on the pre-test, post-test questionnaires and observations by the researchers. The new game will be tested iteratively during its development according to the game design theory to correct the game development process and avoid mistakes.

4.1 The Lean Game Workshop

In this workshop the questionnaire revealed that the time of the game was acceptable and the human interactions during the game such as discussions after every round were the most important part of the game. Participants answered that they learned most from the changes they made in each round and results that has caused. Students also stressed the importance of visual aesthetics of the game and its parts (see Annex 2).

The Lean Game post-test questionnaire also contained some questions about students’ expectations from the game about sustainability and Higg Index. Most of students knew about the Higg Index. However, they were interested to learn more about the all three pillars of sustainability - economy, environment and society. They would most like to know how far back in a supply chain the Higg Index can be used and about an identification of environmental sustainability hot spots and improvement opportunities in a supply chain (see Annex 2).

4.2 Integrating the Higg Index into the game

To follow the purpose of the future game and to meet the students’ expectations researchers had to carefully analyze which aspects and rules of the Lean Game should be taken to the new game and which of them should be changed, developed or transformed. The task was also to integrate the Higg Index 1.0 into the game as an important tool of sustainability assessment of the fashion supply chain.

As was described earlier, the Higg Index consists of three modules each related to specific part and activity of fashion supply chain. The index is planned to be used already by product development teams. These teams can enter various scenarios at the early stages of the design process to evaluate trade-offs of different material choices and other product development decisions (Sustainable Apparel Coalition, 2012). In Brand, Product, and Facilities modules the index requires to answer the questions about brand-level, product-level, and facility-level practices (see Chapter 4.1.2 and Table 3). Therefore, it is important to integrate the special tasks into the corresponding game units, which will require critical sustainable thinking and decision making regarding those issues.

When analyzing the production processes and risks described in the chapter “Fashion supply chain”, researchers can highlight the hot spots of the supply chain where it is important to estimate environmental and social threats of the processes and, if possible, to choose another production and logistics alternatives to reduce the negative impacts of the chain.
Additionally, special sustainability scoring will be a part of the new game where students will be able to see the sustainability performance of their choices. Hence, when choosing fibers in product development stage there is a choice to choose another fiber than the most common used cotton and polyester to support the biodiversity. Accordingly, when producing a fabric there are some variety of dyeing processes that cause less ecological impact as well as washing and drying processes with lower temperature and therefore with less energy consumption.

### 4.3 Layout of the Higg Index Game

The Lean board game structure consists of 6 stations in following order: *Manufacture/Press, Assembly line, Heat Treatment, Quality control, Distributor* and *Customer*. In the new game we will transform them into the stations: *Brand/Raw material, Textile manufacture, Garment manufacturer, Sustainability and Quality control, Distributor/Retailer* and *Customer* to fit the game layout to the traditional structure of the fashion supply chain (Hedén & McAndrew, 2006). With adding the new sustainability operations in the new game authors assign special functions to the person who plays the role of Quality control in the Lean Game. Therefore, the mapping of the stations in both games is shown in the Table 4:

<table>
<thead>
<tr>
<th>Lean game</th>
<th>Manufacture/Press</th>
<th>Assembly line</th>
<th>Heat Treatment</th>
<th>Quality control</th>
<th>Distributor</th>
<th>Customer</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higg Index game</td>
<td>Brand/Raw material</td>
<td>Garment manufacture</td>
<td>Textile manufacture</td>
<td>Sustainability and Quality control</td>
<td>Distributor/Retailer</td>
<td>Customer</td>
</tr>
</tbody>
</table>

Table 4. Facilities transformation from the Lean Board Game to the Higg Index Board Game

The supply chain starts in the Brand & Raw Material and then continues on to the end at the Customer’s table. The layout of the Higg Index Game follows the structure of Lean game, which is the same as in an conventional supply chain, as seen in Figure 3.
In Brand/Raw material station students will set up the supply chain to meet the demand forecast. Brand produces collections with a certain interval of time. There are two possible fiber for the fabric in the beginning of the game - cotton and polyester, but in later rounds more choices will be available (see Table 5).

<table>
<thead>
<tr>
<th>Material</th>
<th>Chemicals</th>
<th>Energy</th>
<th>Water</th>
<th>Waste</th>
<th>Total score</th>
<th>Cost</th>
<th>SPT per product</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cotton</td>
<td>3.4</td>
<td>6.3</td>
<td>3.4</td>
<td>3.7</td>
<td>26.8</td>
<td>3.0 $</td>
<td>-</td>
</tr>
<tr>
<td>Polyester</td>
<td>3.2</td>
<td>4.3</td>
<td>5.2</td>
<td>10.4</td>
<td>23.3</td>
<td>3.0 $</td>
<td>-</td>
</tr>
<tr>
<td>Silk</td>
<td>6.7</td>
<td>1.7</td>
<td>6.9</td>
<td>15.4</td>
<td>30.7</td>
<td>7.0 $</td>
<td>+ 5</td>
</tr>
<tr>
<td>Linen</td>
<td>2.8</td>
<td>3.5</td>
<td>4.0</td>
<td>13.4</td>
<td>23.7</td>
<td>4.0 $</td>
<td>+ 2</td>
</tr>
<tr>
<td>Organic Cotton</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>&gt;26,8*</td>
<td>3.7 $</td>
<td>+ 3</td>
</tr>
<tr>
<td>Lyocell</td>
<td>4.7</td>
<td>5.0</td>
<td>5.6</td>
<td>10.0</td>
<td>25.3</td>
<td>3.5 $</td>
<td>+ 2.5</td>
</tr>
</tbody>
</table>

Table 5. Raw material choices for the Brand/Raw Material station in the game.

In Textile manufacturing facilities are originally represented with conventional methods of the dyeing, washing and drying. In next rounds each facility will have different capacities, environmental and social impact and lead times, that students should consider in constructing an effective and sustainable fashion supply chain.
To be integrated in the new game the textile manufacturing processes are needed to be simplified because these facilities comprise many different procedures for the production of textile fibers and fabrics. It is difficult to cover in the game the whole variety of finishing textile processes including decatizing, desizing, mechanical processes, thermal treatment and chemical finishing that were shortly described in the chapter 2.2.2. All those processes have a high impact on environment and society: cellulosic fabric production has high water consumption whereas synthetic fabric production causes high emissions to air and water along with the use of the non-renewable resources. Natural fabrics production also brings negative impact on water resources and has high energy consumption (Fletcher, 2008). Thereby, for the game only three facilities for the Textile Manufacture were chosen to symbolize the energy, water and chemical consumption: dyeing bath, washing machine and drying machine. The game starts with conventional washing, dyeing and drying processes that symbolize unsustainable choice. New facilities/machines will be offered to players during the game and the short description of the facility’s features will be printed on the game sheet of the related station (see Figure 4).

Figur 6. An example of the process choice at the Textie Manufacture station – one conventional and another one with a longer time but a lower temperature.

Garment manufacturing is initially outsourced overseas in the game. In garment manufacturing the social issues play a big role, especially regarding overseas production. Here, to act more sustainable, the company can choose to follow the Code of Conduct or to move production home. In the case of outsourced manufacturing, for example, in China or Bangladesh, essential carbon dioxide emissions are direct connected to the global transportation needed. Bigger volumes of transportation batch make supply chain less agile but can facilitate GHG reduction, it is a question of compromising. Finally, in the last part of supply chain physical stores can be substituted with online stores in order to reduce land use and resource consumption. The authors will attempt to implement all these choices into the game structure to engage the players in sustainable thinking and decision making.

During the discussion after each round students will review the economic and sustainable performance of the supply chain. Each player should offer constructive feedback on how the team has managed the supply chain economic and sustainable strategies. For a better choices analysis game leaders may ask additional questions to test students’ understanding of functionality of the supply chain and possible sustainability advantages. Students keep track of their round performance in the Game economy table. Sustainability and quality control manager counts additional score for sustainability performance.
A comprehensive Higg Index Game guide will cover key learning objectives given in the game, such as: understanding and assessing how to reduce and improve the ecological and social impact of a supply chain in its different parts; creating a cost-effective and flexible supply chain using a combination of sustainable choices and facilities; managing production and inventory when demand is uncertain.

Furthermore, when integrating all stations and related activities into the new game layout to make the structure of the new game more understandable and visible, they all are represented in Table 6. The Higg Index Game guide with all the rules and learning objectives is available in Annex 6.

**Higg Index game outlines***

<table>
<thead>
<tr>
<th>Higg Index parameters</th>
<th>Brand/ Raw material</th>
<th>Textile manufacture</th>
<th>Garment manufacture</th>
<th>Distributor/Retailer</th>
<th>Sustainability and quality control</th>
</tr>
</thead>
<tbody>
<tr>
<td>•General</td>
<td>•Environmental management program</td>
<td>•Environmental management program</td>
<td>•Materials</td>
<td>- - -</td>
<td></td>
</tr>
<tr>
<td>•Materials</td>
<td>•Energy use and GHG emissions</td>
<td>•Energy use and GHG emissions</td>
<td>•Packaging</td>
<td></td>
<td></td>
</tr>
<tr>
<td>•Packaging</td>
<td>•Water use</td>
<td>•Water use</td>
<td>•Manufacturing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>•Manufacturing</td>
<td>•Wastewater</td>
<td>•Wastewater</td>
<td>•Transportation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>•Transportation</td>
<td>•Emissions to air</td>
<td>•Emissions to air</td>
<td>•Product care &amp; repair service</td>
<td></td>
<td></td>
</tr>
<tr>
<td>•Product care &amp; repair service</td>
<td>•Waste management</td>
<td>•Waste management</td>
<td>•End of life</td>
<td></td>
<td></td>
</tr>
<tr>
<td>•End of life</td>
<td>•Pollution prevention</td>
<td>•Pollution prevention</td>
<td>- - -</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Activity in the game</th>
<th>Product design, material choice</th>
<th>Fabric dyeing process</th>
<th>Sewing process</th>
<th>Warehousing and delivering of ready garments</th>
<th>Scoring of sustainability performance of the chain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional material, organic material</td>
<td>Conventional wet dyeing, or dry dyeing</td>
<td>Local or overseas manufacturing</td>
<td>Physical or online store</td>
<td>External organisation or internal CSR management</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Choices in the game</th>
<th>Scale of sustainability performance, economic efficiency scale (costs)</th>
<th>Scale of sustainability performance, economic efficiency scale (costs)</th>
<th>Scale of sustainability performance, economic efficiency scale (costs)</th>
<th>Scale of sustainability performance, economic efficiency scale (costs)</th>
<th>Nominal scoring not related to Higg Index scoring systems</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>* In the game the Customer’s impact of the Higg Index is neglected since the purpose of the game is to teach players how to critically evaluate and implement sustainable choices only in the textile supply chain process.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 6. Higg Index Game outlines
The main part of the game inventory is Lego platforms and bits that symbolize products in their different stages. The game starts from the moment when the first station, in the new game Brand/Raw Material initiates the process by producing first batch of products. In the Higg Index Game the products are garments. To follow the layout of the Lean Game authors suggest to keep its model of having platforms of three basic colors which will symbolize 3 different type of clothing - T-shirts (green platforms), dresses (yellow platforms) and pants (blue platforms). During the game the platform, that symbolizes the design for the future garment will be built on with additional breaks of different colors that will mean raw material choice and different processing operations like, for example, assembling operations on the Garment Manufacture station (see Annex 6).

