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Evaluation of the QR Code Fabric Tag System for Textile Companies in Turkey

Türkiye'deki Tekstil Firmaları için QR Kod Kumaş Etiket Sisteminin Değerlendirilmesi

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EVALUATION OF THE QR CODE FABRIC TAG SYSTEM FOR TEXTILE COMPANIES IN TURKEY

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ABSTRACT: We proposed a QR Code Fabric Tag system, which provides an online archive for the textile companies to keep detailed information about the fabrics and transactions related to them. To provide easy way to access this information, each fabric cartel used by the company should be labeled with a unique QR code label. When the QR code is scanned by a QR Code Fabric Tag mobile application, installed on a company smartphone, all the information related to the fabric will be displayed. We tested the developed system on a group of 60 volunteers, and evaluated the performance of the system using the System Usability Scale questionnaire, filled by each participant.

Keywords: QR Code Fabric Tag, QR code, fabric tag, fabric label, textile companies in Turkey.

TÜRKİYE'DEKİ TEKSTİL FİRMALARI İÇİN QR KOD KUMAŞ ETİKET SİSTEMİNİN DEĞERLENDİRİLMESİ

ÖZET: Tekstil firmalarının kumaşlar ve kumaşlara ilişkin işlemler hakkında detaylı bilgileri saklayabilecekleri bir online arşiv olanağı tanıyan bir QR Kod Kumaş Etiketleme Sistemi sunmaktayız. Bu bilgiye kolayca erişim sağlayabilmek için firmanın kullandığı her kumaş kartelinin eşsiz bir QR kod etiketi ile etiketlenmesi gerekmektedir. Bu QR kod şirket akıllı telefonuna yüklenen bir QR Kod Kumaş Etiketi mobil uygulaması tarafından taratıldığında o kumaşa ilişkin tüm bilgiler ekrana yansıtılır. 60 gönüllü ile bu geliştirmiş olduğumuz sistemi test ettik ve her katılımcının doldurduğu Sistem Kullanılabilirlik Ölçeği anketi ile de performansı değerlendirdik.

***Anahtar Kelimeler*:** QR Code Fabric Tag, QR kod, kumaş etiketi, kumaş işareti, Türkiye'deki tekstil firmaları.

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1. INTRODUCTION

Firstly used in automotive industry in early 90s, Quick Response code (QR code) [1,2] is now seen frequently in any domain of our daily lives. The most important reason of it is the time- and cost-saving advantages that it provides through its technology. Another important feature is its wide utilization in every domain and sector. It is widely used in medicine packages, products in markets, job advertisements, and even in restaurant menus and museums in global scale. Through the QR code, one can easily access the information such as image, text, video and/or Rich Site Summary (RSS) through barcode-scanning applications and the camera of the mobile device. It is believed that the QR code will gain significant place in mobile payment systems and Near Field Communication (NFC) applications. The awareness about the usage of QR code increases in parallel with the increase in number of smartphone users. Nowadays, the smartphone users closely follow the QR code campaigns. There are many services and campaigns provided through QR codes [3,4].

The QR codes are one of the game changers in mobile marketing domain of these days. The use of QR codes in marketing has affected the settled approaches. The use of these codes allows the marketers to create and design extraordinary interactions with the potential and/or existing customers [3,4].

Cesar [5], a dog food manufacturer, has organized a advertisement campaign via QR code and Pandora. User, through the posters prepared with QR codes, can reach the music and radio service by scanning the QR code. They can listen to the company's radio channel through Pandora. In this channel, there are particular songs that can also be listened by dogs.

World-wide known Kellogg's Co. [6], a well-known cereal and wheat flakes, has used QR codes for advertisement of its new cereal flakes named "Crunchy Nut". Through scanning QR code, a mobile webpage containing the campaign's video titled "It's Morning Somewhere" opens up. Containing 13 videos, the mobile page drew more than 50,000 visitors. Kellogg's, which accomplished a very successful campaign with videos watched more than 38,000 times, could introduce its new product to customers immediately. Another important point is to advertise by triggering the interest of the customers without any pressure.

eBay [7], offering online world-wide purchasing opportunities, has used extraordinary and significantly successful QR code campaign besides its internet advertising. In a study carried out in New York, separate QR codes have been prepared for each of the products located on the booth. By scanning the QR Code of the desired product, the user can easily purchase the product via eBay's application.

