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PAPU DESIGN PRODUCT DEVELOPMENT: INNOVATING SMART TEXTILES FOR CHILDREN

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The purpose of the research was to review the children's smart textiles already available on the market and map the expectations and most appealing features of children's smart textiles by the Papu Design stockholders. The results were then used in brainstorming part of the product development process of Papu Design.

An explorative literature research was conducted online to review the children's smart textiles already available on the market. A customer survey was then implemented for the stockholders of Papu design (N=768) to gain understanding of the needs and desired features of the customers regarding smart textiles. The results of the survey were analyzed by thematization. Based on the results, brainstorming event for the Papu design representatives was held to ideate a new end-product.

The results of the survey revealed that the customers were rather aware of the smart textiles overall, yet they were not familiar with the actual children's smart textiles already available on the market. Customers stated that they would be willing to buy a smart textile produced by Papu Design if they had the need for it and if the product was useful. The most desired technical features included tracking location and measuring feature but features related to durability and usability were also considered important. The biggest worries of the customers were related to the information security of the smart textiles and their health effects.

The online explorative literature research revealed that there is not yet many children's smart textiles available on the market. The response rate of the survey was rather high with 27,5% and it can be stated that the results of the survey do give a good insight on what the customers expect and desire from the children's smart textiles. The results of this research can be used in the further product development process of Papu Design.

CONTENTS

1 INTRODUCTION

Different levels of smartness are needed to create different smart textile products. “Smart” in textile can refer to a functional feature reacting to an outside stimulus and adapting the needs of the user or with electronical feature that can perform logical operations and distribute an output that is goal-oriented (Tünde 2013, 22.). It seems that the smart textiles development has been focused on the technology companies creating new smart materials, yarns and fabrics, rather than creating an actual smart textile end-product.

Papu Design is a Finnish clothing company producing ecologically and ethically manufactured clothing for children and adults and is now willing to merge into smart textiles business. Smart textiles are quite often regarded as textiles related to sports or health care, yet Papu Design is a fashion and design company. Still it is important to notice that the new integrated smart features are becoming softer and embedded and the actual textiles are coming more functional and composite. This creates similar goal for all multidisciplinary sectors of smart textiles development parties (Tünde 2013, 3.).

The need for the research came from the representatives of the Papu Design as they wanted to find out would the customers be willing to buy smart textiles for children. Furthermore, the aim was also to find out the features that customer would expect and desire from the children’s smart textile and what children’s smart textiles are there already available at the market.

2 WHAT IS A SMART TEXTILE?

2.1 Definition of a smart textile

Syduzzaman et al. (2015) define smart textiles as “fabrics that have been designed and manufactured to include technologies that provide the wearer with increased functionality”. So smart textile is pretty much a cloth that has modern computer-based technology woven into it. Related terms are e.g. interactive clothing, intelligent clothing, smart garment, and smart apparel (Suh et al. 2010). Smart textiles also refer to a textile product which interacts with its surroundings and current conditions. Smart textiles have either natural or functional features that differ from classic textile. (Nissi-Rantakömi 2017).

Smart textiles bring together high level of intelligence and can be divided into passive, active and very smart textiles. Passive smart textiles are only able to sense matters of either the environment of the user or the user himself by a sensor. Active smart textiles react to stimuli from the environment and are combined by an actuator and a sensor. Very smart textiles do sense, react and accustom themselves into the environment’s assets. (Stoppa & Chiolerio 2014)

Smart textiles include components such as sensors, data processing, actuators, storage and communication. Sensors are used to sense the outside features and parameters. In data processing the data collected by sensors is processed and actuators function is then to react to processed data by appropriate output. Storage is used to store the data collected. Communication features are used to enable the smart textiles to interact or communicate with other devices or to transfer information. (Barhanpurkar et al. 2015).

The most common communication methods used in interactive smart textiles are Wi-Fi and Bluetooth. Smart textiles require power to function, which is created by the batteries. These batteries are either detachable or attached to the textile structure. Attached batteries can vary in size, being thin or flat, but can also be flexible and must endure being machine-washed, dried, ironed and dry cleaned. (Gonvalves et al. 2018, 2.)

2.2 Smart materials

Metal yarns can be used either as interconnects between components or as electrodes (e.g. ECG). Conductive inks containing e.g. carbon, copper, silver, nickel, and gold can be screen-printed on to garments. These printed areas can be used as switches or pressure pads. Inherently Conductive Polymers (ICPs) such as polyacetylene, polypyrrole, and polyaniline can be used both as a sensor and an actuator. (Syduzzaman et al. 2015).

Optical fibers are made of plastic and can be used as data or light transmitters, detecting deformations in fabrics and chemical sensing. Common applications of optical fibers are safety vests. Nano article coatings are used to enhance performance and functionality of the garments, and offers e.g. anti-bacterial, water-proof, UV-protection and self-cleaning properties. Shape memory alloys such as nickel-titanium can be used to increase protection against heat. There are also Shape Memory Polymers (SMPs) such as cuprous-zinc alloy which is more compatible with textiles than nickel-titanium alloy. Electro active polymers (EAPs) are made of high functionalized polymers and can be used in muscle and tendon protheses. (Syduzzaman et al. 2015).

Chromic materials adopt to their surrounding conditions by changing color. Chromic materials can be either photo chromic (light stimulus), thermo chromic (heat stimulus), electro chromic (electric stimulus), piezoro chromic (pressure stimulus), or solvate chromic (liquid or gas stimulus). These materials are mainly used in fashion industry creating color effects and designs. Phase change materials can be used in e.g. anti-ballistic vests or common underwear. They react to the outside temperature of the user and can store or release heat, and thus either warm or cool the user. (Syduzzaman et al. 2015).

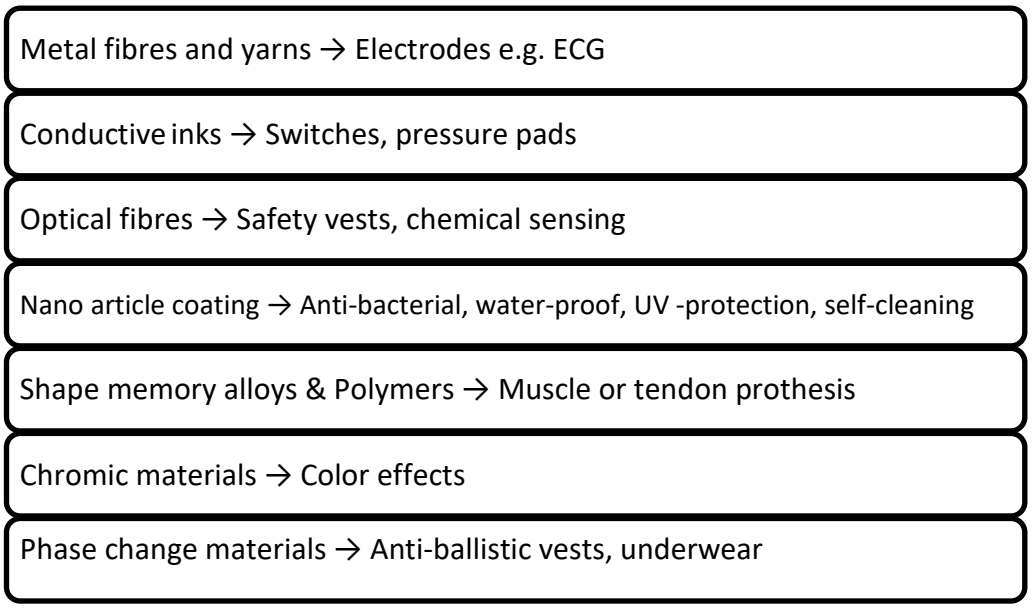

Figure 1. Smart materials and common applications (Syduzzaman et al. 2015).

2.3 Sensor applications in smart textiles

The sensor can be a separated gadget attached or integrated into the clothing known as wearable technology or woven into the yarns and textiles. The usage of them is rather cheap and simple, and they are light, flexible, and strong. As the sensors can be woven into the fabric the normal fabrication process is not altered. (Syduzzaman et al. 2015).

Sensors in smart textiles consists of three main categories: physiological, kinetic and agent detection. Physiological sensors can measure e.g. perspiration rate and its chemistry, composition of urine, composition of saliva, heart rate (pulse), blood pressure, sleep/rest quality, activation and engagement of muscles, blood saturation and body temperature. Sensors that measure steps, pressure, acceleration, direction (gyroscopes), or location (GPS) are called kinetic sensors. These sensors can also be used to detect and prevent stress and injuries but also to generate electricity and can be used in tracking location and activity. An agent detection sensor is used to measure radiation, chemicals, bacteria, fungi, atmospheric pressure, humidity and environment temperature. These sensors are mainly used to produce data to detect dangers and help prevent accidents. (Hanuska et al. 31)

2.4 Other applications in smart textiles

Augmented (AR) reality also known as added reality can be used in smart textiles by creating visual effects e.g.in story-telling by adding images or text into the story. Augmented reality is inserted into the smart textiles patterns and can be read through smart glasses or mobile devices. (Emspak 2018).