4.4 Scoring system of the Higg Index Game

During the game development the researchers were challenged to find a special approach to the scoring of sustainability performance of the supply chain. The sustainability scoring system should both more or less realistically reflect the outcomes of the new sustainable choices made in the game and motivate the players to strive for higher scores.

It was decided to implement an independent sustainability scoring that would be operated by the Sustainability and Quality Control Manager with a help of the game leaders if needed. Likewise the Higg Index scoring method authors have chosen to implement special score for material choice and separate score for facility choice. Thereby, all the choices available in the game are covered by similar scoring method of Higg Index.

In the Brand/Raw Material station to choose new, more sustainable material can mean a higher price for that. Therefore, authors tried to correlate the price difference between the materials in the game with a real price difference on the market for those materials. Some big textiles websites, like fiber2fashion.com and alibaba.com as well as Chinese and Indian textile manufactures’ websites were analyzed to find average prices for materials mentioned in the game (see Table 5). Researchers admit that this correlation may be very rough but still can help to distinguish and estimates the choices made by players.

Accordingly, for facility choices’ scoring the certain amount points for each sustainable alternative method were suggested. For example, to choose local production means not only to save cost but also to get additional points for sustainability. Likewise, to choose lower temperature dyeing process will imply getting sustainability points etc. All game variants of the sustainability scores and their relation to the three pillars of sustainability are represented in the Table 6 in the Higg Index Game Guidebook (see Annex 6).
The Sustainability and Quality Control Manager calculates all sustainable points for material choices and facilities choices under one round. Then the total amount of these points is converted with a special rate into the game money (see Table 7). These money will cause some cost reduction for each round and placed in a special column of the game economy table, see Annex 6 for description of the economical table.

In its general economy scoring the new game follows the model of the Lean Game where costs per station and person are already established in the right proportions for the game functionality.

### 4.5 Learning effect of the Higg Index game

The pre- and post-test from the workshop implied a formal questionnaire where the participants knowledge were tested against the subjects treated in the game. The highest individual score in the pre- and post-test questionnaire was designed as 29 points. In the pre-test the average score from the six participants was 19.8, which is 68.3 % of the right answers, whereas in the post-test...
the average score has become 21.8, which is 75.2% of the right answers. Therefore the growth in
the response rate is 10.1%.
Hence, in general the participants’ scores increased after playing the game whilst one was
unchanged, with the lowest score of 18 before and after the game. Thus, the pre- and post-test
results showed that the students had increased their knowledge in environmental, economic and
social aspects of the fashion supply chain after playing the game but their understanding of the
Higg Index decreased (see Table 8). However, the participants performed more right answers on
the last question of questionnaire (see Annex 5) about relations between the certain concepts
since after the game most of the participants knew that the Product, Facility and Material
Modules were parts of the Higg Index. Though, in the pre-test all participants had answered right
on what the Higg Index is - a tool, whereas after the game two persons had changed their answers
into “Higg Index is an organisation”.

Table 8. Pre- and Post-test results of the learning effect through the Higg Index Game

During the Higg Index Game workshop the researchers observed that obtaining the sustainability
points in the game was though dominated by getting economic revenues. The participants from
the first rounds were focused on reducing time, whereas the sustainable points were not in the
main focus. After the third round the participants focused on the cost reduction after realizing that
they had overproduced products.

The sustainable points were seldom discussed, mainly only when the benefits when the special
sustainable product orders were introduced. They should be made of ecologically friendly
materials, which could be chosen from the raw material choices in the game (see Table 8). Here
the participants decided to use the material with low cost but with relatively high sustainable
points.
According to the observations after playing the game the participants discussed that the introduction information in the beginning was of high importance to be able to understand and grasp the game rules and concepts. Most of the participants argued that functions of the game stations and options should be more clarified. One participant expressed that it should include real life examples where this system or changes have been used:

“Better introduction about Higgs and maybe state out examples where people/companies have used it”.

Another participant said that the effects of the changes should be explained before the game, but the researchers are convinced that this is a part of the learning process - to solve the problems within the boundaries of the game and analyze the results. The researchers observed that the participants did not in a sufficient extent prioritise the sustainability points, but focused more on the lean game aspects such as, lead times and costs. The participants’ own opinion about what they had learned was widely spread. For example, one of participants thought that he or she had not learnt anything about sustainability. Another one stated that the local production that was an alternative for changes (moving tables together) is beneficial both for social issues and communication and therefore should be more promoted in the introduction because it was more efficient in the long run. The third person answered that slow fashion is more sustainable than fast fashion. Whilst one had learnt a combination of lean philosophy and sustainability and stated it like this:

“A more focused based idea concerning demand/supply. Do not over produce that results in more transportation, energy usage and waste in fabric and waste from end customer. Produce better, less but better. “

Half of the participants had noticed that the communication in the supply chain was bad and highlighted this as a problem with suggestion:

“Create a system that helps the communication between the players”.

The Textile Manufacture station had the most alternative choices for possible changes since, as it was pointed out before, textile manufacturing causes the largest environmental impact. However, it was noticed that during the game the players’ focus was kept mainly on time and bottleneck problem, whereas choosing the best machines from sustainable point of view was almost neglected. However, in the answers to the questionnaire students’ theoretical knowledge regarding sustainability improved according to the post-test results.

The researchers observed that the outcome of the game is depended on the participants choices in the discussions and thereby some changes was never tested. Depending on what changes they make they can learn more or less from different areas for example they choose to prioritise the lead times and then they learn the outcome of this decision. The choices are limited to two changes per round and the changes the participants chose to make depends on the persones before knowledge and how much they share their knowledge with each other. Thereby changes as: the last two machines in the Textile Manufacturing station and web-based shop or physical store in the distribution station was never tested.
5. Analysis and Discussion

The problem of human and natural capital having a “zero value” is stressed to be considered in the economy. Both Rockström (2012), Fletcher (2008) and Chouinard (2006) state that the full cost of the products the supply chain produces is not taken up in the economy. Without a sustainable supply chain the business will not survive in a long run (Rockström and Klum, 2012). Thereby, in this project the sustainability of the supply chain was presented as a positive effect in the economical table of the Higg Index Game. Yvon Chouinard argues that saving the natural resources is often seen as making it harder than it is. Therefore, those who play the Higg Index Game should understand that the decisions they make can have both positive and negative consequences on sustainability and the economy of the supply chain. For this game the researchers developed a special sustainability scoring system that results in the cost reduction in the end of each round of the game depending on what structural, raw material or facilities choices were made.

The researchers’ idea was to motivate students to sustainable choices by cost reduction in the economy scoring since the final aim of the game however is to obtain both a sustainable and profitable supply chain. During the workshop with the Higg Index Game researchers observed that obtaining the sustainability points was though dominated by getting economic revenues. The focus was still, as in the Lean Game, on reducing cost, which showed that it is not easy to get the players interested in the possible profit of being sustainable. As Rockström (2012) argues, it is important to make the profit of using sustainable methods in the long-term perspective visible. From the analysis of the observations the researchers could see that students’ decisions in the game were mostly based on short-term thinking and without special regard to sustainability.

The post-test questionnaire revealed that students were perhaps confused by the introduction of the game concerning Higg Index nature, since in this question the amount of right answers decreased - some of the students decided that the Higg Index is rather an organization than a tool. However, the test also showed that their general knowledge about the fashion supply chain and sustainability issues was increased by 10.1%.

During the game development there was some difficulty of assigning the sustainability points for the Brand and Facility Modules. The scoring system of the Higg Index needed to be simplified for the game, because these Higg Index’ modules consist of a wide range of qualitative questions of different facets of production process as it was described in the chapter 2.5.2. This made it difficult to evaluate the weight of different sustainability areas of the modules and how it should be scored in the game. On the other hand The Product Module of the Higg Index was integrated in the game almost in the same form of material sustainability index, where the more sustainable materials have higher sustainability points. The Product Module actually consist of more parts, for example packing and transportation etc. Those aspects were integrated in the game by sustainability scoring for changes concerning those areas, for example negative sustainability scoring for smaller size of transportation. The sustainability scoring system in the game may need to be more taken in focus and developed further, because of its importance for the purpose of the game. The sustainability scores should influenced the students in taking more careful decision and help them to turn the focus from decreasing costs in the supply chain to cashing revenues or other profits from sustainable choices implemented there.
Hence, the Higg Index aspects of the supply chain were integrated into the scoring table of the game and the participants had some information for every alternative change i.e. how it would affect environment and society. Students’ knowledge concerning these areas is increased. They understood that the decisions they make influence the sustainability over the supply chain.

Authors would like to highlight that the environmental impacts of the supply chain were easier to interpret for the sustainability scoring system of the game due to available information of the Higg Index, whereas the interpretations of the social impacts were more abstract. In the fall 2013 the Sustainable Apparel Coalition is planning to release a new version of the Higg Index where a measurement scale for social and labor issues will be developed (Sustainable Apparel Coalition, 2013). The main social issues considered and integrated with sustainability scoring in the game are related to outsourced or local garment manufacturer where the social capital is most important and chemical hazards in the textile manufacturing processes that employees are subjected to (Glock and Knuz, 2005). Thereby in the sustainability scoring of the game extra points were given for local production as well as for more sustainable dyeing methods with less risk for humans. In practice the local production results in higher labor cost, or changing equipment for more sustainable machines results in additional fixed assets costs and that is not reflected in the game. Any cost of removing person or even changing machine costs in reality but is not included. Here the researchers followed the principles of the Lean Game but would like to stress that players should be aware about these game simplifications and take their decisions more carefully keeping those issues in the mind.

The developed game was supposed to simulate the functional process of the fashion supply chain, possible choices for taking decisions and motivate to forecast and analyze the consequences of such decisions. This is the learning through a game - to make choices and solve the problems within the boundaries of the game rules. The participants should be engaged in learning new information, discovering new possibilities and developing or improving the result. The players would not feel challenged if the game does not involve these components (Fabricatore and López, 2012). Thus, learning something new about the fashion supply chain was positively reflected in the post-test where the participants had more right answers.