In order to improve the brand recognition, the companies increasingly participate into social responsibility projects in recent period. Many companies are the sponsors of the social responsibility projects in domains related with them.

One of the examples for that is Heinz Co. [8]. By adding QR codes to its environment-friendly bottles, the company has made an extraordinary design. The customers scanning the QR code via their mobile devices may donate for Wounded Warrior Project operating in America. As a result of their work with QR code, 1 million of codes have been scanned, and a very successful campaign has been accomplished.

In globalizing world, people work more, and they have less time for shopping. Having the awareness of the situation, Tesco [9] designed the billboards like market shelves rather than organizing billboard advertisings. Hence, 10,287 customers purchased something while waiting for the metro. Therefore, the online sales of the company raised by 130%.

In New York's Central Park "World Park" [10] campaign, an interactive game has been prepared for Arbor Day. Many QR codes have been distributed throughout the park in order to draw the attention of young people. These QR codes have been carrying different information.

The Association Media & Publishing [11] conference has been organized as a paperless event last year. That conference has utilized QR codes at various locations in order to guide the participants. Through the QR codes, the organizer of the conference have provided information about the speakers and events, offered local restaurant options, received the opinions of the participants, and show the conference plan. The QR codes have also been used in name badges which were used like a virtual business card.

The Cleveland Museum of Art [12] (just like many other museums) uses QR codes in order to guide the visitors to the online or audio tours via smartphones, or in order to offer more detailed information.

During Google's [13] Favorite Places campaigns, approximately 100,000 companies within the borders of United States have been tagged as "Favorite places on Google". Each of these companies has received a unique QR code to be attached on the window. Through these QR codes, the people passing in front of the companies can find information about the company, reviews of previous visitors/customers, and star the business as their favorite.

For Mercedes-Benz Fashion Week, L'Oreal [14] has established a partnership with Glamour, and then transformed a certain number of cabs into Taxi Shops by placing QR codes in them. The customers of the taxis were able to purchase the products during their trips. The L'Oréal's mobile application has been downloaded by 90% of the passengers that used their smartphones. 1/3 of the passengers scanned the QR code, and 25% have purchased product(s). Because of the traffic in New York City, most of the taxi passengers are bored in vehicles during the trip, and these results of the campaign indicate a great success in terms of utilization of QR code.

Walmart [15] has recently introduced its new application named Scan & Go that enables clients to scan and bag groceries as they shop. After completing shopping, the clients go to the self-checkout register, and tap the "Transfer Scan & Go Basket" button on the checkout display. The items are transferred from the phone to the register by scanning the QR code located on the screen. After this process, the customers can pay the bill as they normally would.

Some examples of how QR code was utilized in Turkey follow. Jack Daniel's [16] prepared a QR code campaign for its special cocktail Lynchburg Lemonade. Through the QR code used in special packages and brochures, the customers desiring to continue enjoying the Jack Daniel's Lynchburg Lemonade in their houses were provided with the access to the video explaining how to prepare a Lynchburg Lemonade. Jack Daniel's explains the feedbacks of their campaign as follows; "More than 30,000 single users watched the video by downloading to their mobile by using QR code. There are also the watchers of the video in addition to this number". Now, the Jack Daniel's Turkey Facebook page is reached through QR codes both on gift-packs and other communications with customer.

SoftTech [17], through the mobile payment system "Parakod" developed by them for İş Bankası [18], used the QR code for payment purposes for the first time in Turkey. Hence, without any physical credit card, it became possible to purchase by scanning the QR code in display of the Point of Sale (POS) device via customer's mobile device through Parakod application in IşCep. This technology also allows us to avoid from entering our personal and financial information such as name-surname, credit card number, and expiration date or security code in internet shopping. SoftTech aims to make it available to pay the bills via scanning the barcode or QR codes on the bills.