QR-codes can be printed into e.g. in the product labels of the garment and be used in tracking the origin and the manufacturing process of the garment as well as in the authentication of a product. The QR-code is read via mobile device and can direct the user to a website containing the origin and all manufacturing processes of a single garment and the authentication verification. (Website of QR -code)

Gamification features in smart textiles refer to a garment with playful interaction. A smart textile is used together with e.g. mobile device and can be used in e.g. activation of a child. The aim of the gamification is to make systems or processes more fun and thus increases the acceptance of the technology. (Vega-Barbas et. al. 2015)

Visual effects in smart textiles e.g. by led lights or chromic materials. Led lights are embedded into the textiles illuminating and creating color effects. (Price 2016). Chromic materials can be woven into the structure of the garment or used as an ink in patterns. These materials are mainly used in fashion industry creating color effects and designs. (Syduzzaman et al. 2015).

3 REVIEW ON SMART TEXTILES FOR CHILDREN AVAILABLE ON THE MARKET

A Finnish company Reima has a concept called ReimaGO®. The concept consists of location tracking, activating, monitoring and gamification parts. The sensor, produced by Suunto, is placed in a specific pocket and it tracks and records the child's activity and the transfers the data to a smart phone application for both adult and child's use. (Website of Reima 2018). The parents can set a child goals, surprises and rewards and check how active a child has been. The child's side of the application is utilizing gamification. Children can move their avatars through virtual worlds according to their own activity. ReimaGO® application is free to download for iPhone and Android. The clothing line is available in different sizes from small children to teenagers. (Paakkunainen 2016)

VTT has created a textile that tracks the temperature surrounding the user temperature and then reacts to it by either cooling or heating the user. This technology is based on Human Thermal Model -calculating tool. This means that for an example a textile's heating or cooling features change according to the needs of the user. (Seppälä 2017). The smart textile produced by VTT is a part of the Smart Clothing -project and the textile does not only heat or cool the user but can also detect the extend of how much heating or cooling is needed as there is differentiation in the sensation of temperature by men, women and children (Tuomaala 2016). Even though there is not yet an exact product produced, this technology could be used in children's smart textiles.

A company called Mimo has created a tracker attached to a baby's onsie. The tracker sends data to mobile application in which a parent can monitor the breathing, respiration, moisture, body positioning, skin temperature, and wake/sleep of the baby in real-time. The sensor is ultrasonically welted into the garment ensuring waterproofness of the mechanical parts allowing the garment to be machine-washed up to 90 times. Yet, in case of malfunction, a special x-ray machine is needed to find the broken part. Mimo is currently developing an application with sleep training features. (Crichton 2015)

Welspun has created rugs and duvets with AR (augmented reality) technology attached. AR included in the textiles enables a new kind of storytelling creating interactive, multi-dimensional and educational atmosphere for children. Special markers on the textiles are scanned with either a tablet or smart phone. The AR stories include videos and narrations. Some of the stories are activating, encouraging children to e.g. do yoga poses, and some are pacifying encouraging sleep. (Shah 2017)

An American company Del Sol produces clothing that uses Spectrachrome® Technology to make colors in the clothing change or pop-up when exposed to ultraviolet waves. This is technology uses molecular excitation transition and it goes the other way too, shifting back to its original color. Spectrachrome® Technology is not creating new colors, but rather makes all colors included in the garment visible for eye when exposed to sun light. This technology also lets the user know when the UV index is high. Spectrachrome® technology needs no energy supply and the technology endures throughout the clothing's lifeline. (Website of Del Sol 2018)

Owlet Smart Sock produces specially designed socks for infants with integrated wireless pulse oximeter attached. A base station or a mobile application follows the infant's sleep and oxygen and heart rate and alarms and notifies the parent with colors or sound if the rates go either too low or too high. The base and the sock are connected with Bluetooth. With the mobile application a parent can receive notifications, stream real-time heart rate and oxygen levels and see historical trends or sleep data. The base station changes color according to the state of the baby, lighting green, when the rates are in normal level, allowing the parents to check the baby's condition at one glance. (Website of Owlet 2018)

Recco® rescue system is designed to help avalanche rescue by helping to detect lost or buried persons. The system works two ways; rescue teams send out search signals via Recco® detectors and the signal is then bounced back with Recco® reflectors used by the outdoors people. Multiple reflectors on a person improves the detection. The detector can be used e.g. in ski centers or helicopters. The bounce-back of search signal needs no effort from the user as it works automatically. The Recco® reflectors are permanently integrated into skiing textiles and equipment. They are light and need no training or battery to function. (Website of Recco 2018)

4 PRODUCT DEVELOPMENT PROCESS

4.1 Smart textile product development process and trends

Product development refers to developing and launching into market totally new or altered already made products. The phases of product development are ideation and evaluation, development and testing, productization and launching. Productization in product development refers to a phase where the idea is brought into actual product. The result of the product development process and productization is a well finalized entirety (Bergström & Leppänen 2007, 118-120). The Smart textile product development emphasizes on testing the co-operation of different features and device. The smart textile product development must include clothing and device focused processes (Rosenberg 2016, 24.).

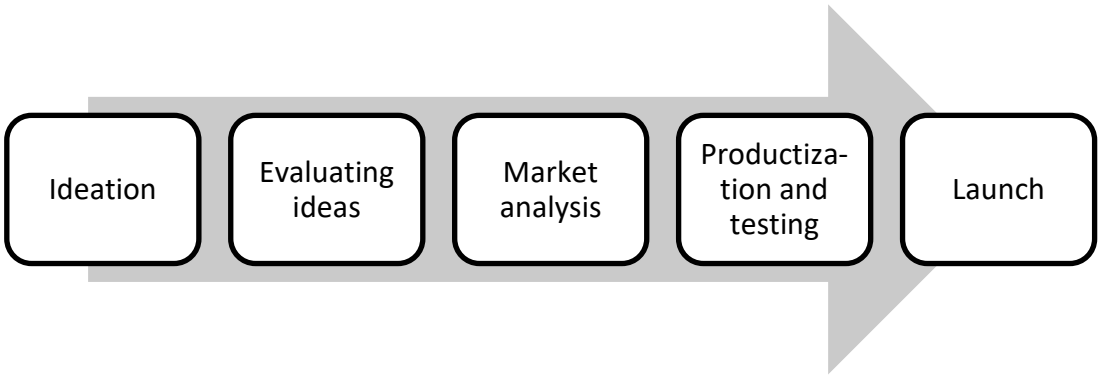

Figure 2. Product development process (Leppänen 2009, 55).

Previously the focus was on the computing field but lately the smart textile developing team has been consisted of people from different governmental and academic organizations, laboratories, design consultancies, clothing companies and technical companies. Yet, the fashion thinking and techniques have not been successfully utilized. (Ariyatum, Holland & Harrison 2006, 2-3.) Lately the focus has also changed into more user-centric as the need of absorption from fashion industry and user demands have been acknowledged.

4.2 Potential of smart textiles

By developing new smart textiles, the number of separate gadgets can be reduced. Textiles are a natural base for smart features, as clothing is worn constantly and thus the smart features are easy to carry along. As the “smart” is integrated into the textiles, there are also less parts to get broken and the textile can immediately react to stimuli. Smart textiles are considered being trendy and futuristic, which is fascinating to both the developer and the end-user. Well-designed smart features add value to the textile. (Rosenberg 2016, 4.)

Due to demand in mobile technology, sensor technology has evolved lately. Smaller, more accurate and multi-dimensional, inexpensive and reliable sensors have been created. Smart textiles tell the user about the user’s health condition and it guides and directs the user to a better performance or to a healthier lifestyle. (Hanuska et al. 31)

Data collected via smart textiles can be referred as big data. Narrow definition for Big Data according to Healthcare Information and Management Systems Society (2018) states that “big data is when massive amounts of both structured and unstructured data are available and need to be mined and analyzed”. The big data analysis can be used to discover patterns, correlations, trends in the market, customers preferences or other vital information that can be used in business decision making and product development. (Rouse 2017)

4.3 Barriers related to smart textiles

Two main reasons for smart textiles still lacking dramatic growth in the market are technical and cultural challenges. Main barriers related to smart textiles technology are power supply, heat dissipation, wash-ability, comfort and flexibility. Cultural challenges concern data privacy, cost of the device and style. The consumers are yet not fully aware of the market offerings leading to a slow adoption of the smart technology. (Hanuska et al.. 3,8,36.)

There are many smart technology studies and projects done and ongoing financed by either EU or private companies. The EU -financed -projects tend to focus on health care while the fashion applications are mostly focused on the visual aspects creating a gap between the research and commercial applications. The mass production companies have not yet been interested in producing smart textiles, whereas smart textiles have remained a project of small companies or artists (Berglin 2013). Due to the lack of knowledge, the fashion companies have not yet integrated new fashion approach themselves rather just adopting existing technical features (Ariyatum & Holland 2003,4.).