One more finding of the researchers is that the introduction plays an essential role for the understanding of subjects and concepts involved into the game. The authors believe that the more detailed and complete theoretical introduction part could significantly influence the results of the game and answers in questionnaire. For example, it could be helpful and beneficial for the participants to give more comprehensive description of sustainable facilities’ choices, chemical hazards for people from textile manufacturing, more deep information about the Higg Index and its purpose etc. In that case, to do not overwhelm the players with a big volume of new information it could be reasonable to split it into parts and present just related part of information before each round of the game.

Thus, the game was tested for simulating of the fashion supply chain function with its limitations and consequences of different choices, involved students into discussions and showed the positive learning effect with a deeper understanding of involved subjects. As stated by Elizabeth et al. (2012) the students who participate in academic discussion demonstrate more effective group problem solving and reasoning for their choices. Decisions about changes made in the group discussions are more informed and careful. Accordingly, in this game players in the group can practice their knowledge in relation to simulated reality. What the participant learns from the discussions is somewhat influenced by the game leader.
The game leader has to lead the players in a direction where they are motivated to consider all parts of the game and not only be focused on one subject. For example, solely decreasing the time will not by itself improve the economic outcome of the round, whereas only a balanced summation of lead-times, sustainability and cost options in the game will enhance the result. The discussion between the rounds is of high importance and the level of participants’ activity in making choices will affect the outcome of the learning process. Thereby if the game leader highlights the benefits of sustainable choices the participants could consider it more consciously in the discussions and deepen their knowledge about Higg Index and sustainability.

Sustainability still needs to be learnt and understood in a greater extent by professionals and society in general. It is not easy for people to grasp the meaning of what it is because of the complexity of this subject. It needs to be educated in a easier and more engaging way where the participants is involved beyond academic readings. The Higg Index Game offers simplified visualizing of the fashion supply chain activities and therefore the participants can get a holistic view of the processes and sustainability hot spots in the supply chain. Fullerton (2008) states that a game should include a combination of challenge, competition and interaction where players can have fun, but also opportunity to learn something more. Easier and thought-provoking way to learn sustainability in a game might reach a larger population become a starting point of teaching sustainability in systematic perspective.
6. Assessment of the research

6.1 Relevance

To make education process for learning sustainability more effective special tools are required. This study contributed to teaching about sustainability in the form of the Board Game for the fashion supply chain. The researchers explored its potential as a teaching module of high education for textile and fashion students and think that the game can be also useful for all other interested in a better sustainability performance in the fashion supply chain.

Existing and widely used in different educational programs Lean Game, which served as the basis for our Game, is rather focused on a better economic performance without consideration of social and environmental issues. The Sustainability Game is designed to form new mindsets for taking the better managerial decisions in the complex dynamic of the fashion supply chain with respect to environmental and human resources, the assets that have "zero value" in the current industry model.

6.2 Validity and reliability

In this chapter the researchers will analyze internal and external validity of the study and its reliability. Internal validity refers to the question if the independent variable affects the dependent variable. In this study this is the question if it can be trusted that playing the game really causes new knowledge for players.

Experimental design usually implies a high internal validity (Bryman, 2012). When randomly assigning people to two groups and having enough participants in the study to achieve the desired probabilistic equivalence, researchers may consider the experiment to be strong in internal validity and have a possibility to assess whether the treatment causes the desired outcomes. In case of quasi-experimental design the random assignment to group is absent. This threatens the study’s internal validity (Bryman, 2012). That is why interpreting the pre- and post-tests needs special attention when analyzing differences in the pre-test and the post-test results caused by the treatment, i.e. the game.

Particularly, pre-testing of the experimental group can threaten the internal validity. After the pre-test the participants may become more aware of the aims of the experiment and therefore more experienced at taking the post-test. In case of no control group, that could experience the same effect, it can discount the internal validity (Bryman, 2012).

Reliability, external validity and generalization are particularly linked with the quantitative research field. They represent if the study is repeatable and if the measurement is consistent. The consistency of a measurement can be tested by a test-retest-method, that helps to see if the result of the test is correlated (Olsson and Sörense, 2011). In this study the researchers were limited by the time and the quantity of participants to test the measurement with another group, according to this method. Nevertheless, the questionnaires were tested on a small group of students to see if they understand the questions of the pre- and post-tests right to exclude bias caused by misinterpretations of the questions. Particularly in the quality of generalization and replication of a qualitative study is hard to meet. When interpreting the measurement system for a qualitative research, the inter-observer consistency, when more than one observer is involved, can be discussed for this report.
When there is more than one observer that agrees on the outcome of the research, the reliability of the study is increased. On the other hand, when there is more than one observer inconsistency can occur when the observer does not agree or has interpreted the analysis differently (Bryman, 2012). In this report the two researchers were involved in the analysis process of what themes should be used when analyzing the observations to come to conclusions together. They also read and discussed each other’s observations to get an understanding of each other’s view of the experiments.
7. Conclusions

From the analysis and discussion represented in the previous chapter, the authors came to the following conclusions and answers to the research questions.

How can a board game help players to understand how sustainability in a fashion supply chain can be increased?

As the result of the project analysis the researchers conclude that the Higg Index Game helps to visualize the flow and the hot spots of the supply chain where large ecological impacts happen. The layout of the board game represents the simplified structure of the fashion supply chain that makes it easier to understand and overview the most important processes involved in the apparel production. The given under the game choices for rounds changes help players to analyze and understand possible processes alternatives with less environmental impact and social risks. The presentation of the raw material choice in the first station of the game, Brand/Raw Material, stresses the importance of the material’s role for the sustainability of the whole supply chain. Players are forced to think ahead about advantages and disadvantages of using certain fiber for their collections in relation to what environmental and social benefits or threats it might cause and if the sustainable choices could be profitable.

Some determined facilities choices given in the game, where along with economic costs the sustainability cost is integrated - sometimes contrary - motivate the players to take thoughtful and balanced decisions. For example, choosing the less batch size for transportation could benefit the supply chain with a better agility and therefore economy, but was penalized with negative sustainability scoring and, thus, some economic loss.

In terms of the social impact the sustainability scoring was also implemented in the game. For example, taking away one person from the supply chain meant saving costs but gave the negative sustainability points instead; or the facility option with a better human or social impact could be slower with the process but gave additional social sustainability points and therefore some cost reduction in the end. Accordingly, the players were engaged to discuss and analyze the balance between economic and social advantage of the change. The game discussion was an important part of the learning process, thereby the game leader play a significant role for guiding the players through discussions. The game leader’s task in the game is to highlight the meaning of sustainable choices and control how much the participants learn about all subjects.

How can a board game explain the function of the Higg Index?

Regarding this question the researchers can conclude that the Higg Index Game is able to be a potential teaching tool in educational programs for academics, managers and consults in fashion industry since the game helps to visualize the flow and hot spots of the fashion supply chain and reveal problems in interactions between its members. The lean philosophy that directly connected to waste elimination and therefore to a better sustainability performance is the basis for the Higg Index Game. Certain Higgs index metrics of its different modules were integrated into the products and facilities options in the game that correlates with the purpose and function of the Higg Index, but some improvements regarding this aspect are still needed.
The authors believe that after some further development the game could be used as a teaching module for learning sustainability and the function of Higg Index in the fashion supply chain in a simplified and understandable way.

This study contributed to the academic and business world with a game that could increase the knowledge of Higg Index and sustainability in the supply chain. Sustainability is a complicated subject and many people still don’t know what is it and how to deal with it. The Higg Index Game could be a starting point of an sustainability learning engaging process that involves more stakeholders – students, professionals, managers etc. The combination of learning games with the sustainability high school or training programmes could popularize the subject of sustainable development and facilitate the altering of random or too complicated programmes to systematic sustainability education approach.

In the study the researcher faced the complexity of integrating the "zero" values into the supply chain in an understandable and comprehensive way. There is not one solution to the problem of sustainability within the industry and the variety of the presented alternatives was hard to integrate into this version of the game. Thereby, the game is presented only as a prototype and needs further development. The further game development should follow the idea of a holistic view on the supply chain and catching the values of the natural and social capital without seeing it as a pressing obligation or costly activity but instead as an asset and investment to future business and global welfare.
8. Future research

During the analysis of the project’s results authors came with some suggestions for the future research of the subject. They would like to improve the current version of the game with an Excel scoring tool and as a further development to make the game completely web-based.

Furthermore, under their observations and while the project analysis the researchers noticed that economic focus is still dominating in the game strategies and to engage the players more into sustainable thinking and decision making authors would like to develop and test another sustainability scoring system without the connection to the economic table of the game. For example, to not try to convert the sustainability points into the cost reduction but instead to set some sustainability points limit, where the round cannot be considered as successful if the players do not obtain some minimum amount of the sustainability points.

With the introduction of the newer version of the index - Higg Index 2.0, social aspects of sustainability could be integrated in the game in a more proper way. Having a Higg Index tool for sustainability’s assessment regarding this issue could help to elaborate more correct scoring system of the Higg Index Game to estimate the choices. That could motivate the players for discussions and sustainable choices even more.

The Sustainability manager function could be extended with labeling, Code of Conduct and CSR work for social sustainability points. Embracing of these activities could be initiated by the Customer with ordering products that should be produced under the Code of Conduct, if the supply chain does not have this activity chosen in previous rounds this order cannot be fulfilled and part of revenues will be lost.

As it was mentioned in the beginning, the customer’s environmental impact is out of this research but to integrate the customer into the game is more relevant to ideas of use&service and products lifecycle, that are in the Brand and Product modules of the Higg Index. The customer now is somewhat effecting the supply chain in the developed Higg Index Game, for example, she is placing the special orders which require organic or more sustainable materials unlike the ones initially given in the game. The customer’s impact on the fashion supply chain can be further developed, where the customer has a higher impact on the supply chain’s sustainable behaviour.

To perform a better observation’s results the researchers would like to test the game on larger groups of participants or companies but in this project they were limited to the small group of the students because of the bounded time of the thesis work.
References


**Websites:**


Miller, H, 2013. *Patagonia founder takes aim: “The elefant in the room is growth”*. [online] GreenBiz Group Inc. Available at:


Annex 1. Lean Board Game Workshop

<table>
<thead>
<tr>
<th>Seven stations (tables)</th>
<th>Eight activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Press</td>
<td>• Production planner</td>
</tr>
<tr>
<td>• Assembly</td>
<td>• Press</td>
</tr>
<tr>
<td>• Heat treatment</td>
<td>• Assembler</td>
</tr>
<tr>
<td>• Quality control</td>
<td>• Heat treatment</td>
</tr>
<tr>
<td>• Distributor</td>
<td>• Quality controller</td>
</tr>
<tr>
<td>• (Customer)</td>
<td>• Material handler</td>
</tr>
<tr>
<td></td>
<td>• Store manager</td>
</tr>
<tr>
<td></td>
<td>• (Customer)</td>
</tr>
</tbody>
</table>

The Lean board game has six stations: Press, Assembly, Heat treatment, Distributor and Customer. At these stations there are eight activities: Production planner, Press, Assembler, Heat treater, Quality controller, Material handler, Store manager and Customer. The game is played in six rounds each of 12 minutes. After every round the participants analyze the result of the round and make changes for the next round. The changes are made to improve the result, i.e. the profit of the production process.