Developing mobile applications, Pozitron (sold to Monitise in 2014) [19] prepared a project of "withdrawing money from ATM via QR codes" for Türk Ekonomi Bankası (TEB-Turkish Bank of Economy) [20]. Thanks to this feature, that is first in both Turkey and world, the users can withdraw money from ATM through the code they created with their iPhone.

Thanks to QR code application started by Divriği Ulu Camii and Darüşşafaka, listed in UNESCO's "World Culture Heritage" and accepted as "El-Hamra of Anatolia", the visitors are offered the opportunity of the presentation in 4 languages via smartphones and tablet computers without need for any guide [21].

Türkiye Newspaper [22] delivers its important news, photo portfolios, and news videos to its readers via QR code. Linking the newspaper pages to internet via smartphones, Türkiye Newspaper connects from paper to digital media for the first time in Turkey. Readers scanning the QR codes of the important news within the papers of newspaper via the cameras of their smart phones will be able to reach the rich photo content and the video of the news within seconds.

1.1 QR code

1.1.1 What is QR code?

In year 1994, the QR code has been developed by Denso Wave [1], [2]. Example of QR code is depicted in Figure 1. That version was a 2D Code, since it has been coded in vertical and horizontal directions. Through that design, it was possible to store larger amount of information into the code. There are also other types of 2D Codes available on the markets. Each of them has unique advantages and disadvantages.

Some of the features, which are thought to be useful for clients, of QR code are listed below:

- First its data capacity, QR code can contain up to 4296 alphanumeric data or 7089 numeric data or 2953 binary data. It means in clear that you can write a text long of 4296 character within your code that will be readable by any translating software.
- In order to translate the barcodes, there are many price-free applications in online application stores. Through these codes, you can not only code the important product info into the code, but you also can provide your clients with direct interactive links.
- This code can be used in textile forms, and it will still be able to be scanned and read.
- Should the code be smudge or partially damaged QR code system has an error correction capability up to approximately 30%.
- In order to keep the same amount of data stored by a traditional 1D Barcode, the required space is only 10% of the space that is required in case of Barcode.
- It can also encode the Kanji Characters (漢字) .
- It is capable of 360 degree high speed reading.
- In this system, 1 Code can be divided up to 16 smaller codes. This feature is useful when it is needed to print on smaller surfaces.

Figure 1. QR Code.

1.1.2 How does it work?

There are many free QR code applications that can create a code from the data. User enters the data to be embedded into the code,

and then the application creates the QR code that can be used in digital form or in printed form. In order to decode the data embedded in the code, the camera of any mobile device such as smartphone or tablet PC that includes QR code scanning application can be utilized. After the user scans the code, the application decodes it [23].

QR codes are capable of storing significantly complex information into a small matrix. The common denominator glue is the mobile phone. The new social interactions generally make use of various sources such as face to face meetings, voice calls, SMS, email, IM chat, social applications such as Twitter & Facebook and many others [3,4].

1.2 QR Code in Textile Industry

Textile sector is one of the firsts using QR code. QR code, seen especially while shopping, offers the chance of having detailed information about the product when scanned via mobile device. It increases the satisfaction of the customers, who like to shop alone and who don't want to interact with store personnel within the crowd.

Manufacturer can keep the records of the customer habits via scanned QR codes. Due to this advantage of them, the mentioned technology is now used by any marketing and sales channel aiming to "touch" the end user.

Victoria's Secret [24], a world-wide known underwear company, allows its advertisements in America to be demystified through QR codes. Victoria's Secret's QR code campaign "Sexier Than Skin" has got very good responses in America.

Macy's [25] has placed QR codes on clothing signage. These QR codes were providing fashion hints to the clients from the designers about how to wear the clothes consumers purchased. It has been observed that this implementation has brought increase in sales.

Many of large brands and well-known retailers such as Harrods [26], H&M [27], and Ralph Lauren [28] have announced that they are planning to use QR codes for targeting a new customer base. H&M placed QR codes on billboards and magazine advertisements in order to direct the users scanning the code to the official H&M webpage. In this page, the users will be provided with the color and size options of the product they saw in the ad. They can also place an order, and pay the price through mobile payment.