5 PURPOSE AND OBJECTIVES OF THE THESIS

5.1 Aim and purpose of the research

The aim of the research was to find out what is already on the market in children's smart textiles. Another purpose of the research was to map the expectations and most appealing features regarding children's smart textiles by the customers of the Papu Design. The results of the research were used in Papu Design product development by gaining insight to the needs and requirements of the customer.

5.2 Research questions

1.What different kind of smart textiles is already available on the market in children's clothing?
2. What are the customer expectations and most appealing features like, regarding children's smart textile?
3. What guidelines the study findings could provide for PAPU Design to be utilized in its custom design?

6 METHODOLOGY AND IMPLEMENTATION OF THE RESEARCH

The research was conducted first by gathering theoretical data via explorative literature research. Next a customer survey was created and focus group was selected to be the stock holders of Papu Design (N=768). The data collected from the customer survey was analyzed by thematization. After the analyzing, the results were presented to Papu Design representatives and a brain storming event was held to ideate a new children's smart textile produced by Papu Design.

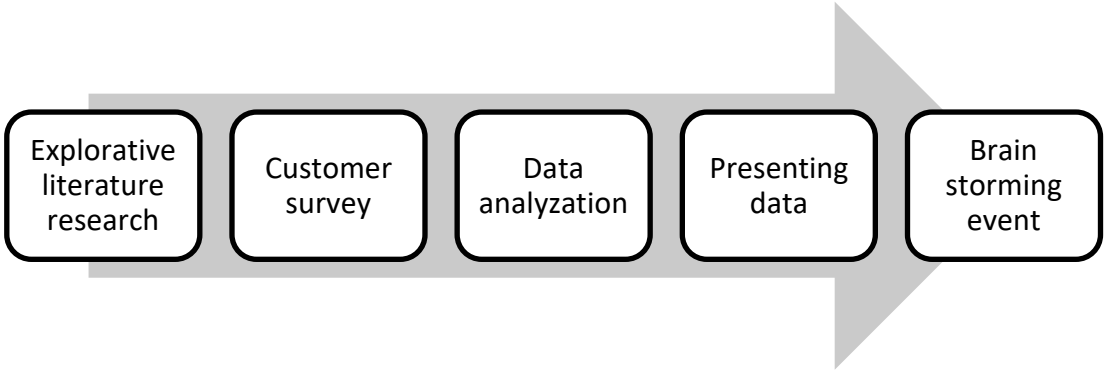

Figure 3. Process of the research

6.1 Explorative literature research

An exploratory literature research was conducted to map the children's smart textiles already available on the market. In explorative literature research, the aim is merely to search and explore the research questions, yet it does not intend to find or discover solutions to existing problems (Dudovskiy 2018).

Formally, a literature review studies books, scholarly articles, and any other sources relevant to an issue, area of research, or theory (University of Southern California 2018). In this research the search was conducted online, reviewing for companies providing smart textiles for children.

6.2 Implementation of customer survey

The survey part of the thesis was done by customer survey. In quantitative research, surveys are one of the most commonly used. While conducting a survey, the researcher

selects a target group and then administers a questionnaire to that target group. Surveys can be used to collect data from different sizes of populations, small all large. (Colorado State University 2018)

Focus group refers to a method to gain information and understanding about the views and experiences of a selected group of individuals by organized discussion. According to Anita Gibbs (1997) focus group interviewing is particularly suited for obtaining several perspectives about the same topic. The focus group in this research was the stockholders of Papu Design and the questions were created in collaboration of the founder of Papu Design, Anna Kurkela.

The electronical customer survey was created by using the application called Kyselynetti. First the survey was sent to a test group and altered according to comments received. The survey was then sent to the target group by email in May 2018. The customers were given a set time of two weeks to reply the survey. To prevent the email get caught in the junk mail folder of the recipient, it was sent by Papu Design's CEO Jussi Kurkela. To increase the number of replies, the informant letter attached to the survey stated that two gift vouchers would be drawn among the people who responded the survey.

The questions of the survey were categorized into seven categories. These categories were the background information, awareness of smart textiles, the technical specifications of smart textiles, the appearance of smart textiles, customers' desires and expectations, customers' fears and worries, and customers' willingness to purchase a smart textile produced by Papu Design.

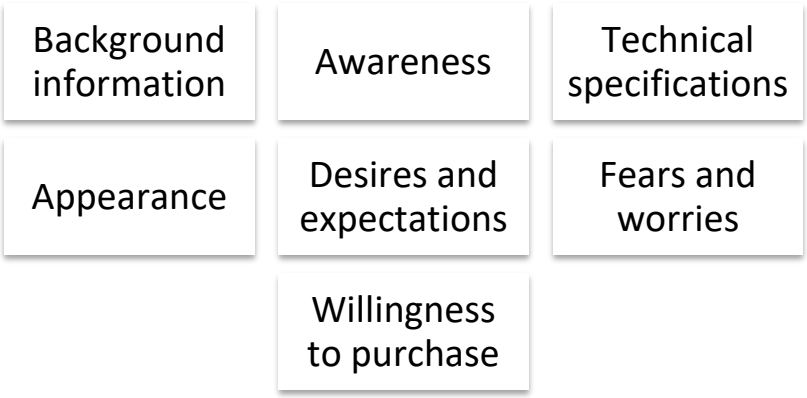

Figure 4. The categories of the questions in the customer survey.

The background information was asked but not used in the analyzing process of the research as all the answers were analyzed autonomously. In this study the background information was used only to draw the vouchers. Yet, in case of restudy or another type of research the background information could be used without the need for a re-surveying the customers.

The awareness of the smart textiles category was included into the survey because it was important to state the level of awareness of smart textiles. To truly understand the desires of the customers, it's worthy finding out the knowledge base and understanding related to the topic. To proceed with the product development process, it was beneficial to study the prefers customers would have on the technical specifications of the children's smart textiles.

As Papu Design is a clothing design company, the appearance category was a crucial part to be included. In the next part of the survey, the customers were asked about the desires and expectation they have on children's smart textiles and the following category of questions was related to the fears and worries the customers have on smart textiles. Last, the customers were asked whether they would be willing to purchase a children's smart textile product produced by Papu Design and if so, what kinds of products they would purchase.

6.3 Data collection and data analysis

Total number of replies to the survey was 211 (N=211). After the data collection was completed, the results were being analyzed by thematization. In thematization is aim is to find out patterns of meaning from the database. The process of thematization begins with data familiarization, next step is finding out the themes and coding them. Next the themes are defined and named. The final step is the revision of the themes and finally writing up the results. (Website of The University of Auckland 2018)

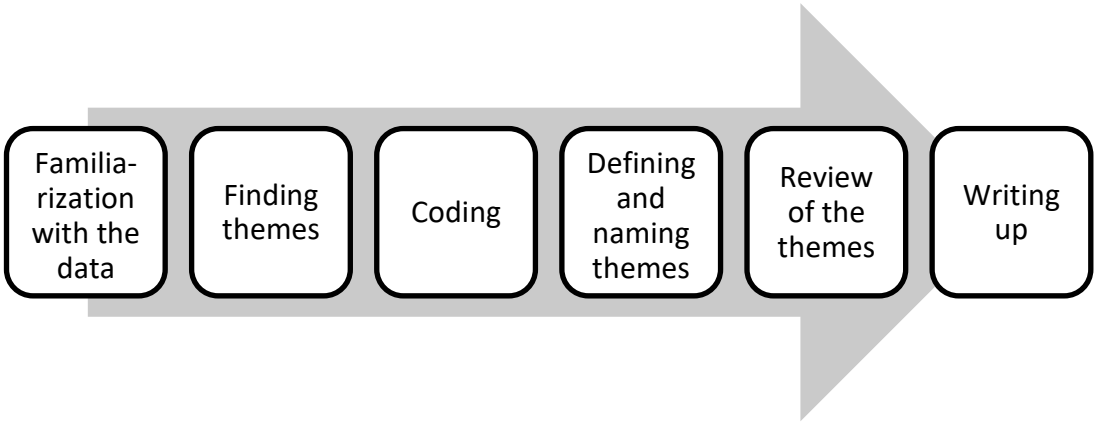

Figure 5. Process of thematization (Website of The University of Auckland 2018).

In this research the results of the survey were printed out and studied carefully. The coding of the themes was done by colors, searching for similar patterns in answer by words or phrases. The themes were then named and the number of answers within each theme were calculated referring to the importance of the theme. Yet all the themes were taking into consideration during the analysis and all the themes were presented to the Papu Design representatives during the brain storming event. The writing up of the results is shown in the paragraph “Results of the customer survey”.

7 CUSTOMER SURVEY RESULTS

The survey was sent to 768 stockholders of Papu Design. Total number of replies to the survey was 211 (N=211) and the response rate was 27,5%. During the analyzation part it was discovered that some of the responses included multiple themes. Also, not all respondents answered all the questions as no question was marked mandatory to answer. It is also important to notice, that some question were open-end questions, and some multiple or single choice questions. Thus, there is variation between the numbers of replies and themes in each question. All questions and analysis of the results are presented in this chapter.