The product flow in the game is symbolized by Lego platforms and bricks. The platforms and bricks are of different colors and can have different combinations with each other.

The Customer starts the game by placing an order to the Distributor and continuously places new orders every 15 second. The Distributor in the beginning of the round has an inventory of three products of every color, in total 9 products.

The Product Planner starts the production process and has a schedule for different kind of products (platforms of different colors) that will be produced. The Planner sends the products to the Press. The time between batches is 30 seconds.

When the Press is done with six products they are send with the Material Handler to the next station - the Assembly line. All containers that are sent with the Material Handler must be filled in with six products, not less or more. The Assembly line adds more bricks to the platforms and sends them with the Material Handler to the Heat Treatment station. This station has an initial inventory of three products of the most common color - green. The Heat Treatment has an oven where there is a time frame of heating of max 8 products in 60 seconds.

When six products are done they are sent to the Quality control station. There they are being checked for the defects and sent later with the Material Handler to the Distributor. Finally, Distributor gives earlier ordered products to the Customer.

Totally, in the timeframe of 12 minutes the Customer places 48 orders. In last three rounds special orders can be added that have a time limit of delivery 3 minutes and give an extra profit if delivered in time.
When the round was finished, the products that have not been delivered to the Customer but were in progress, counted as “work in progress products” (WIP). The economic result of the game is calculated as below:

\[
\text{Profit} = \text{Revenue} - \text{Costs}
\]

\[
\text{Costs} = \text{started products} \times 25 \text{ kr} + \text{boards} \times 50 \text{ kr} + \text{persons} \times 20 \text{ kr} + \text{initial WIP (including finished goods)} (3\text{ kr per product})
\]

\[
\text{Revenue} = \text{special order} \times 25 \text{ kr} + \text{delivered in time} \times 12 \text{ kr} + \text{delivered late} \times 4 \text{ kr} + 25 \text{ kr for removed operator}
\]

\[
\text{Started products} = \text{customer’s orders} + \text{WIP (including finished goods)} + \text{cassation} - \text{not delivered} - \text{initial WIP (including finished goods)}
\]

The Customer does not cost the supply chain anything and is thereby not counted as a cost for the person or table in the calculations.

**First round**

*Delivered products to customer:*
- 13 were in time
- 28 were late
- 7 were not delivered

*Observation by participants:* the participants marked that it was a lot of waiting and the Customer noticed that a lot of products were delivered late.

*Observation by researchers:* for players it was hard to know how much to produce and there were a lot of stress and bad communication between participants. All the players were turned away from each other and did not cooperate with each other. The participants did not discuss much about the changes but just chose some changes from the list of possible changes.

*Changes made for round two:*
- Smaller transportation size - 4 products per container
- The oven machine was changed to a new one with longer time but with two sections (8 products /60 second to 4+4 products /80 second)

**Round two**

*Delivered products to customer:*
- 20 were in time
- 27 were late
- 1 was not delivered

*Observations by participants:* there was much more to do in the Heat Treatment station that lead to longer lead times. The participants acknowledged that they had over produced - there were much more WIP products when the time was out.

*Observation by researchers:* the participants discussed more about the changes, but not everyone was involved in the decision making. Players discussed taking away the Quality control, but decided to wait with it until next round. They chose to cut production time to 15 sec and take a more efficient oven.
Changes made for round three:
New oven with four sections with the same lead-time as the one before (2+2+2+2 products/ 80 seconds)
Production time with 15 sec between the batches instead of 30 sec

Round three
Delivered products to customer:
- 42 were in time
- 4 were late
- 2 were not delivered

Observations by participants: over produced products, more than the customer requested. Assembly line and Press stated that they were out of stock of bricks and it was more to do in assembly and in oven activities. They noticed also that it was less waiting time in the process. Less products were delivered late and the Customer said she was more satisfied.

Observation by researchers: most of the participants were involved in the discussion concerning the changes and shared more information about their activities and the problems in their stations. There was more team play in the group. They chose to dramatically cut the costs after this round.

Changes made for round four:
To move the Assembly line over to the Heat Treatment table and thereby to have less cost (a table costs 50 kr)
To remove the Quality control activity to save the cost for the person

Round four
Delivered products to customer:
- 43 were in time
- 3 were late
- 2 were not delivered
- No special products were delivered in time

Observations by participants: it was a better flow in the production process. But still there was over production (WIP).
Observation by researchers: the participants were still turned away from each other but they had better overview in the Press, Assembly line and Treat treatment stations. They were talking more with each other and the communication enhanced. Two participators were disagreeing about the tables for round five and had a good discussion about where to make a change with the tables (stations).

Changes made for round five:
Smaller batches – 1 product per batch
Pull-push system
To push two tables together
To remove the production planner
Round five
Delivered products to customer:
- 31 were in time
- 13 was late
- 0 was not delivered
- 4 special products were delivered in time

Observations by participants: the defects increased and the communication between the stations was messy.

Observation by researchers: the kanban system was adopted. Players chose to use kanban sheets in two places. One kanban sheet was placed at the Distributor station and the other one between the Press and Assembly line. They had a hard time keeping track of the stocks at the Distributor. In the discussion after the round all participants were involved in choosing changes for round six. They decided that the best was to arrange the tables.

Changes made for round six:
To use two tables
To leave three people (except the Customer)
To use pull-push system (on demand)
To remove kanban
To remove Distributor station
To remove the Material Handler (transportation)

Round six (last round)
Delivered products to customer:
- 35 were in time
- 5 were delivered late
- 0 was not delivered
- 8 special products were delivered in time

Observations by participants: the communication was better and the overview of the customer’s demand was clearer when they could see the inventory and the orders from the Customer.

Observation by researchers: it was more quiet and less stress in the production flow. Players were talking to each other and were more involved in each other’s activities. They had more flexibility and could prioritize the special products due to a better communication.
The economy sheet of the Lean Game looked like this:

<table>
<thead>
<tr>
<th>Round</th>
<th>Started products</th>
<th>Customer’s orders</th>
<th>Delivered on time</th>
<th>Delivered late</th>
<th>Not delivered</th>
<th>Defects</th>
<th>WIP + finished goods</th>
<th>Initial WIP + finished goods</th>
<th>Persons</th>
<th>Tables</th>
<th>Spec. order in time</th>
<th>Costs</th>
<th>Revenue</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>46</td>
<td>48</td>
<td>13</td>
<td>28</td>
<td>7</td>
<td>0</td>
<td>17</td>
<td>12</td>
<td>7</td>
<td>5</td>
<td>-</td>
<td>564</td>
<td>240</td>
<td>-324</td>
</tr>
<tr>
<td>2</td>
<td>54</td>
<td>48</td>
<td>20</td>
<td>27</td>
<td>1</td>
<td>3</td>
<td>15</td>
<td>12</td>
<td>7</td>
<td>5</td>
<td>-</td>
<td>588</td>
<td>348</td>
<td>-240</td>
</tr>
<tr>
<td>3</td>
<td>70</td>
<td>48</td>
<td>42</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>31</td>
<td>12</td>
<td>7</td>
<td>5</td>
<td>-</td>
<td>638</td>
<td>520</td>
<td>-116</td>
</tr>
<tr>
<td>4</td>
<td>70</td>
<td>48</td>
<td>43</td>
<td>3</td>
<td>2</td>
<td>0</td>
<td>34</td>
<td>12</td>
<td>6</td>
<td>3</td>
<td>-</td>
<td>516</td>
<td>578</td>
<td>62</td>
</tr>
<tr>
<td>5</td>
<td>58</td>
<td>48</td>
<td>31</td>
<td>13</td>
<td>0</td>
<td>3</td>
<td>19</td>
<td>12</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>460</td>
<td>561</td>
<td>101</td>
</tr>
<tr>
<td>6</td>
<td>46</td>
<td>48</td>
<td>35</td>
<td>5</td>
<td>0</td>
<td>3</td>
<td>7</td>
<td>12</td>
<td>3</td>
<td>2</td>
<td>8</td>
<td>334</td>
<td>740</td>
<td>406</td>
</tr>
</tbody>
</table>
Annex 2. Lean Game Questionnaires

**Pre-test Lean Game**
Have you ever played learning games before in your studying program?

- Yes (1)
- No (5)

If yes, what the game was it?

Was it useful for you and your studies?

- Yes (1)
- No

Do you think if playing learning games is a good way of studying process?

- Yes (5)
- No

**Post-test Lean Game**
Do you think your understanding of the supply chain has increased?

- Very much
- Yes
- A little
- No

How do you like the time frame of the game?

- Good
- Okay
- To long
- Much to long

What were the most important aspects for you in this game?

- Human interaction in the game
- Visual aesthetics of the board and pieces
- Reading and understanding the rules
Other:

Which part of the game did you learn the most from?

Which part of the game did you like the most?

Which of three pillars of sustainability in a supply chain would you like to learn more about?

- Economy
- Society
- Environment

Do you know what the Higg Index is?

- Yes
- No

What would you like to learn about Higg Index?

a) The purpose of Higg Index
b) The outputs of Higg Index
c) The limitations of Higg Index
d) How far back in a supply chain the Higg Index can be used
e) How the data from the Higg Index can be used
f) Identification of environmental sustainability hot spots and improvement opportunities in a supply chain

Other:
Annex 3. Higg Index Game Workshop

The workshop started with a pre-test questionnaire about players’ knowledge of the subjects that were involved in the game. The questionnaire comprised four subjects regarding the three pillars of sustainability and Higg Index, divided in the questionnaire as sections: Higg Index, Environment, Society and Economy. After the participants had filled in the questionnaire, the game introduction started. Some theoretical framework about sustainability, Higg Index and lean philosophy were presented as well as the structure and rules of the game. Then the participants had chosen which station they wanted to operate at and read out loud the instructions for that station so each member of the game could hear what others would do at their stations. To clarify how the stations operate the workshop stated with a trial round. This round lasted few minutes until everyone had got what to do. After the trial round the participants started the first round of the game.