In year 2008, Polo Ralph Lauren [28] has introduced its new QR code based mobile commerce service. The codes were distributed to various locations and sources. The distributed QR codes were directing the users to a site featuring Ralph Lauren's limited edition 2008 U.S. Open collection. Through these codes, the users were also be able to read the RL Magazine, to access style guides Questions and Answers (Q & A), to watch exclusive RLTV videos and tennis videos, to read tournament articles, and to experience the brand fully.

Mobile-Life application developed by Pierre Cardin [29], the first for Turkish textile industry, eliminates the obligation of carrying the credit card physically. Customers can use Fashionality Card number in purchasing from Pierre Cardin stores; they don't need to carry the card. They can display bonuses from purchases; can use bonuses in purchases via QR code without needing the card etc.

The opportunities provided by QR code are also studied by the textile designers, and it is aimed to offer new perspectives to the integration of smart technologies with craftsmanship [30]. For instance, by establishing a connection between the meanings and the patterns and motives of Muhu Skirt, which is the traditional cloth of Estonia, various QR code implementations were performed via embroidery technique. In first of QR code applications consisting of 3 prototypes, the lifespan of the used material was involved, while a tale about the codification of the tradition was involved in second and the proverb and idioms of the region were involved in third application [31,32].

There are various examples of QR code's implementation via printing, knitting, embroidery, beadwork, patchwork, and other methods in real life [30].

The QR-3D project designed by Sally Fort [33] focuses on integrating the matrix bar codes into textiles. The codes are cross-stitched into samplers, quilted onto clothing, printed onto fabric, and knitted straight into a sweater. With their pixel-based formats, QR codes resemble two-color textile patterns of many varieties, which inspired Fort to challenge textile artists to combine high tech and artisanal craft.

During the preparation of the quilt exhibit Frugal and Fancy: Quilts of Indiana at the Indiana State Museum during 2010 and into 2011 [34], video was shot documenting the conservation and installation of objects as an effort to extend and deepen the visitors' museum experience. The museum turned to the use of QR codes, as a means of accessing the video. The QR code was made into a quilt and hung in a quilt exhibition.

1.2.1 Labels with QR codes

The use of QR codes and the number of QR code scanning applications increase as the number of QR code implementations on textile sector increases. The use of QR codes on the labels brings many new benefits such as marketing, engagement with social networks, identification and traceability [35-37].

Marketing

By adding a QR code on the label, one can allow the user to scan it and to get the embedded information. So, a woven label involving a QR code becomes a new marketing tool that communicates the user with the company's website or with a promotion.

Engagement with social networks

Through adding a QR code on the label, the companies can allow their customers to reach the companies' official social media pages such as Twitter or Facebook profiles. This strategy will bring the closeness, and also allow the company to use the social media more productively.

Identification

By sewing the woven label onto the label and adding a QR code will enable the development of many new opportunities in terms of identification. The woven labels involving QR code for personal identification can be utilized in clothing. This implementation may be useful for identifying the person in some cases such as accidents, business purposes, and etc.

The use of identification has a wide spectrum of possibilities when it is applied within people in degenerative disease environments (Alzheimer, senile dementia,..) and children in which the identification will be possible in case lost.

The fact that the QR code is sewed to the label permanently and consequently it cannot be deleted or eliminated when washed, will make easier to read the person's details in extreme conditions, allowing its identification in any moment and immediately.

ICEid developed ICEid Tags and ICEid QR CODE stickers [38] in order to identify people and provide medical information about them in case of emergency. ICEid Tag is made of plastic and is waterproof. It can be washed while attached to clothes in the washing machine and can be attached to a zip on clothing whilst cycling, running or any outdoor activity. It can also attach to school bags, hand bags and backpacks. The ICEid QR CODE sticker can be attached to bicycle, motorbike, scooter or any helmet. Both ICEid Tag and ICEid QR CODE sticker feature a unique QR code and matching alphanumeric code. The QR code can be scanned to access personal and medical information or this information can be accessed via the ICEid website.

childIDcode [39] developed identification stickers for kids prone to wandering and elopement. These waterproof stickers are custom-printed with a QR code. When the code is scanned with a smart phone it will display, "I Have Autism" along with the emergency contact. Stickers can be placed on clothing, hats, backpacks, etc. They're vital for school field trips, vacations, even daily outings where child may be at risk of wandering or bolting. They are also a great option for kids with sensory issues who are unable to tolerate ID bracelets.