7.1 Background information

Majority of the respondents were women by 71,1% (n=150) and minority were men by 20,9% (n=44). 8,0% (n=17) did not answer the question about the gender.

The year of birth of the respondents varied between 1947 to 1995. 74,9% (n=158) stated that they had minor children in their family and 17,1% (n=36) did not. 8% (n=17) of all the respondents did not reply whether they had minor children or not.

The ages between underage children of the respondents varied between 0 to 17.

7.2 The awareness of smart textiles

Most customers, 56,4% (n=119), stated that they think they know what a smart textile is and 31,8% (n=67) stated that they do know what a smart textile is. Only 11,8% (n=25) stated that this was the first time they had heard about the smart textiles. All 211 respondents answered this question (N=211), so the response rate was 100%.

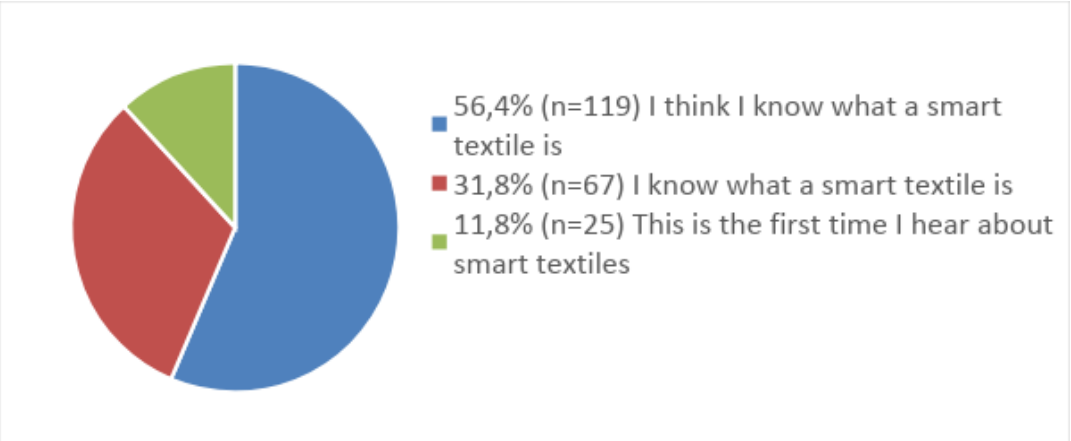

Figure 6. Awareness of smart textiles.

Quite a large fraction of the customers, 44,6% (n=91,) stated that they were not aware on the smart textile available on the market for children and 48% (n=98) had only heard of smart textiles, but not seen them in reality. Only 5,4% (n=11) had seen children's smart textiles in reality and the minority of 2% (n=4) had purchased a children's smart textile themselves. Total number of responses was 204 (N=204), so the response rate was 96,7%.

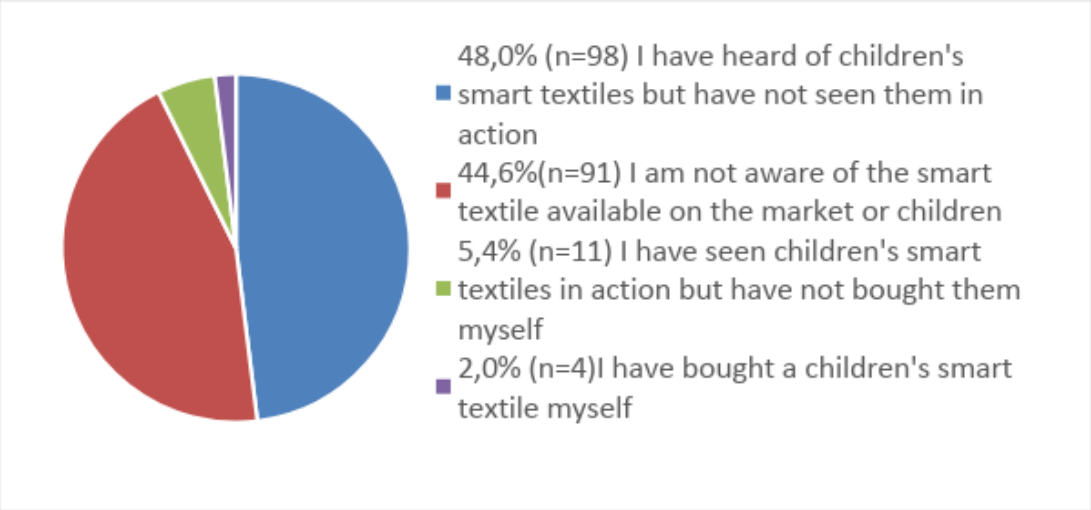

Figure 7. Awareness of children's smart textiles available on the market

The most common children's smart textile the customers were aware of and was stated by name by 63,4% (n=45) was the Reima Go brand. 12,7% (n=9) stated that they were not aware of children's smart textiles at all. Other types of children's smart textiles mentioned were UV -clothing by 8,5% (n=6), sports/activity clothing by 4,2% (n=3), outdoor jackets or technical clothing by 4,2% (n=3), garments containing silver by

2,8% (n=2), sleep monitor clothing by 1,4% (n=1), temperature detection by 1,4% (n=1) and Recco avalanche detection garment by 1,4% (n=1).

Total number of responses was 68 (N=68). There were nine different themes and the replies to different themes was 71 (n=71). Response rate was 32,2%.

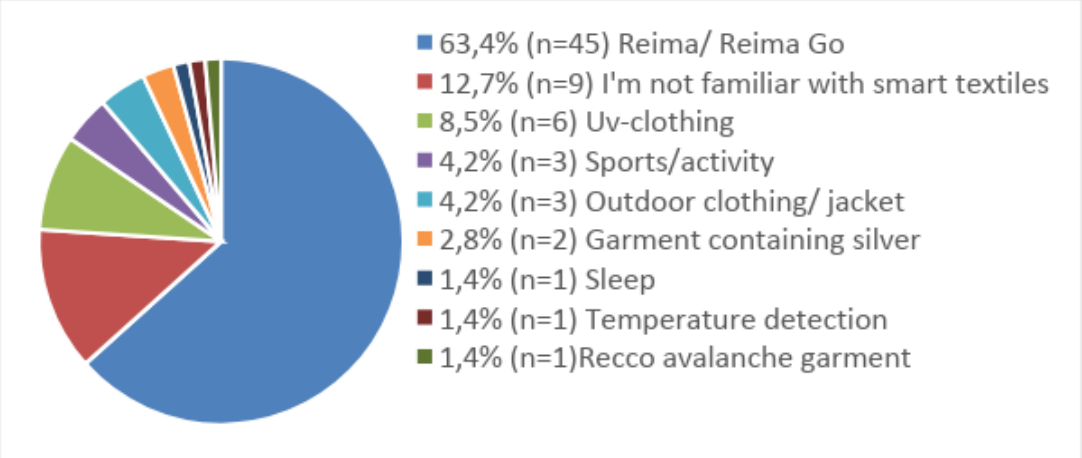

Figure 8. Most common children's smart textiles recognized by the customers.

The most common reason for the customer not having purchased a children's smart textile by 45% was that the customers were not familiar or had not encountered any smart textiles (n=41). Quite a many responded that they had not even heard of the smart textiles as a concept or had not encountered them in stores or online.

Second most common reason stated by 28,6% (n=26) was that the customer does not have a need for the smart textiles. Out of these 26 responses, 11 stated that on their opinion their kids were too small and six that they were too big and two did not have children at all. Three out of these 26 stated that the smart textiles were not interesting enough and one that the technical clothing is enough.

The third biggest reason for not purchasing children's smart textiles by 17,6% (n=16) was the price. Some customers considered the price of the smart textiles being high and some stated that they assume that the price is high. Also, the quality and features of the technology attached to the smart textiles were considered low compared to the price of the garments. Some considered that they do not have the funds or resources for the smart textiles at the moment.

Technology itself worried 3,3% (n=3) of the respondents. Looking more closely, one was worried about the gadgets held close to a child's skin and one also did not want to measure children at all. There was also a worry about the information security by one respondent.

Technological features in smart clothing were not satisfactory enough by 3,3% (n=3) of the respondents. 2,2% (n=2) replies referred to the method of purchasing as one stated they are purchasing clothing second hand and one purchase different brand of clothing than smart textile brands.

Total number of responses to this question was 139 (N=139) so the response rate was 65,9%. The number of themes was 6 and there was total number of 91 (n=91) responses to these themes.

7.3 Technical specifications on smart textiles

The most preferred technical specification on children's smart textiles stated by the customers was location tracking feature by 25,8 % (n=136). Second most common reply by 20,5% (n=108) was the feature to measure something and 16,5% (n=87) desired visual effects. 15% (n=79) preferred tracking the origin and manufacturing process of the product. 10% (n=53) preferred gamification features and 8,9% (n=47) authentication of the product. Only 3,4% (n=18) stated that they prefer augmented reality feature. Total number of respondents was 187 (N=187) by altogether 527 (n=527) replies. Response rate was 88,6%.