Round 1
The first round was played as normal Lean Game, no sustainability points were involved in the result of the first round, thereby the sustainability manager only functioned as Quality control. After the first round the new choices (group A) were presented: new dyeing, washing and drying machines with a better sustainability performance, smaller transportation batches and decreased time for designing collections at the Brand/Raw Material station. The game leader explained the sustainability points system for the choices and introduced the Sustainability Manager the sustainability scoring sheet.

Discussion by participants: they discussed the choices and the players from the Textile Manufacture station argued for changing their machines. They discussed the transportation batch size but mainly saw the Textile Manufacture as the “bottleneck”. The sustainability points table were discussed and that the changes for the textile manufacturing were beneficial, but however the focus was on that they could not get the products through the station quickly enough.

Observations by researcher: the participants were quiet and the product flow was moving slow. In the Brand/Raw Material station the production was fast but the Drying process at Textile Manufacture was slow. The players were quiet and had full focus on their stations. Most of the products were stuck in the Drying and the Brand was producing very fast. In this round the Brand operators were confused about the 30 seconds lead time between the collections. There was a misunderstanding about the lead-time. The Brand/Raw Material station produced one collection (color) under the lead-time of 30 seconds when it should one collection be produced and then should be a waiting time of 30 seconds. That is probably was one of the reasons why they failed with the result.

First round result:

<table>
<thead>
<tr>
<th>Started products</th>
<th>Delivered in time</th>
<th>Delivered late</th>
<th>Not delivered</th>
<th>WIP products</th>
</tr>
</thead>
<tbody>
<tr>
<td>80</td>
<td>10</td>
<td>18</td>
<td>18</td>
<td>62</td>
</tr>
</tbody>
</table>
**Changes for next round**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>New Washing machine 2 sections (40 sec), lower temperature</td>
<td></td>
</tr>
<tr>
<td>New Dyeing bath 2 sections (70 sec), lower temperature</td>
<td></td>
</tr>
</tbody>
</table>

**Round 2**

In the second round the players already knew what to do thereby they operated faster and had more products coming on time. Additionally, the changes they had done had a big effect on the round performance. After this round they did not change anything further at the Textile Manufacture. The participants considered that otherwise it would be too much timers to keep track of. Therefore the workshop did not reveal how the other two choices affect the game. The first sustainability points were calculated in the economical table of the round.

*Discussion by participants:* the participants perceived that the late deliveries is the biggest problem and discussed how to decrease the product development lead time at the Brand station. Thereby they decided to make two changes that decreased the lead time at the Brand/Raw Material station. Even if they were notified that the option would decrease the sustainability points and therefore, perhaps, the economy, the Textile manufacture station insisted for the change.

*Observations by researchers:* the participants saw the problem in the planning lead time whilst were sure that changing the machines at the Textile Manufacturing did not help. In the group one person was more active than the others. The Brand/Raw Material station did not argue for making some other changes even if one person from this station noticed that it was an unnecessary change.

**Second round result:**

<table>
<thead>
<tr>
<th>Started products</th>
<th>Delivered in time</th>
<th>Delivered late</th>
<th>Not delivered</th>
<th>WIP products</th>
</tr>
</thead>
<tbody>
<tr>
<td>68</td>
<td>24</td>
<td>20</td>
<td>4</td>
<td>72</td>
</tr>
</tbody>
</table>

**Changes for next round**

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Decreased transportation batches from 6 to 4 product/batch</td>
<td></td>
</tr>
<tr>
<td>Reduced product development lead-time from 30 to 15 seconds at the Brand/Raw Material station</td>
<td></td>
</tr>
</tbody>
</table>

**Round 3**

The players over produced the products because of the changes after the round two and the costs rose from 630$ to 828$. New choices (group B) were introduced: players could now move or remove tables or persons in the supply chain. The special product order was added to the game. For next round they could choose the more sustainable raw material for the special products and gain sustainability points. The more sustainable materials cost extra but they gave sustainability points. The group had chosen organic cotton and lyocell which had the lowest cost.
Discussion by participants: after this round the group discussed that the costs where their biggest problem now whereas the game leader tried to engage them to think beyond decreasing a time. In this round the players had a longer discussion than in previous round and most of the participants were included in the discussion. The Brand/Raw Material station’s person was more active after noticing that she was right about the previous change. The group argued about which station that could be removed or moved to another table. They also discussed the materials for the special products and deciding to go for lower cost and low sustainability points.

Observations by researcher: the participants thought they would have increased their revenue but after seeing the result they had to think why it did not give a better result but rather vice versa. The game leader explained that the reason is that the group had chosen to decrease the time in the previous round and now produced even more than the Customer ordered. They were asked to think beyond the time reduction and figure out what was the problem. They the players focused on the costs that had increased. The sustainability aspect was in focus in the discussion. The players wanted to merge the Sustainability Manager function with the Distributor. The group agreed that they would benefit from it even if the game leader warned that removing a person resulting in negative sustainability points.

Third round result:

<table>
<thead>
<tr>
<th>Started products</th>
<th>Delivered in time</th>
<th>Delivered late</th>
<th>Not delivered</th>
<th>WIP products</th>
</tr>
</thead>
<tbody>
<tr>
<td>134</td>
<td>24</td>
<td>18</td>
<td>4</td>
<td>102</td>
</tr>
</tbody>
</table>

Changes for next round

- Removed 1 person - Sustainability manager
- Removed 1 table - Sustainability Manager station

Round 4
In this round the special products were involved. The team produced 2 special products and none of them were delivered in time. The production volume in the supply chain had decreased whilst the players were now delivering more products in time. They did not make any profit yet and the discussions after the round were mainly concerning the costs. For the fifth round they could choose make supply chain’s flow changes such as Canban and push-pull system.

Canban: the players could place out two Canban’s sheets. They chose to place one sheet between the Brand/ Raw Material station and Textile Manufacturing and the second one between Garment Manufacturing and Distributor.

Discussion by participants: the players agreed that they want to remove one table. They discussed the Canban and was unsure how it works. Some of the participants argued for producing on demand, but the group concluded that it would be hard because it would always be late.
Observations by researcher: the material choice the participants made was unexpected. The researcher thought the participants would prioritize the sustainability points and not the cost for the materials: here they choose first to focus on decreasing cost and then gain revenue from the sustainability points. Even if the game leader explained that moving Garment Manufacturing closer to another station would give extra sustainability points, the group have chosen to move Textile Manufacturing station to Brand/Raw Material station.

Fourth round result:

<table>
<thead>
<tr>
<th>Started products</th>
<th>Delivered in time</th>
<th>Delivered late</th>
<th>Not delivered</th>
<th>WIP products</th>
</tr>
</thead>
<tbody>
<tr>
<td>101</td>
<td>28</td>
<td>7</td>
<td>0</td>
<td>65</td>
</tr>
</tbody>
</table>

Changes for next round

- Canban: decreased transportation batches from 4 to 2 products per batch
- Move one table - Textile Manufacturing to Brand/Raw Material

Round 5
In this round the participants communicated with each other, discussed the inventory and tried to match it so they would not not over produce as they did before. Mainly the Garment Manufacture and Distributor communicated backwards in the discussion about what was needed. For round six the team could do any changes left in choices but the limitation was to keep 3 people and 2 tables (the Customer is not encountered).

Discussion by participants: after the Canban implementation one of the participants was frustrated because she argued that they could as well produce when the Customer orders instead of visible "forecasting". But her argument got critic from the other players that they would not deliver in time if they produce when the Customer orders.

Observations by researchers: the game leader now explained that they should try to create the perfect supply chain for meeting the Customer needs without any unnecessary waste. The team discussed for a while the options and pushed some tables together. They kept four people and used 2 tables. The Distributor and the Customer were sitting together but they chose not to remove the Distributor even if the game leaders said they could.

Fifth round result:

<table>
<thead>
<tr>
<th>Started products</th>
<th>Delivered in time</th>
<th>Delivered late</th>
<th>Not delivered</th>
<th>WIP products</th>
</tr>
</thead>
<tbody>
<tr>
<td>65</td>
<td>27</td>
<td>13</td>
<td>3</td>
<td>32</td>
</tr>
</tbody>
</table>
Changes for next round

- Moved three tables together
- Removed one in textile manufacturing

**Round 6**

In the last round the team played with production on demand. The Distributor and Sustainability Manager talked upwards in the supply chain what was ordered and what was out of stock. The Textile Manufacturer operator talked to the Brand/Raw material station what she needed next. The Garment Manufacturer was mostly quite under the round. After this round the team reached a positive economic result after what the participants answered the questionnaires.

*Discussion by participants:* after the last round they discussed the game and some of them thought it had too little about sustainability whilst the Sustainability Manager thought she had learned a lot about the supply chain and sustainability. The participants argued that the supply chain seemed more like a business to business relationship between the Customer and the supply chain and the end customer doesn’t put an order in that way.

Four of the participants stayed in the class and discussed the game further. They noticed that the game introduction theory should be fore informative and include more information about the supply chain and Higg Index. That could benefit the players that did not have any knowledge about the supply chain. They also debated the Brand/Raw Material station that they thought was not clear why it was merged with the raw material because these activities do not operate in the same place in reality.

*Observations by researchers:* After the workshop the team discussed for a while and pointed out problems that they noticed in the game. For example the game’s link to reality. They thought it was not clear that the Brand/Raw material represented the “wholesaler” in the supply chain and questioned why the Raw Material was integrated into this station. This revealed that the message about significant role of the raw material choice for the sustainability performance of the fashion supply chain was not got in a proper way.

The problems, noticed by the researchers in the Lean game were also same in the new game: the participants had a low insight in each other’s stations and thereby did not learn every operation in the fashion supply chain but only the process that was related to their station. It is important when the participants discuss and share the information about their station with each other between the rounds. This is where they see the effect of their choices and learn from each other by sharing and discussing their view of the change.

There was also confusion about the Customer. Two of the participants argued that the game was only relevant for business to business, because the Customer acted more like a business.