If I Need Help [40] is a nonprofit organization working to reunite those who are lost, disoriented or can't self-advocate with their loved ones and caregivers. They use QR code patches for emergency identification. These QR code patches can be sewn onto items of clothing or a variety of clothing with the QR code patches already attached may be purchased.

Traceability

Adding a QR code on a woven label will allow the customers to easily obtain the information about the product they are interested in. Some of the information that can be obtained through QR codes labels are the country of manufacture, composition of the fabric used in the product, instruction and washing conditions, season, line, campaign, and etc [41].

Fairtrace [42] aims to introduce the technologies that support Semantic Web Technologies (SWT) in order to ensure the useful traceability in supply-chains, particularly for the textile sector. The main objectives are the identification throughout the supply-chain, managing the orders, and tracking and reporting the problems. The traceability provided by these solutions can also contribute to the customer satisfaction through providing them with additional data about the product, company and/or etc. The main contribution of this research is the utilization of Semantic Web in real-world industrial traceability solutions that have been verified in Switzerland and India. The presented solutions have started to be commercialized. The developed solutions also allow the consumer to benefit from the traceability through information pages available by scanning the QR codes available on the finished products (clothes, clocks, etc.).

A technology for tracing the textile production process has been developed by "HeiQ" [43], a Swiss textile technology innovator, and "tracekey", its German technology partner. The application named IDENTITY verifies the authenticity and accountability, it also aims to satisfy the customers requesting even more. The operation of the IDENTITY technology is based on the unique serial numbers (like Swiss banknotes) located in an individualized QR code. Through these unique serial numbers, all of the traceable components determined by the brand can be traced. By easily scanning the code located on the hangtag or textile care label, the clients can easily track the information about each of the components such as its origin, its consumer labels certifications, and even the name of production personnel and the date. By using IDENTITY by HeiQ, the clients can transparently reach the information about the products they are about to purchase. The important part of this technology is that it offers the guarantee to its customers about the full product accountability and authenticity from fiber to point of sales; it is a first in industry.

The R Cert [44] is a consumer-facing standard for recycled textile clothing. It has been announced for a second time for the "Recycled Collection by Esprit" in a breakthrough indicating the new era for Asia's sustainable fashion innovation. The R Cert is now available in many markets such as Mainland China, Taiwan, Singapore, Hong Kong and Malaysia. It is planned to reached New Zealand and Australia before the end of the year. The R Cert has been designed by Redress, an Asian fashion Non-governmental Organization (NGO), in order to encourage the brands for recycling their textile wastes and for educating the

users about positive effects of using recycled clothes. Through this technology, the users can track the whole process of recycled textile product from the factory to the store only by scanning the QR code located on the product. Then the users will be directed to their brand's customized, mobile-friendly animation that allows them to reach information about how the recycled clothes have been manufactures and about the contributions of recycled clothes to the environment. Users can also use the R Cert webpage for this purpose.

Diving headfirst in the 21st century of fashion, and thus bringing the clothes industry to an age of technology, the collaboration between Avery Dennison [45] (a packaging and labelling giant that puts label on products for brands like Nike, Adidas, Hugo Boss…) and Evrythng [46] (described here and there as the Facebook for things firm backed by Cisco and Samsung) aims at creating unique web identities for various products (apparel, shoes and accessories) over the course of the next three years. By assigning these IDs, at the point of manufacturing, this will create new personalized interaction opportunities between consumers and those products that go beyond the point of sale. In most case, things will start simple with printed QR codes that consumers will scan with their smartphone to access a service or identify a piece of apparel. Using different kind of technology, depending on the kind of cloth (connected thanks to wireless chips using NFC or Radio-frequency Identification (RFID) technology), the products will then generate extra data that may be used in multiple ways: have implications for stock control, lost prevention, detect fraudulently returned products, check the authenticity and manufacturing history, enabling consumers to participate in new after-sale loyalty schemes or rewarding programs, see exclusive content, re-order products [47].