Durability was the most common response on other features on children's smart textiles preferred by the customers by 26,1% (n=17). Out of these 17, six customers preferred factors such as durability itself, three preferred safeness, two preferred waterproofs and another two wash-ability and also two preferred high quality. Other features related to durability were operational reliability and easy care.

A feature that measures something was desired by 21,5% (n=14). These 14 respondents mentioned the following matters to be measured: outside temperature (and furthermore the smart textile's ability to react to the outside temperature by either cooling or heating the user), activity, UV-light index (and furthermore smart textile's ability to alarm and either advice the user to add sun lotion or go to shade), fluid balance, and blood glucose level. Other measuring features, such as dirt recognition and indicators to state the level of waterproofness and moisture of the garment, were also mentioned.

It was stated by 16,9% (n=11) that they do not know or need any smart features at all.

Next common desired feature was the usability of the smart textiles by 15,4% (n=10). Out of these 10 replies, three customers wanted the smart textiles to be comfortable, two customers wanted easy to use textiles, one desired light textiles, one well fitted textiles, one breathable textiles, one a self-cleaning feature and one aesthetic textiles.

Ecological and recyclable smart textiles were desired by 6,2% (n=4). Another 6,2% (n=4) customers desired a feature that would not just track the location, but would also either call for help, enable the adult to call the child or alert of the child crossing set limits and enabling smart textiles to communicate by each other so that e.g. gloves would alarm if left in the park.

Protecting features such as hardening of the fabric in collision, windproof and led/ alarm lights were preferred by 6,2% (n=4). Only 1,5% (n=1) stated that they would prefer that the price would be reasonable. Total number of respondents was 49, so the response rate was 23,2%. There were 8 themes and total number of 65 (n=65) responses to these themes.

The importance of measuring something with children's smart textiles was measured on the scale 1-5. Scale was 1=Important, 2=Slightly Important, 3=Undecided, 4=Less important, 5=Not important. According to arithmetic mean, the most important feature seemed to be tracking location (Ø 1,97) and the least important measuring the pulse (Ø 3,20).

Table 1. Arithmetic mean of the importance of a measurement.

	ARITHMETIC MEAN
Location	1,97
Sleep	2,32
Activity	2,54
Temperature	2,79
Pulse	3,20

On measuring activity and the quality of sleep was “slightly important” was the most common reply. On measuring pulse, the most common reply was “less important”. On measuring the location, the most common reply was “important”, and on measuring the temperature, the most common reply was “slightly important”. Overall conclusion on the importance of the features can be said that the most important feature is considered being measuring location, and the less important feature is measuring pulse.

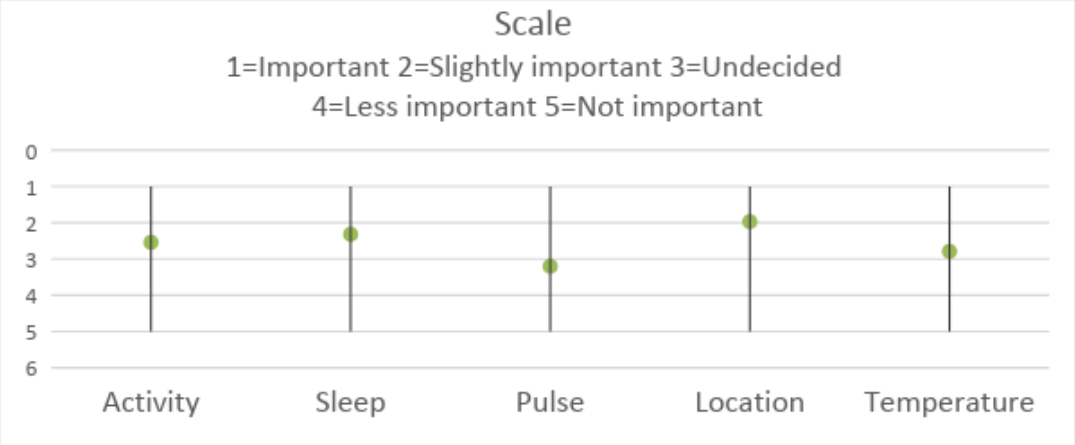

Figure 9. The importance of a measurement

As other things to be measured was asked from the customers, 29,2% (n=7) did not know what to measure or why measure anything. 12,5% (n=3) wanted to measure UV -radiation and another 12,5% (n=3) wanted to measure blood glucose level and have the smart textile to alarm if level is too low. 8,3% (n=2) wanted to measure fluid balance, 4,2% (n=1) wanted to measure the amount of light (to ensure safe reflectors on

the textile) and another 4,2% (n=1) wanted to measure outside temperature and have the smart textile notice the user to put on or take off clothes. Stress level measurement was desired by 4,2% (n=1) as well as measuring time spent with mobile device by 4,2% (n=1), mold or indoor air quality measurement by 4,2% (n=1), pulse measurement by 4,2% (n=1), measuring body temperature by 4,2% (n=1), and load factor of diaper by 4,2% (n=1). There were 24 respondents to this question, so response rate was 11,4%. There were 12 different themes and 23 of total responses to these themes. One reply was related to the safety of the smart textiles, not on measuring features.

Most customers stated that they find both gaining data for an adult use and bringing joy for the child as important by 57,4% (n=109). 21,6% (n=41) found adults gaining data more important yet almost the same amount 21,1% (n=40) stated that it was more important to bring joy to the child. There was total number of 190 (N=190) respondents, so response rate was 90%

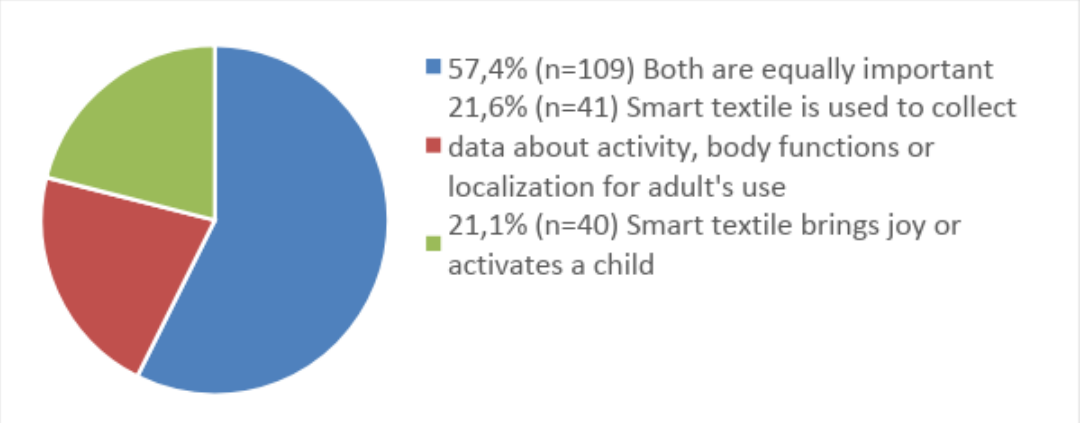

Figure 10. Gains information for an adult vs. brings joy to a child

7.4 The appearance of smart textiles

The appearance of the smart textile and its technical features were considered equally important by 68,8% (n=130) of the respondents. 20,1 % (n=38) preferred appearance over technological features and 11,1% (n=21) preferred technological features over the appearance of the textile. There was total number of 189 (N=189) to this question, so response rate was 89,6%.

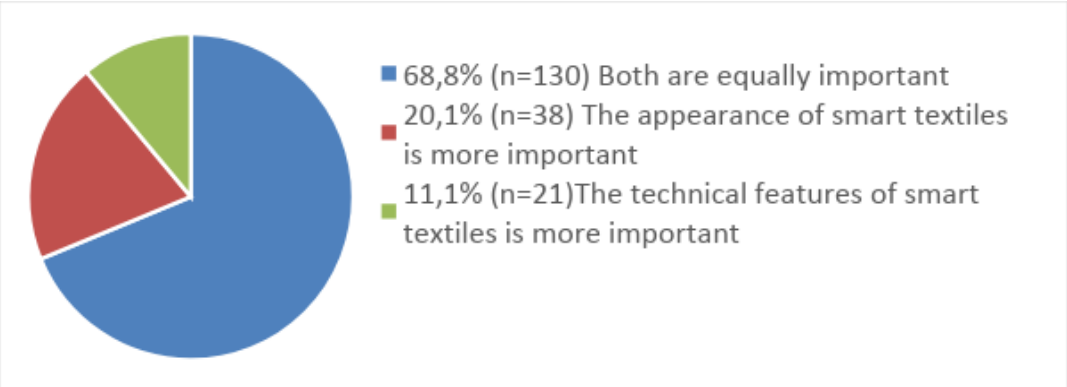

Figure 11. Importance of the technical specifications vs appearance of the textile

As asked what kind of appearance factors the customers would prefer on children's smart clothing, the most common answer was related to "normal" or commonness by 27,9% (n=19). Next desired appearance feature was smart feature being unnoticeable by 16,2% (n=11), textile being aesthetic, elegant and modern by 16,2% (n=11) and colors be down-to-earth, unisex and not too bright by 16,2% (n=11). 8,8% (n=6) stated that the appearance of the children's smart textile should be something that the children themselves would like to wear. 5,9% (n=4) wanted the textiles to not be too sporty. Another 5,9% (n=4) also wanted the textiles to be usable and 2,9% (n=2) wanted the smart textiles to be either bright or colorful. There was total number of 57 respondents, so response rate was 27%. Total number of responses was 68 in eight different themes.