They as well discussed that the link between the economy and sustainability was unclear and the effects of the changes both in economy and sustainability were confusing. One player suggested that the introduction should be complemented with more detailed information about the hHigg index and how it is integrated in the game, also about the link between sustainability and economy in the game. The participants also thought that for people that have insufficient knowledge about the fashion supply chain it may be not easy to understand the game and that is way a more comprehensive introduction to the game is needed.
Sixth round result:

<table>
<thead>
<tr>
<th>Started products</th>
<th>Delivered in time</th>
<th>Delivered late</th>
<th>Not delivered</th>
<th>WIP products</th>
</tr>
</thead>
<tbody>
<tr>
<td>56</td>
<td>35</td>
<td>2</td>
<td>1</td>
<td>22</td>
</tr>
</tbody>
</table>

Higgs Index Game workshop economy table

<table>
<thead>
<tr>
<th>Rounds</th>
<th>Start Products</th>
<th>Customer’s Order</th>
<th>Delivered in Time</th>
<th>Delivered Late</th>
<th>Not Delivered</th>
<th>WIP Products</th>
<th>Initial WIP Products</th>
<th>Employees</th>
<th>Tables</th>
<th>Spec ial orde r on Time</th>
<th>Cos t</th>
<th>Sustai n. Cost reduction</th>
<th>Rev enue</th>
<th>Profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>80</td>
<td>48</td>
<td>10</td>
<td>18</td>
<td>18</td>
<td>62</td>
<td>12</td>
<td>7</td>
<td>5</td>
<td>-</td>
<td>6</td>
<td>66</td>
<td>-</td>
<td>19.2</td>
</tr>
<tr>
<td>2</td>
<td>68</td>
<td>48</td>
<td>24</td>
<td>20</td>
<td>16</td>
<td>72</td>
<td>12</td>
<td>7</td>
<td>5</td>
<td>-</td>
<td>6</td>
<td>30</td>
<td>32.5</td>
<td>36.8</td>
</tr>
<tr>
<td>3</td>
<td>134</td>
<td>48</td>
<td>22</td>
<td>18</td>
<td>4</td>
<td>0</td>
<td>10</td>
<td>2</td>
<td>12</td>
<td>7</td>
<td>5</td>
<td>8</td>
<td>17.5</td>
<td>33.6</td>
</tr>
<tr>
<td>4</td>
<td>101</td>
<td>48</td>
<td>28</td>
<td>7</td>
<td>-</td>
<td>1</td>
<td>65</td>
<td>12</td>
<td>6</td>
<td>4</td>
<td>-</td>
<td>6</td>
<td>38.9</td>
<td>38.9</td>
</tr>
<tr>
<td>5</td>
<td>68</td>
<td>48</td>
<td>26</td>
<td>13</td>
<td>-</td>
<td>1</td>
<td>32</td>
<td>12</td>
<td>5</td>
<td>3</td>
<td>1</td>
<td>4</td>
<td>39.5</td>
<td>43.5</td>
</tr>
<tr>
<td>6</td>
<td>58</td>
<td>48</td>
<td>34</td>
<td>2</td>
<td>-</td>
<td>0</td>
<td>22</td>
<td>12</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>89.2</td>
<td>59.1</td>
</tr>
</tbody>
</table>
Annex 4. Pre-test Higg Index Game

All participants are anonymous in the game testing and questionnaire. The questions below can have multiple right answers.

**Higgs index**

**What is the Higg Index?**

- A self-assessment software for designing apparel and footwear products
- A sustainable textile process for apparel and footwear products in the supply chain
- An environmental organization that measures the environmental and social impacts in the supply chain.

**How can the Higg Index help the actors in the supply chain to decrease their environmental impact?**

- By creating a common language between the actors in the supply chain
- Reducing redundancy in measuring sustainability
- Understanding and quantifying sustainability impacts
- By measuring the non-value adding time in the supply chain

**What is the purpose of Higg Index?**

- To become an assisting tool for decreasing the supply chain’s environmental impact
- To reducing risks and uncover efficiency
- To be an universal tool for designing apparel and footwear products
- To promote environmental products to customer

**Environmental**

**What is material diversity?**

- When you use several different minority materials for your products
- When you use one type of material for all your products
- When you use different production processes for different materials
- When you use one production process for different materials

**What is the outcome of applying material diversity in apparel production?**

- It decreases local jobs and has a negative impact on the natural ecosystems of the local agriculture.
- It reduces resource consumption and promotes varied and local agricultures, more local jobs and higher use of regional fibers
- It reduces the production costs
How can carbon emission to air be decreased in the supply chain?
- By scheduled transportation
- By packing large batches per trip
- By packing smaller batches per trip
- Cut transportation (local production)

How can you reduce your energy use in textile manufacturing?
- To choose alternative processes of washing, dyeing and drying with longer processing time and lower temperature
- To choose alternative processes of washing, dyeing and drying with shorter processing time and higher temperature
- To operate more processes at the same time
- To use less employees at the same time

How can you reduce your water and chemical consumption in textile manufacturing?
- Reuse chemicals and water in coloring and washing processes
- To stop the process for 80 seconds
- Automatic dosing of chemicals
- To process less products per bath

What is the first step to a more sustainable supply chain?
- Raw material choice
- More efficient cutting processes
- Use only one type of fiber
- Use more sustainable textile manufacturing processes

Social
How are the prosperity of human life and business linked together?
- Business world provides service and products that fulfill our needs
- It provides workplace for people
- It provides social inclusion in the community
- The business is not linked to prosperity of human life

Which of the statements below are correct?
- Human capital is a key asset and cost over the whole supply chain
- Human capital is a key asset and cost primarily in the product development process
- Human capital is a key asset and cost primarily in the textile manufacturing process
- Fixed assets are main asset and cost over the whole supply chain

Does local production contribute to a better society?
- Yes
- No
What does local production mean?
- Building business and products based on the needs and culture in the local community
- Working far away from the home market
- Working close to the home market
- Having the head office of the Brand close to the home market

Economy
What is the purpose of lean production?
- Elimination of waste and non-value adding activities in production process
- Reduction of employees in production process
- To add more time to the processes for a lower price

How does environmental development affect the revenue and cost?
- It increases cost and makes it harder to produce products of good quality
- It can decrease cost in a long-term perspective
- It requires longer time for all processes
- It requires shorter time for all processes

Link the following blocks with the correct concept: A), B) or C):

<table>
<thead>
<tr>
<th>Economy</th>
<th>A) Higg Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Society</td>
<td>B) The three pillars of sustainability</td>
</tr>
<tr>
<td>Environment</td>
<td>C) Lean philosophy</td>
</tr>
<tr>
<td>Facility modul</td>
<td></td>
</tr>
<tr>
<td>Product modul</td>
<td></td>
</tr>
<tr>
<td>Reduce waste &amp; non-value adding activities</td>
<td></td>
</tr>
</tbody>
</table>
Annex 5. Post-test Higg Index Game

All participants are anonymous in the game testing and questionnaire. The questions below can have multiple right answers.

**Higgs index**

**What is the Higg Index?**
- A self-assessment software for designing apparel and footwear products
- A sustainable textile process for apparel and footwear products in the supply chain
- An environmental organization that measures the environmental and social impacts in the supply chain.

**How can the help the actors in the supply chain to decrease their environmental impact?**
- By creating a common language between the actors in the supply chain
- Reducing redundancy in measuring sustainability
- Understanding and quantifying sustainability impacts
- By measuring the non-value adding time in the supply chain

**What is the purpose of Higg Index?**
- To become an assisting tool for decreasing the supply chain’s environmental impact
- To reducing risks and uncover efficiency
- To be an universal tool for designing apparel and footwear products
- To promote environmental products to customer

**Environmental**

**What is material diversity?**
- When you use several different minority materials for your products
- When you use one type of material for all your products
- When you use different production processes for different materials
- When you use one production process for different materials

**What is the outcome of applying material diversity in apparel production?**
- It decreases local jobs and has a negative impact on the natural ecosystems of the local agriculture.
- It reduces resource consumption and promotes varied and local agricultures, more local jobs and higher use of regional fibers
- It reduces the production costs
How can carbon emission to air be decreased in the supply chain?
- By scheduled transportation
- By packing large batches per trip
- By packing smaller batches per trip
- Cut transportation (local production)

How can you reduce your energy use in textile manufacturing?
- To choose alternative processes of washing, dyeing and drying with longer processing time and lower temperature
- To choose alternative processes of washing, dyeing and drying with shorter processing time and higher temperature
- To operate more processes at the same time
- To use less employees at the same time

How can you reduce your water and chemical consumption in textile manufacturing?
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- Automatic dosing of chemicals
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- Raw material choice
- More efficient cutting processes
- Use only one type of fiber
- Use more sustainable textile manufacturing processes

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Link the following blocks with the correct concept: A), B) or C):

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<td></td>
</tr>
<tr>
<td>Product modul</td>
<td></td>
</tr>
<tr>
<td>Reduce waste &amp; non-value adding activities</td>
<td></td>
</tr>
</tbody>
</table>

What is still not clear for you about Higg Index and its function?

What actions can be taken to improve the sustainability performance of the fashion supply chain?

Your suggestions for further Sustainability Game development?
Annex 6. Higg Index Game Guidebook

Higg Index Learning Board Game
Preface

This version of the game is a prototype and needs further development. However it is applicable to play for understanding the principles of sustainable choices. Authors will be grateful for any feedbacks from players that one can send to e-mails irina.dobrosmyslova@gmail.com and amilia.tangne@gmail.com.
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GAME RULES ............................................................................................................ XXIX
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  TEXTILE MANUFACTURE ....................................................................................... XXXIX
Game Inventory

The inventory for the game functioning should be provided as follows:

**Lego platforms:**
- Green (T-shirts) - 30
- Yellow (Dresses) - 8
- Blue (Pants) – 8

**Lego bricks:**
- Black – 24
- Red – 24
- White – 24
- Blue – 24

**Customer’s order cards:**
- Green – 32
- Yellow – 8
- Blue – 8

**Customer’s cards for special products:**
- Green - 3
- Yellow - 3
- Blue - 3

**Timers** – 8

**Baskets for the product transportation** – 12

**Game sheets with instructions for the station** - 7

**Power Point Introduction with the theoretical framework for the game**
Game Layout

This game visualizes the fashion supply chain process in a simplified way:

There are 6 stations (tables) and 9 activities in the game, therefore the least number of participants is 9.

<table>
<thead>
<tr>
<th>Station</th>
<th>Activity</th>
<th>Number of players</th>
<th>Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brand/Raw Material</td>
<td>Planning collections, choosing raw materials</td>
<td>2</td>
<td>1 Timer, Lego platforms and Lego bricks</td>
</tr>
<tr>
<td>Textile Manufacture</td>
<td>Textile manufacturing: dyeing, washing, drying</td>
<td>2</td>
<td>3 Timers (+ 3 in later rounds)</td>
</tr>
<tr>
<td>Garment Manufacture</td>
<td>Garment assembling</td>
<td>1</td>
<td>Lego bricks</td>
</tr>
<tr>
<td>Sustainability and Quality Control Manager</td>
<td>Quality control, Sustainability points scoring</td>
<td>1</td>
<td>Scoring sheet</td>
</tr>
<tr>
<td>Distributor</td>
<td>Ready product inventory and delivery to the Customer</td>
<td>1</td>
<td>Inventory sheet</td>
</tr>
<tr>
<td>Material Handler</td>
<td>Transportation the garments between the stations</td>
<td>1</td>
<td>Basket</td>
</tr>
<tr>
<td>Customer</td>
<td>Order placing, round time control</td>
<td>1</td>
<td>1 Timer</td>
</tr>
</tbody>
</table>
The instructions for how each station operates are written on the station sheets:

**Brand & Raw Material**

*Product planning and textile fiber choice*

At the Brand and Raw material station two employees handle design and planning of collections and fiber choices.