1.3 Our contribution

In order for a textile company operating commercially to survive in market environment, it must know the Research and Development (R&D) information and unit costs of the product it manufactures or sells. The companies that manufacture and sell fabric keep an archive of the fabrics they produce. In this archive, there is all the information about the fabric. This information includes the brand of fiber needed for fabric, its price, the name of contract manufacturer and the information about the machine producing the fabric, raw weight of the fabric, contract manufacturing cost of the fabric, in which dye house the fabric has been dyed, dye prices, the dyeing and finishing procedures, dye loss of the cost, and the cost of the fabric. The price offered to customer is specified. The USD and € prices (according to the actual exchange rates) are included in this archive. This archive is very important for fabric manufacturers. When reproducing the fabric, the manufacturers utilize the archive information as reference. So, there will be no need for a new R&D operation for the fabric. It is required to prepare a chart from the manufactured fabrics, and to keep it in archive folder. When client wants to see the fabric, he/she can more easily make a decision about making an order by observing the fabric.

It takes too much time to gather all the information about the fabrics and to file them. These files occupy very large places. For this reason, they need to be classified after a while. In order to eliminate this classification operation and the excessive filing, we developed an online QR Code Fabric Tag system which gathers all the information about the fabric online on its QR Code Fabric Tag web site. All the information will be entered by the textile company. Moreover, using the QR Code Fabric Tag web site textile company will create and print QR code labels/tags for all of its fabrics and stick them on to the cartel of the fabric. That QR code is unique for each fabric. Whenever the textile company wants to access the information related to any fabric, they will scan the QR code label/tag placed on a cartel of the fabric using QR Code Fabric Tag mobile application installed on their smartphones.

We tested the developed system on a set of 60 volunteers from various textile companies which manufacture and produce fabrics. To evaluate the usability of the system, after using the QR Code Fabric Tag system for a week they were asked to fill System Usability Scale (SUS) questionnaire [48-50]. There are numerous surveys available to usability practitioners to aid them in assessing the usability of a product or service. Many of these surveys are used to evaluate specific types of interfaces, while others can be used to evaluate a wider range of interface types. We used the SUS questionnaire because it is one of the surveys that can be used to assess the usability of a variety of products or services. There are several characteristics of the SUS that makes its use attractive. First, it is composed of only ten statements, so it is relatively quick and easy for study participants to complete and for administrators to score. Second, it is nonproprietary, so it is cost effective to use and can be scored very quickly, immediately after completion. Third, the SUS is technology agnostic, which means that it can be used by a broad group of usability practitioners to evaluate almost any type of user interface, including Web sites, cell phones, interactive voice response (IVR) systems (both touch-tone and speech), TV applications, and more. Lastly, the result of the survey is a single score, ranging from 0 to 100, and is relatively easy to understand by a wide range of people from other disciplines who work on project teams [48-50].
We evaluated all the questionnaires filled by the participants and obtained mean SUS score, which is above the success threshold; this makes the developed system usable and satisfactory.

2. MATERIALS AND METHOD

QR Code Fabric Tag system helps the textile companies that manufacture and sell fabric to store and provide easy access to all the information related to the fabrics. QR Code Fabric Tag system consists of three parts; web site, database and a mobile application. QR Code Fabric Tag web site is used by the textile

companies to enter/update information related to their company, to enter/modify information about the fabrics and print the QR code labels. Each fabric used by the textile company is assigned a QR code, which is placed on the cartel of the fabric. When QR code label is scanned by the QR Code Fabric Tag mobile application, installed on the smartphone of the company, all the information available related to the fabric will be displayed on the smartphone. QR Code Fabric Tag database is used to keep all the information about the companies, records related to the fabrics and their transactions. QR Code Fabric Tag system is depicted in Figure 2.