7.5 Desires and expectations

Easy-to-care smart textiles were desired by 16,5% (n=15) of the respondents. Out of these 15, two desired smart textiles that are easy to wash and two desired smart textiles that are practical in everyday life. The appearance of the textiles was desired by 8,8% (n=8) and another 8,8% (n=8) preferred the fact that the textile brings joy to the child or the child prefers the smart textile. Again, 8,8% (n=8) also wanted the smart textiles to a reasonable price.

It was stated by 7,7% (n=7) that they do not have any expectations or are not interested in children's smart textiles. 6,6% (n=6) desired smart textile to be safe (regarding factors such as materials, technology itself or information safety). 6,6% (n=6) were having doubts regarding smart textiles or didn't want to control a child with a smart feature

on a textile. 5,5% (n=5) desired durable and 4,4% (n=4) reliable and functional smart textiles.

Tracking location feature was desired by 4,4% (n=4) and another 4,4% (n=4) desired activating feature. Also, 4,4% (n=4) desired the smart textile to be recyclable. 3,3% (n=3) desired safety creating features such as alarming if a child is endangered and also 3,3% (n=3) desired the textiles to be modifiable and long-life. 2,2% (n=2) desired rapid developmental process of the smart textiles. Other things stated were low battery usage of the smart textile by 1,1% (n=1), compatibility with mobile device by 1,1% (n=1), or not compatible with mobile device by 1,1% (=1), and authentication of brand clothing wit 1,1% (n=1).

Total number of respondents was 69, so response rate was 32,7%. There were 19 different themes and a total number of responses to these themes was 91.

7.6 Fears and worries

Biggest worry with smart textiles was related to information security by 32,2% (n=48). Customers were worried who would have access on the data or if it would be possible to hack the data.

Second most common worry dealt with the health impact that the smart textiles could have on a child by 30,9% (n=46). Some were worried about the somatic health impacts such as short-circuit, radiation, skin comfort and effect of Wi-Fi. Another health impact worry was the psychological health impact such as passivating and addicting features. Some customers stated that there is no need to activate a child with technology and some were worried about the non-equalization of children and the effect of smart features on a child’s psyche.

Durability and usability were factors that concerned the customers by 12,8% (n=19) and features such as wash ability, weather a smart feature is integrated or separate part, what happens when the smart feature gets broken, and the possibility of the smart textile to be resold or be used by siblings were mentioned.

Over control and coordination of the child and the child's own privacy were a concern for 6,7% (n=10) of the customers. 6% (n=9) of customers were worried about the price of the smart textiles. 3,4% (n=5) mentioned the worry about the electronical waste and 2% (n=3) were concerned about the appearance of the smart textile.

No worries or fears related to children's smart textiles was stated by 2% (n=3) and 1,3% (n=2) stated that they had no need for children's smart textiles at all. Another worries and fears were worry of "going too far" by 1,3% (n=1), worry of an expensive clothing being stolen by 1,3% (n=1), over the top compel of the smart textile products by 1,3% (n=1), and how is the energy needed by the smart feature produced by 1,3% (n=1).

There was total number of 111 respondents with response rate of 52,6%. There was 13 different themes and total number of 149 responses to these themes.

7.7 Willingness to purchase a smart textile produced by Papu Design

Most customers by 32% (n=60) stated that they might purchase a smart textile produced by Papu Design, if…. The answers to "if" question are explained in the next chapter. 31,5% (n=59) stated that they would purchase a smart textile product produced by Papu Design. 25,1% (n=47) stated that they would purchase if it doesn't increase the price of the product. Only 11,2% (n=21) stated that they would not purchase a children's smart textile product produced by Papu Design. There was a total number of 187 (N=187) respondents to this question, so response rate was 88,6%.

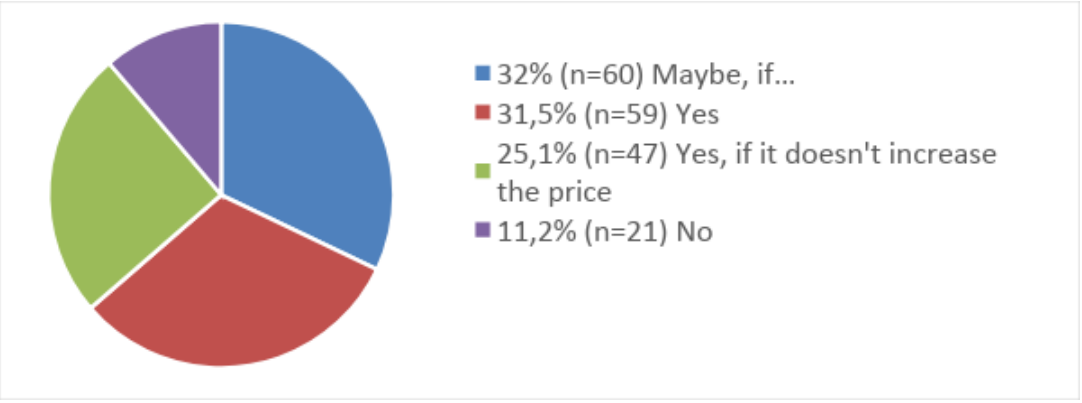

Figure 12. Willingness to purchase a smart textile produced by Papu Design

Most common reply for the “Maybe, if…” question was that if the smart feature is useful or there is need for it by 54% (n=40) of the replies. 17,6% (n=13) mentioned the price of the product to matter 4 % (n=3) of the customers would buy the product if it was safe, another 4% (n=3) would buy it as a present, 4% (n=3) would buy the product if the design or style was good, 4% (n=3) would buy the product if they would have own children and 4% (n=3) would buy the product if it would bring joy to the child. 1,4% (n=1) mentioned to purchase the smart textile product if it can be found second-hand, 1,4% (n=1) if the sizes were available also for teenagers, 1,4% (n=1) if the smart feature was durable, 1,4% (n=1) if the smart feature is removable, 1,4% (n=1) if the product is ethically produced, and 1,4% (n=1) if the customer gained more information on the smart textiles. There was a total number of respondents was 60 (N=60) and 13 different themes with 74 replies (n=74).

Most customers stated that they would purchase a children’s smart textile product produced by Papu Design with location tracking feature by 25,5% (n=110). 21,1% (n=91) would buy a product that measures something, such as body functions, produced by Papu Design. 17,4% (n=75) would buy a product produced by Papu Design with visual effects such as color changing feature or color effects, 13% (n=56) would buy a product produced by Papu Design with gamification features, 11,6% (n=50) would buy a product produced by Papu Design with tracing the manufacturing process and origin of the product, 6,5% (n=28) would buy the product produced by Papu Design with authentication feature and 4,2% (n=18) would buy a product produced by Papu Design with augmented reality feature. 0,7% (n=3) replied “other”, and these replies were; innovation to ease e.g. eating or sleeping, dirt monitoring clothing and temperature recognition and the indicator for the state of water proof. There was total number of 174 respondents with a total of 431 responses.