The Brand plans and designs the collections for every season. The Brand team has a planning sheet that it follows. In the first round you send products according to plan 1: 8 green, 2 blue, 2 yellow. The group can later change to plan 2 or 3, earliest after round 1. You can not change the plan during the round.

Between every collection you have a design lead-time of 30 seconds. Thereby the first employee, Planner, sends six products of one color (type) to the second employee, Raw Material Supplier, and then sets clock for 30 seconds when the next color can be sent to the Raw Material Supplier.

The Raw Material Supplier makes a fiber choice that means adding a brick of related to the fiber color to the product. For the T-shirts polyester* is used and for the pants and dresses cotton** is used. After that he sends the Textile Manufacture with the Material Handler. In the first round of the Game only when six products are done, they can be transported to the next station.

*Polyester = Black brick
**Cotton = White brick

---

**Textile Manufacture**

*Dyeing, Washing & Drying*

At the Textile Manufacture the fabric is treated according to the Customer’s order.

This station consists of two employees, the first one is dyeing and washing the fabric and the second one is drying it and then sends it with the Material Handler to the Garment Manufacturer.

The dyeing and washing processes are operated by the first employee, who first puts the products into the dyeing bath. When the dyeing process has begun the products can not be moved in or out of the bath.

When the dyeing process is ended the products can be washed. When the washing process has begun the products can not be moved in or out of the bath.

The second employee dries the products in the oven. When the drying process has begun the products can not be moved in or out of the oven.

In every round the dyeing process starts with an initial inventory of 3 Green products.
Garment manufacturer
Cut, Make and Trim

The Garment manufacturer is the last station before the quality control. At this facility the garment is assembled.

Here the garment should be assembled and every brick represents each stage of the finishing process.

Red = Cutting
Black = Sewing
Blue = Trimming

Distributor
Keeps track of the stock and sends products to the Customer

The Distributor (or Retailer) keeps track of the incoming and outgoing products and send demanded products to the Customer.

The Game starts with an inventory consisting of 9 products - 3 Green (T-shirts), 3 Yellow (Dresses) and 3 Blue (Pants). The Distributor sends products to the Customer and keeps track of the product that are delivered, late or not delivered. The Distributor hands the products to the Customer direct without the Material Handler.

1 Employee
1 Delivery performance sheet
Customer
Places orders and keeps track of incoming products

The Customer is the starting and the end point of the Game. The Customer keeps track of the time of the round and places orders to the Distributor.

The Customer places an order every 15 second to the Distributor in the timeframe of one round - 12 minutes. The Customer places an order according to a random sequence from a pile of product cards.

You start and stop the game; thereby you need a timer for keeping track of time. When you start the game you yell out 'start' and places the first order after 30 seconds, then after that you place an order every 15 second. When the time has run out you shout ‘stop’.

You also record in the delivery performance sheet how many products are delivered in time, late delivered and not delivered.

Special product
If the game leader tells you to order a special product, then you change from the next color in your product pile to a special product in the same color. Then you tell the distributor that you will pay extra if it is delivered within 3 minutes. Measure the time!

Sustainability Manager
Sustainability and quality control

The Sustainability Manager records the sustainability scoring points for products and facilitates and control the quality of the products.

Here special sustainability points are given according to raw material choice and facility option that can decrease or increase you environmental and social impacts.

The Sustainability manager also checks the quality of the products. The products should be correct assembled, if some parts are missing or broken, the product is being sent back to the brand. When the products have been inspected they are being sent with the Material Handler to the Distributor.
Here the initial disposition of the players in the classroom and the direction of the product flow are shown:

Picture 1. Disposition the players in the classroom
Game Rules

The aim of the game is to gain profitable production process. The profit is calculated in simple way: \textbf{Revenues} \textit{–} \textbf{Costs} \textit{=} \textbf{Profit}. Normally, the first rounds of the game show negative results, i.e. economic loss. In this game the production costs are influenced by sustainability scoring. The choices players make in the next rounds can bring certain improvements for the process and at the same time some positive or negative sustainability points from the change. These points are converted into the money with a special formula, which can cause increased or decreased costs of the production process. Therefore, the players should actively participate in the discussions and carefully consider the changes they make.

The game is played in \textbf{6 rounds} of \textbf{12 minutes} each. After every round the participants have \textbf{10 minutes discussion} about possible changes for next round to improve the result of the round. There are two groups of choices for possible changes in the game – group A (mostly for rounds 1-3) and group B (for rounds 4-6). Making changes is limited by two changes before each next round. For the last sixth round the players can make any number of changes, though they have to keep minimum 2 tables and 3 persons. Here the Customer is not counted as one of those persons.

Every time the round starts with an \textbf{initial inventory of 12 products}. The Textile Manufacturing starts with 3 green products in the dyeing bath and the Distributor starts having the inventory of 3 Yellow, 3 Blue and 3 Green products.

The \textbf{Customer} starts each round and keeps track of the time. When the time of the round is out the Customer shouts “stop”. She always places \textbf{48 orders} during one round. The players should count the products that are left in the supply chain (WIP products) and make calculations in the economy table of the game:
START PRODUCTS
The start products are calculated as below:
**Start Products** = customer’s orders + WIP (work in progress) + cassation – not delivered – initial WIP products

CUSTOMER ORDER’S
The customer orders are always **48**. That’s because the customer puts an order every 15 seconds in the timeframe of 12 minutes.

(720 sec (12 min) / 15 sec = 48 orders)

INITIAL PRODUCTS
Every round starts with an **inventory of 12 products**. The Textile Manufacturing starts with 3 green products and the Distributor starts with 3 Yellow, 3 Blue and 3 Green.

DELIVERED IN TIME/DELIVERED LATE/NOT DELIVERED
These columns are filled in according to the Customer’s **Delivery performance sheet**. The total number of products should be 48. Except for the 4-6 rounds when the special products come in (see rule Special products).

DEFECTS
The defects are filled in by the Sustainable and Quality Control Manager that check the products for the defects.
PLAYERS & TABLES
Here the number of participants and tables is calculated, except for the Customer and her table, because the Customer is not a part of the supply chain production process.

SPECIAL ORDER ON TIME
When a special order is delivered on time, its quantity is added in this column. The total amount of the products should still be 48 (see rule Special products):
\[\text{Delivered in time} + \text{Delivered late} + \text{Not delivered} + \text{Special orders} = 48\]

COST
The cost of the supply chain is calculated as below:
\[
\text{Cost} = \text{start products} \times 3\$ + \text{tables} \times 50\$ + \text{number of employees} \times 20\$ + \text{initial WIP} \times 3\$
\]

SUSTAINABILITY COST REDUCTION
Cost reduction for sustainability with total sustainability points (TSP) comes from special sheet from Sustainability and Quality Manager. These points are calculated in a separate sheet and the total number of the sustainable points is multiplied with 0.5$:
\[
\text{Cost reduction for sustainability} = \text{sustainability point} \times 0.5$
\]

REVENUE
The revenue of the supply chain process is:
\[
\text{Revenue} = \text{special orders} \times 25\$ + \text{products delivered in time} \times 12\$ + \text{products delivered late} \times 4\$ + \text{operator taken away} \times 25$
\]

PROFIT
\[
\text{Profit} = \text{Revenue} - (\text{Costs} - \text{Sustainability costs reduction})
\]
The sustainability scoring comes from the alternative choices for changes:

<table>
<thead>
<tr>
<th>Sustainability scoring</th>
<th>Water</th>
<th>Energy/GHG</th>
<th>Amount (T/P)</th>
<th>Chemicals</th>
<th>Social</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dyeing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyeing bath 2</td>
<td>5</td>
<td>5</td>
<td>20</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dyeing Bath 3</td>
<td>5</td>
<td>10</td>
<td>20</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Washing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bath 2</td>
<td>10</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Dryer</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oven</td>
<td></td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Transportation</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batches (6&gt;4)</td>
<td></td>
<td></td>
<td>-20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Batches (4&gt;2)</td>
<td></td>
<td></td>
<td>-30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Local production</td>
<td></td>
<td></td>
<td>20</td>
<td>30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(moving Garment to Brand)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moving 1 table/person</td>
<td></td>
<td></td>
<td>30</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(E*A)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Removing 1 person</td>
<td></td>
<td></td>
<td></td>
<td>-10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A*S)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total facility scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Material scores</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(total)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total Sustainability</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>points (TSP)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sustainability cost reduction (TSP * 0,5$)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the beginning of the game the players start with conventional materials and processes in the fashion supply chain.

Here the transportation batch between the stations consists of 6 products. It cannot be passed on to the next station if they are more or less than 6. The batch sizes can be changed in later rounds (see the rule: decrease transportation batches). The transportation between the stations is operated by the Material Handler, except the distance between Distributor and Customer or when two or more stations (tables) are moved together.

Special orders as variants of Customer’s order can come from the round four. In the fourth round 2 special orders are placed (instead of normal orders), then 4 in the fifth round and 6 in the last sixth round. These products have a different assembling scheme and special description card for assembling (see the picture below) that follows the product through the supply chain back to the Customer. The delivery time for the special order is 3 minutes and they bring higher revenue when delivered in time. If not, then they are included in the table as the standard products “delivered in time”. Three special orders exist in each color and can have two types of raw
materials symbolized by added red or blue bricks. The Sustainability Manager keeps track of the special points for these materials. Even if the product is not delivered within timeframe of 3 minutes the sustainability points for the material (red and blue) are still counted. The game leader tells when the Customer should order a special product and when this happens the next product order card is replaced with a special product card of the same color.

![Image](image.jpg)

Picture 2. Assembling cards for the Special Order products.

### Station Activities

**Brand/Raw Materials: 2 players**

<table>
<thead>
<tr>
<th>Brand</th>
<th>Raw Materials</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product development process &amp; Planning (schedule)</td>
<td>Sourcing</td>
</tr>
<tr>
<td>Plan new collections, initial lead-time 30 sec</td>
<td>Add textile materials:</td>
</tr>
<tr>
<td>Clothing type – platforms of different colors:</td>
<td>White brick - Cotton</td>
</tr>
<tr>
<td>Green platforms – T-shirts</td>
<td>Black brick - Polyester</td>
</tr>
<tr>
<td>Yellow platforms – dresses</td>
<td>(+Alternative materials)</td>
</tr>
<tr>
<td>Blue platform – pants</td>
<td></td>
</tr>
<tr>
<td>Material choice – bricks of different colors</td>
<td></td>
</tr>
</tbody>
</table>

Two persons from Brand/Raw Materials sit at the same station (table). This station designs the collections and takes the decision about what material they should be made of. For the collections Brand/Raw Materials has a schedule with a lead-time of 30 seconds. It also has a scheme what type of clothing and in which proportions should be produced. The Brand-person passes designs of garments (Lego platforms) to the Raw Material-person who adds the raw materials (bricks) to the designs (see the picture below). The initial choice of raw materials in the game is cotton and polyester - the most commonly used fibers in the textile industry. In later rounds of the game more material choices will be available. Then the Raw Material-person requests the Material
Handler who transports the products to the next station. Initially the products can be transported to the next station only as batches of six products.