Initially, interested textile company has to register to the QR Code Fabric Tag web site. The user is asked to choose a strong password. After the account is created, member is required to enter the detailed information about the company and provide detailed information and transactions related to each fabric used by the company. When the process is completed a unique QR code label/tag is generated for each fabric. This label can be printed and placed on the cartel of the fabric. Users can change their information any time by logging in into the web site. QR code label does not have to be issued again as it does not contain the information, it contains the link to the password protected web page. But it can be printed as many times as necessary.

Moreover, the amount of single-plate knitted fabric in kg/h and all the costs per kg of that fabric in TL currency can be automatically calculated by the web system. Every company can calculate a standard cost specific to that company by using their own data, which they have to enter into the QR Code Fabric Tag web site.

Figure 2. QR Code Fabric Tag.

2.1 QR Code Fabric Tag system

QR Code Fabric Tag system consists of three parts; web site, database and a mobile application.

Web site

The QR Code Fabric Tag web site may be used by textile companies to:

1. register into the system
2. login into the system
3. enter information about the company
4. update the information about the company
5. enter transactions related to each fabric used by the company
6. update transactions related to each fabric used by the company
7. print the QR code tag/label containing the link to the information about the fabric
8. enter data related to cost calculation of the company
9. calculate costs specific to that company by using their own data
10. log out of the system.

When entering information about the transactions related to the fabric used by the company. This data has to be provided:

1. the brand of fiber needed for the fabric
2. price of fiber
3. the name of contract manufacturer
4. information about the machine producing the fabric
5. raw weight of the fabric
6. contract manufacturing cost of the fabric
7. in which dye house the fabric has been dyed
8. dye prices
9. the dyeing and finishing procedures
10. dye loss of the cost
11. cost of the fabric
12. information about the customer
13. price offered to the customer
14. the USD and € prices (according to the actual exchange rates)
15. the amount sold

Mobile application

The QR Code Fabric Tag mobile application may be used by textile companies to:

1. login into the system
2. scan the QR code tag/label containing the link to the information about the fabric
3. view the information about the fabric after the QR code has been scanned
4. log out of the system.

Database

The QR Code Fabric Tag database is used to:

1. keep the records of all the registered textile companies

2.2 Hardware requirements

In order for this system to be implemented successfully, the following hardware requirements have to be satisfied.

Textile companies need to have:

1. at least one desktop computer or a laptop
2. an Android smartphone
3. a printer
4. an internet connection.

Laptop will be used in order to:

1. use the QR Code Fabric Tag web site
2. send request to a printer to print the QR code tag/label containing the link to the information about the fabric

Smartphone will be used to:

1. scan the QR code tag/label containing the link to the information about the fabric
2. view the information about the fabric after the QR code has been scanned.

Printer will be used to:

1. print the QR code tag/label containing the link to the information about the fabric

Internet connection will be used to:

1. connect laptop and smartphone to the QR Code Fabric Tag web site
2. connect laptop to the printer.

The advantage of QR Code Fabric Tag system that it does not require any special hardware, such as servers, the only hardware it requires is most likely already available in any office, which makes this system cost-efficient and easily installed.

2.3 Software requirements

The software requirements for the QR Code Fabric Tag system are listed below.

Software requirements for the laptop:

1. any web browser installed to successfully connect to the QR Code Fabric Tag web site.

Software requirements for the smartphone:

1. Android operating system

2. any web browser installed to successfully connect to the QR Code Fabric Tag web site
3. QR Code Fabric Tag mobile application installed on the smartphone to scan the QR code tag/label containing the link to the information about the fabric.

QR Code Fabric Tag web site and the database are located on our dedicated server. Textile companies using QR Code Fabric Tag do not have to worry about web site and database management. Maintenance of our system is performed by a web administrator.

2.4 Cost Calculations

In this study, the amount of single-plate knitted fabric in kg/h and all the costs per kg of that fabric in TL currency can be automatically calculated. Every company can calculate a standard cost specific to that company by using their own data.