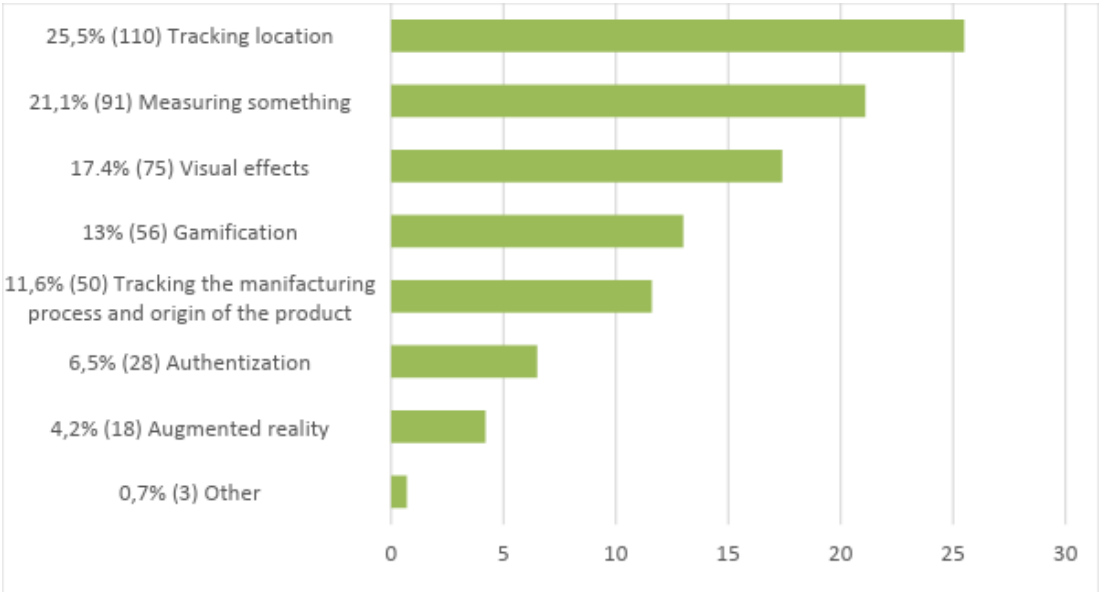

Figure 13. What kind of smart textile produced by Papu Design would customers purchase

8 DISCUSSION

8.1 Brainstorming event

After the exploratory literature research and analyzing the results of the customer survey, a brainstorming event was held for the Papu Design representatives on June 20th, 2018 in the city of Nokia. The Business Dictionary (2018) defines brainstorming as "process for generating creative ideas and solutions through intensive and freewheeling group discussion." The aim of the brainstorming event held for the Papu Design representatives was to come up with one or more product development ideas. At the event two head designers of Papu Design, Anna Kurkela (also the founder of Papu Design) and Hanna-Riikka Heikelä and the CEO of the company, Jussi Kurkela, were present.

At the beginning of the event the results of the customers survey were presented and discussed. Examples of different kinds of children's smart textiles garments were also presented to Papu Design representatives during the brainstorming event. This resulted into a free discussion and brainstorming and at the end of the event an idea for a new smart textile possibly produced by Papu Design was ideated.

8.2 Conclusion of the results

Overall awareness seems rather high on smart textiles, yet not many customers had purchased a smart textile product themselves. Customers were not familiar with the actual children's smart textile products available on the market or had not seen them on display on stores or advertisements. The conception of children's smart textiles was that it is rather expensive, and that the customers might not have adequate resources to purchase them. Some customers did not find the technological features of children's smart textile satisfactory enough. Issues related to the removability of the smart feature and the problems with recycling were mentioned. Also, a rather interesting point was that some customer stated that they do not have a need for the smart textiles. Does it mean that there should always be need for something rather than purchasing something just for fun?

Regarding the technological features of smart textiles, tracking location was the most desired by the customers and a measuring feature was the second. Customers stated some new ideas, as they wished the garment should do something with the data instead of just monitoring and collecting it. Examples of this were either heating or cooling the user, as the smart textile measures the outside temperature of the user and another example was that smart textile would alarm the user to either go to shade or put on more sun screen as it measures the UV-radiation. Another new idea was that when tracking location, the smart textile would also either alarm or communicate. Examples were given like, allowing parent to call a child or alarm if a child crosses set limits.

As the customers were asked what other features they would prefer on children's smart textiles, most common reply was related to durability. Usability also arose to be a preferred feature. As a conclusion it can be said, that the customers pay attention to the usability and durability factors, rather than only on the technical or smart features. Some of the respondents mentioned recycling or ecological factors to be important. Papu Design is a company that produces ethically and ecologically produced sustainable clothing, so these factors should be considered in their product development process.

As a relation weather children's smart textile should collect data to a parent or bring joy for the child, both factors were considered as important. Most customers desired normal looking children's smart textiles, with unnoticeable smart features and down-to-earth colors and the textiles should not be too sporty. Only minority of the customers desired bright or colorful textiles. The usability of the children's mart textiles should be good so that the child himself wants to wear the garment. It can be stated that the product development process should not just focus on the technological specifications and on the parents' needs, but also on enhancing the features that a child would desire.

Most customers preferred easy-to-care textiles. It was also stated that the price should be reasonable, and that the textiles should be safe to wear and use. The textiles were desired to be durable, reliable and modifiable. As combining technology with fashion, the product development process should focus on the easy-care, modifiability and affordable price of smart technology.

Customers' biggest worry or fear on children's smart textiles was related to the information security. The customers were worried where the data would be stored, who would have access of the data and how it could be used. Also, the possibility of hackers to access the data was a concern. The over the top coordinating of the child was also seen as a worry as some customers stated that they did not want to control a child too much. Some customers were worried about the health impacts smart textiles would have on children, both somatic and psychological.

As the customers were asked for the willingness to purchase a smart textile produced by Papu Design, the clear majority replied that they would purchase the product if the smart feature is useful for them and there is a need for it and if the smart feature adds value to the product. At the beginning of the survey these same specifications were mentioned to be the reasons for why the customers had not yet purchased a smart textile themselves, as there is no such children's smart textile available on the market. As a conclusion, it can be said that the customers would be willing to purchase children's smart textiles produced by Papu Design if the smart features are beneficial for the user.

8.3 Limitations of the study and personal reflection

The topic of the research was pleasant and the collaboration with Papu Design representatives was smooth. The timeline was kept throughout the whole process. The results of the research were beneficial for Papu Design, as they can be used in their product development process giving insight to the customers' expectations and desires.

The explorative literature research was done online and even though the research method itself is rather simple, it was found there were not many smart textile companies providing children's smart textiles or some of them were difficult to find. It was discovered that many of the smart textiles available on the market concentrated mainly on sports rather than children's design clothing. It was time consuming to search the internet and finding correct key words to search with.

While creating the survey, the theoretical background of the thesis was taken into consideration, so the answers received from the customers were reliable, significant and

usable in product development. At the beginning of the survey the customers were given a short description of smart textiles, the aim of the survey and reminder that they as stockholders, can now have a chance to influence the product development of Papu Design. This ensured the customers filled the survey with thought and devotion. It was rather easy to plan the survey with Kyselynetti and modify it after being tested by the test group.

The validity of the survey means that the questions do measure the property they are supposed to measure (University of Wisconsin Survey Center 2010, 6-7.). Validity of the survey was ensured by creating the survey questions in collaboration of Papu Design representatives. During the analysis of the data it was noticed that the responses did answer the research questions set earlier. One aim was to receive as many answers as possible and thus create even better insight to the customers' wills. This aim was met, possibly with the help of the vouchers drawn among the respondents. The survey included background information, such and age and number of the children, this improved validity as it is possible to conduct similar research repeatedly. Also, in case for a restudy or later need for another type of research this information could be utilized.

During the writing up process of the research, it was noticed that the thematization could have been done more precise and thus some of the results were thematized again under less number of themes. Due to multiple themes is a single response, it was sometimes difficult to find and mark all the themes. All in all, the number of themes turned out to be rather high. Yet, it can be stated that thematization worked well as an analyzing method, for there were multiple open-end questions in the survey to be analyzed.

8.4 Suggestions for further research

To proceed with the development of a children's smart textile product ideated by Papu Design representatives during the brainstorming event of this research, a review of such technology already available on the market could be done. Also, a detailed product development plan for that product could be created.

More attention could be paid on the worries and fears the customers have on children's smart textiles and a research could be done on how these concerns can be overcome. Focus could be paid on the information security and resolving the issues related to it.

The desires and expectations of the fashion designers could be surveyed, and it could be studied how they meet the customers' desires and expectations and set standards for children's smart textiles.

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APPENDIX 1

Background information questions and answers

Question 16. Sex. Single choice question. N=194
150 (77.3%): Woman
44 (22.7%): Man

Question 17. Year of birth. Open-ended question. N=192.
1947 ↔1995

Question 18. Do you have underage children in your family? Single choise question. N=194.
158 (81.4%): Yes
36 (18.6%): No

Question 19. Ages of children. Open-ended question. N=158.
0↔17

Question 20. Contact information. Open-ended question. N=186.
First name, Last name
Street address
Postal code and city
E-mail address
Phone number

APPENDIX 2

Awareness of the smart textiles questions and answers

Question 1. Are you familiar with smart textiles? Single choice question. N=211.
119 (56.4%): I think I know what a smart textile is
67 (31.8%): I know what a smart textile is
25 (11.8%): This is the first time I hear about smart textiles

Question 2. How familiar are you with the smart textiles available on the market? Single choice question. N=204
98 (48.0%): I have heard of smart textiles, but have not seem them in reality,
91 (44.6%): I am not aware on children's smart textile available on the market
11 (5.4%): I have seen children's smart textiles, but have not purhased them
4(2.0%): I have purchased a children's smart textile

Question 3. With free words, explain which children's smart textiles are you familiar with or have bought yourself? Open-ended question. N=68.