Picture 3. The assembling card for the standard products

---

**Raw Material**  
*Material planning sheet*

The Lego bricks that represent materials should be assembled onto every platform: the black ones are Polyester and the white ones are Cotton. The material bricks are assembled as shown in the picture.

If the group decides to implement material diversity, then you will assemble the materials according to the plan below.

**Plan for Green platform:** 4 Black, 4 Blue repeatedly
```
B B B B BL BL BL B B B B BL BL BL
B B B B BL BL BL B B B B BL BL BL
B B B B BL BL BL B B B B BL BL BL
B B B B BL BL BL B B B B BL BL BL
```

**Plan for Blue and Yellow:** 4 White, 4 Red repeatedly
```
W W W W R R R R W W W W R R R R
W W W W R R R R W W W W R R R R
W W W W R R R R W W W W R R R R
W W W W R R R R W W W W R R R R
```

Picture 4. Production plans for the Brand/Raw Materials station
At the textile manufacturing station the following processes are operated: dyeing, washing and drying. For every process there is a lead-time and a certain amount of products that must be placed in the bath or drying machine at the same time for the process to start. This station starts with an inventory of three most common products – T-shirts (green platforms with added bricks).

### Garment Manufacturer: 1 player

<table>
<thead>
<tr>
<th>Cutting</th>
<th>Sewing</th>
<th>Trimming</th>
</tr>
</thead>
<tbody>
<tr>
<td>Add one brick for the cutting</td>
<td>Add one brick for the sewing</td>
<td>Add one brick for the trimming</td>
</tr>
<tr>
<td>process - Red brick</td>
<td>process – Black brick</td>
<td>process – Blue brick</td>
</tr>
</tbody>
</table>

At this station the garment making process of cutting, sewing and trimming takes place. Every process is represented by a brick of certain color. The time of the processes depends on how fast the person assembles the bricks to the platforms. When the six products are ready they are sent to the next station with the Material Handler. The products can only be transported to the next station when the batch of six products is produced.

### Sustainability and Quality Control: 1 player

<table>
<thead>
<tr>
<th>Quality control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control that the products have all the parts and assembled in a right order.</td>
</tr>
<tr>
<td>If the product has a defect it is sent back to the Brand/Raw Material station.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sustainability control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calculate the sustainability points of the products</td>
</tr>
</tbody>
</table>

The Sustainability Manager has two processes to take care of: quality control and sustainability control. Under the quality control this person checks if the product matches the description of order and if any defects occurred the product is sent back to the Brand/Raw Material station. The number of defects should be recorded for further calculations in the economy table of the game.

This operator also calculates the sustainability points for the alternative more sustainable material of the products (points per product – see Table 1) and for more sustainable facility’s process. Here different bricks symbolizing different raw materials give different sustainability points for the product (Higg Index Product Module).
**Distributor: 1 player**

Distribute products to the Customer (no batch limit)  
Keep stock of finished products  
Keep track of products delivered, late or non-delivered.

When the game starts the initial inventory at this station consists of three products of each color – green, yellow, blue. The Distributor keeps and stocks the finished products and delivers the product when the Customer demands it. If there is missing a product, this is calculated into a table as late or not delivered. There are no limitations in the size of batches between Distributor and Customer.

**Customer: 1 player**

Order products every 15 second (the first order comes in 30 seconds after the game start)  
Keep track of the round time, 12 minutes  
Keep track of products delivered on time, delivered late or not delivered.

This is the point where the round starts and ends. The Customer places orders one by one to the Distributor every 15 seconds, but the first order comes in 30 seconds after the game has started. This person keeps track of the time of the round (12 minutes) and also writes down in the special table the delivered, late or non-delivered products (see picture below):

<table>
<thead>
<tr>
<th>Round</th>
<th>Delivered in time</th>
<th>Delivered late</th>
<th>Not delivered</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Green Blue Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Green</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Blue Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Green Blue Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Green Blue Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Green Blue Yellow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Green Blue Yellow</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Material Handler: 1 player**

Deliver the products between the stations

The person on this position to handles the transportation between the stations and has also an overview of the supply chain. There is no transportation with Material Handler between Distributor and Customer.

**Alternative choices**

Two changes per round are allowed. In this game the variants for changes are presented in group A for rounds 1-3 and group B for rounds 4-6. Group A includes alternative choices as follows:

**Brand/ Raw Materials**

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Material diversity</td>
<td>Alternative more sustainable materials</td>
</tr>
<tr>
<td>Shorter product development time</td>
<td>Faster and shorter collections planning to respond to the market demand</td>
</tr>
</tbody>
</table>

**MATERIAL DIVERSITY**

Sustainable materials are used for the special order products and will be introduced in the fourth round. The Game leader presents a table of materials based on the Higg Index (see the table 1). Sustainable materials bring sustainability points per product but its cost increases depending on material selected (see rule Special products). The sustainability manager then counts the point for every product that is produced in the new material (see the Table 2). This station also keeps track of the sustainability points for the new materials. When the new material is added the Raw Material starts to follow a planning schedule of the materials, black, white, red and blue.
At the Brand/Raw Material station the lead-time is 30 seconds. This time can be decreased from 30 to 15 seconds. That means that the players at this station need to wait 15 seconds between every collection instead of 30 seconds. This change can be made after the first round and brings more agility in the supply chain.
Textile Manufacture

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 New dyeing baths</td>
<td>1) Eight products on 70 seconds/70 degrees (longer processing time but more eco- &amp; human friendy and has two bath’s sections)</td>
</tr>
<tr>
<td></td>
<td>2) Eight products on 80 seconds/60 degrees (longer processing time but more eco- &amp; human friendy and has four bath’s sections)</td>
</tr>
<tr>
<td>1 New washing machine</td>
<td>Eight products on 40 seconds/ 40 degrees (longer processing but more eco- &amp; human friendy and has two washing sections)</td>
</tr>
<tr>
<td>1 New drying machine</td>
<td>Eight products on 40 seconds/ 100 degrees (longer processing but more eco- &amp; human friendy and has two drying sections)</td>
</tr>
<tr>
<td>Local production/No transportation</td>
<td>Move production closer to the Brand (can be only completed in the last round)</td>
</tr>
</tbody>
</table>

DYEING
The conventional dyeing machine can be replaced after the first round. The next machines have two sections instead of one but 10 seconds longer lead-time (70 seconds instead of 60 sec). Four products can be dyed at the same time in each bath section: blue and yellow can be placed into the same bath while the green products cannot be mixed with others. The processing time is becoming longer because the temperature is lowered. Also this process reuses water and colorants in the process. This saves energy, water and chemical consumption and therefore gives sustainability points. Another dyeing bath has even more longer time but 4 bath sections for two products each. Every section has a dyeing process time of 80 seconds. This machine uses pad-batch dyeing method where more energy and water are saved whereas less chemicals are used, therefore this process gives sustainability points. The latter machine cannot be chosen unless the first change is made.
These choices are represented in the game sheets:
**WASHING**

The conventional washing machine can be replaced after the first round. The new machine has two sections instead of one but a 10 seconds longer processing time (40 sec instead of 30 sec). Four products can be washed at the same time in each baths: blue and yellow can be placed into the same bath while the green ones can be washed only with green ones. The time is longer because the temperature is lower and thereby it saves energy and gives sustainability points.

These choices represented in the game sheets:

![Washing Bath](image1)

**DRYING**

The conventional drying machine can be replaced after the first round. The new machine has two sections instead of one and has a 10 seconds longer processing time. Four products can be dried at the same time in each section: blue and yellow can be placed into the same section while the green can be dried with the green ones. The processing time is longer because the temperature is lower which saves energy and gives sustainability points.

![Drying Oven](image2)

**LOCAL PRODUCTION**

Local production cannot succeed fully until all stations (tables) or players sit together. A full local production gives sustainability points. However, the team can save costs by moving a table or person. Removing an employee brings negative sustainability points (see rule Moving a person or removing a table).
Supply chain flow

<table>
<thead>
<tr>
<th>Change</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Push &amp; Pull- Canban</td>
<td>Better product flow visualization</td>
</tr>
<tr>
<td>Move processes together</td>
<td>Lower cost, better sustainability</td>
</tr>
<tr>
<td>Local production</td>
<td>Better sustainability performance</td>
</tr>
<tr>
<td>Remove one process/person</td>
<td>Less costs, negative sustainability points</td>
</tr>
<tr>
<td>Decrease transportation batches</td>
<td>More efficient flow, negative sustainability points</td>
</tr>
</tbody>
</table>

**PUSH&PULL - CANBAN**
Canban can visualize the product flow and somewhat forecast the customer’s orders. Players have two Canban cards that they can position in any place of the supply chain. One card is placed between two stations so the players see what product is running out from the inventory soon. The Canban card consists of eight cells where eight products can be placed. The team selects how many products of each color should be in the card. When the card is full the previous stations stops producing until it is again clear the product of what color is running out faster. The Brand planner then stops planning the collection and starts to produce on demand. The lead-time at the Brand & Raw Material station stays same. When using the Canban the transportation batches can be decreased without counting it as a change because it is a part of the Canban system.

**DECREASE TRANSPORTATION BATCHES**
The transportation batches can be reduced after the first round. Smaller batch brings more negative sustainability points because of more transportation miles per product:

- Batch of 6 products
- Batch of 4 products - 20 SPT
- Batch of 1 product – 30
MOVING A PERSON OR REMOVING A TABLE
In the third round of the game the participants can chose to produce closer to market. They can thereby move one person (station) to another table or move two tables together. Thereby they exclude the transportation between the stations. It decreases the environmental impact (carbon emission to air). When moving a person (station) it saves costs.

REMOVING A PERSON
Removing a person from the supply chain can happen when the team decided that some station does not add value to the product and not essential for the production and that the activity in case can be handled by the person from another station. To remove a person means to decrease the cost but it results in negative sustainability points because the employee is fired.
In the game the minimal number of tables is 2 (excluding Customer’s table) and 3 players (excluding the Customer). The Customer, Textile-, Garment- manufacturing and product development process (Brand/Raw Material) cannot be removed from the supply chain.