- Reima/ Reima Go (45)
- I am not familiar with smart textiles (9)
- UV -clothing (6)
- Sports/Activity (3)
- Outdoor clothing/jackets (2)
- Technical clothing (1)
- Garment containing silver (1)
- Sleep (1)
- Temperature detection (1)
- Recco avalanche garment (1)

Question 4. Why have you not purchased a children's smart textile? Open-ended question. N=139

- I am not familiar or have not encountered them (41)
- I don't have the need or desire for them (26)
    - Children are too small (11)

    - Children are too big/adults (6)
    - Textiles are not interesting enough (3)
    - I have no children (2)
    - Technical features are enough (1)
- Price (Too expensive) (16)
- Worries related to technology (3)
    - I don’t want my child to wear technology (1)
    - Worry about the information security (1)
- The technology is not satisfactory (3)
    - Technology should be removable and recyclable (1)
- Method pf purchase (2)
    - I purchase my clothes second hand (1)
    - I purchase different brand of clothing (1)

APPENDIX 3

Technical specifications questions and answers

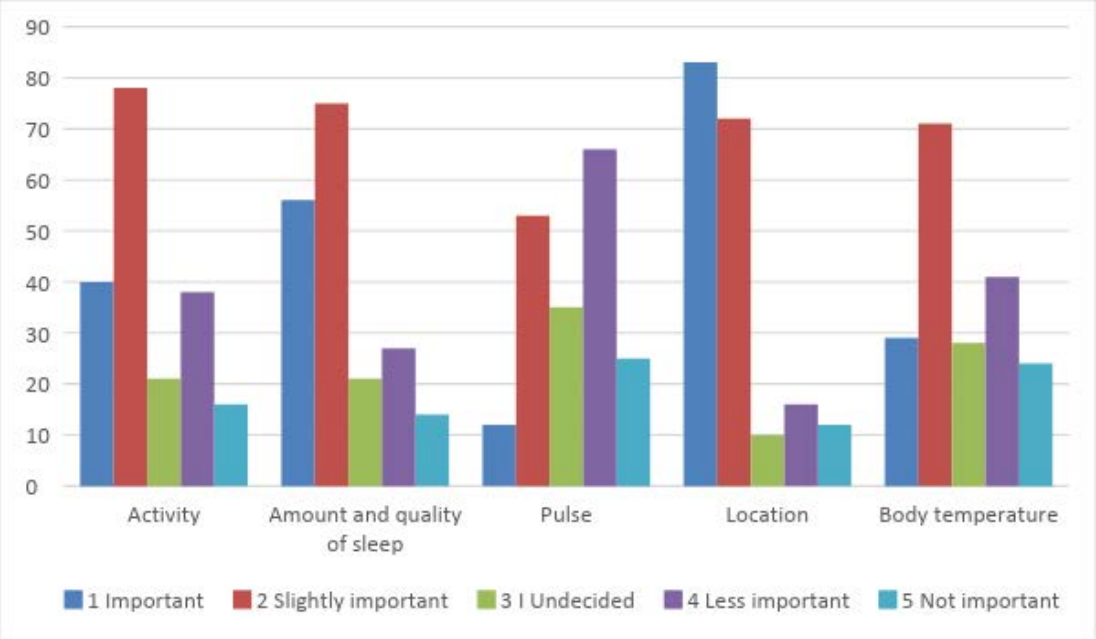
Question 5. Which technical specifications do you prefer on children's smart textile? Multiple-choice question. N=187.

Question 6. What other features do you prefer on children's smart textile? Open-ended question. N=49

- Durability (17)
    - Durable (6)
    - Safeness (3)
    - Waterproof (2)
    - Wash-ability (2)
    - High quality (2)
    - Operational reliability (1)
    - Easy care (1)
- Measuring feature (14)
    - Recognition of temperature and such either warming or cooling feature (4)
    - Activity (4)
    - UV -light recognition (2)
    - Fluid balance (1)
    - Blood glucose (1)
    - Dirt recognition (1)
    - Indicator to state the state of waterproofness (1)
    - Indicator to state the state of waterproofness (1)
- I don't know/ I don't need any (11)
- Usability (10)
    - Comfortable (3)
    - Easy to use (2)
    - Light (1)
    - Good fit (1)
    - Breathability (1)

    - Self-cleaning feature (1)
    - Aesthetic (1)
- Ecological / Recyclable (4)
- As tracking location, also the possibility to communicate (4)
    - call for help (1)
    - call the child (1)
    - alert if a child wonders too far (1)
    - with other smart textiles (e.g. alerting when gloves are left in the park) (1)
- Protecting features (4)
    - Protecting (1)
    - Hardening of the fabric in collision (1)
    - Windproof (1)
    - Led/ alarm lights (1)
- Price (1)

Question 7. How important do you consider measuring the following things? Single choice question. N=193



Question 8. What other features do you desire to measure with smart textile? Open-ended question. N=24

- I don’t know what/ why measure something (7)

- UV -radiation (3)
- Blood glucose level (3)
- Fluid balance (2)
- Amount of light (1)
- Outside temperature (1)
- Load factor of diaper (1)
- Stress level (1)
- Time spent with mobile device (1)
- Mold/ indoor air quality (1)
- Pulse (1)
- Body temperature (1)

Question 9. Which one do you consider being most important? Single choice question. N=190.

109 (57.4%): Both are as important

41 (21.6%): Smart textile is used to gather information about child's activity, body functions or location for adult's use

40 (21.1%): Smart textile brings joy or activates the child

APPENDIX 4

Appearance of children's smart textiles questions and answers

Question 10. Which one do you consider being most important? Single choice question. N=189

130 (68.8%): Both are as important

38 (20.1%): The appearance of the smart textile

21 (11.1%): The technical features of smart textile

Question 11. With your own words, describe what kind of features of appearance do you prefer on smart textiles. Open-ended question. N=57

- "Normal" appearance/ commonness (19)
- The smart feature unnoticeable (11)
- Aesthetics/ elegance/ modernity (11)
- Down-to-earth/ Unisex/ Not too bright colors (11)
- Something that pleases the child/a child wants to wear (6)
- Not too sporty (4)
- Usable (4)
- Bright/ colorful/ personal (2)

APPENDIX 5

Question 12. With your own words, describe which kinds of desires and expectations you have on smart textiles? Open-ended question. N=69

- Easy to use and care (15)
    - Wash ability (3)
    - Soothing everyday life (2)
- Appearance/ good looking (8)
- Brings joy to a child/ a child prefers (8)
- Reasonable price (8)
- I have no expectations/ I am not interested (7)
- Safety (materials, technology and information safety) (6)
- I have doubts/ I don’t want to control a child (6)
- Durable (5)
- Reliable/ functional (4)
- Tracking location (4)
- Activating (4)
- Ecological/recyclable (4)
- Creating safety (3)
- Ability to modify/ long life (3)
- Constant, rapid development (price/accessibility) (2)
- Low battery usage (1)
- Compatibility with mobile device (1)
- Not compatible with mobile device (1)
- Authentication of brand clothing (1)

APPENDIX 6

Fears and worries questions and answers

Question 13. Is there something that worries you on children's smart textiles? Tell freely. Open-ended question. N=111

- Information security (48)
- Health impact (46)
    - Somatic health impact/ safeties (29)
        - Short-circuit (4)
        - Radiation (3)
        - Skin comfort (3)
        - Wi-Fi (1)
    - Psychological health impact (17)
        - Passivating/ no need to activate a child with technology (8)
        - Addictive (5)
        - Non-equalization (2)
        - Effect on child psyche (1)
- Durability/usability (19)
    - Wash ability (9)
    - Is smart feature integrated or separate part (1)
    - What happens when the "smart part" gets broken (1)
    - Resale/ usage on siblings (1)
- Over the top coordinating/control/ privacy of the child (10)
- Price (9)
- Electronical waste (5)
- Appearance (3)
- No worries (3)
- Smart textile is not necessary (2)
- Worry of "going too far" (1)
- If someone would steal an expensive clothing (1)
- Over the top compel (1)
- What is the energy supply (1)

APPENDIX 7

Willingness to purchase questions and answers

Question 14. Would you be willing to purchase a smart textile product produced by Papu Design? Single choice question with one choice with an open-ended. N=187.

Maybe, if…. (N=60)

- The smart feature is useful/there is need/is interesting/adds value (40)
- Price (13)
- Safety (3)
- As a present (3)
- Design/style is good (3)
- I had own children (3)
- Is fun/brings joy to child/is interesting to a child (3)
- Can be found second-hand (1)
- Sizes also for teenagers (1)
- Smart feature is durable (1)
- Smart feature is removable (1)
- Ethically produced (1)
- I gain more information on topic (1)

Question 15. Which kind of smart textile produced by Papu Design would you be willing to purchase? Multiple choice question. N=174

110 (63.2%): With tracking location

91 (52.3%): With measuring something, such as body functions or activity

75 (43.1%): With visual effects such as color change and light effects

56 (32.2%): With gamification features

50 (28.7%): With tracking the manufacturing process and the origin of the product features

28 (16.1%): With authentication features

18 (10.3%): With augmented reality features

3 (1.7%): Other

Other (3)

- Innovation to ease e.g. eating or sleeping
- Dirt monitoring clothing
- Temperature recognition and the indicator for the state of waterproof