Calculation of the Amount of Production

To calculate the cost of a single-plate knitted fabric, it is required to calculate the amount of fabric produced in a unit of time.

$$\text{Meter/Hour} = \frac{n \; x \; MS \; x \; 60 \; x \; R}{\frac{line}{cm} x \; 100} \quad (1)$$

$$\text{Kg/Hour} = \frac{\frac{m}{hour} x \; W \; x \; G}{100 \; x \; 1000} \; x \; 0{,}95 \quad (2)$$

n= speed of machine (rpm)

MS= Number of system in the machine

R= Returns of the machine

W= The width length of fabric when exiting the machine (cm)

G= per m^2 weight of the fabric when exiting the machine

Calculation of Unit Cost:

In general, the cost of knitted fabric is calculated as the sum of raw material, wastage of raw material, knitting contract costs, painting costs, and painting wastage.

KFC= [(YC x W) + KCC + DFC) X W] (3)

KFC= Knitting Fabric Cost

YC = Yarn Cost

W= Waste

KCC= Knitting Contract Cost

DFC= Dyeing Fabric Cost

Labor Costs

While calculating the labor cost, the total wage paid to the personnel working in knitting business, the total number of knitting machine and the total of working hours per month are considered.

Energy Cost:

Electric cost is the cost on the unit of fabric from the amount paid for electric energy.

Depreciation Cost:

Depreciation cost is the depreciation of any fixed asset for a given time period or the cost of replacement of that asset with new one. To calculate the depreciation cost, it is required to know the value of fixed asset, average life span of that asset or the useful life.

Maintenance Costs:

It is the cost borne by the companies for machines' monthly maintenances, spare parts, or reparation.

$$\text{TL/Hour (labor per hour)} = \frac{sum\ of\ personnel\ wages}{the\ number\ of\ knitting\ machines\ x\ day\ x\ working\ hours\ per\ day} \quad (4)$$

$$\text{TL/kg (cost per kg)} = \frac{cost\ of\ labor\ per\ hour}{amount\ of\ fabric\ manufactured\ in\ an\ hour(kg)} \quad (5)$$

$$\text{TL/kg (energy consumed per kg)} = \frac{energy\ fee\ (per\ machine)}{amount\ of\ fabric\ manufactured\ per\ hour(kg)} \quad (6)$$

$$\text{TL/Hour (depreciation per hour)} = \frac{cost\ of\ knitting\ machine}{depreciation\ period(year)x\ hour/year} \quad (7)$$

$$\text{TL/kg (depreciation per kg)} = \frac{depreciation\ cost\ per\ hour}{amount\ of\ fabric\ manufactured\ per\ hour(kg)} \quad (8)$$

$$\text{TL/hour} = \frac{monthly\ cost\ of\ maintenance}{number\ of\ machines\ x\ day\ x\ working\ hour\ per\ day} \quad (9)$$

$$\text{TL/kg} = \frac{TL/Hour}{Amount\ of\ production\ per\ hour(kg)} \quad (10)$$

Finishing Costs:

According to the demands of clients, the fabric is subjected to various finishing processes. The price paid directly affects the cost of knitted fabric. Since the water and chemicals are also used in finishing businesses differently from knitting businesses, these costs directly affects the knitting costs.

2.5 Implementation

We have developed a system which consists of a web site, database containing the records and a mobile application using PHP [52], MySQL [53] and Java [54].

Although PHP is a server-side scripting language that has been designed for web development, it is also utilized as a general-purpose programming language. It has thousands of programming functions easing almost any task.

MySQL database was used to keep the records. MySQL is the world's second most widely used open-source relational database management system.

In order to design applications which will be operated on any device, notwithstanding the operating system, we prefer the PHP and MySQL since utilization of PHP scripting and MySQL database eases the task of programmers.

We developed a mobile application for Android mobile phone. Android [55] operating system has been designed based on the Linux kernel with a user interface based on direct manipulation; its primary targets are the touchscreen mobile devices such as smartphones and tablet computers. We prefer to use the Android, because it is, as of the year of 2011, the largest installed base of any mobile OS and, as of the year 2013, the devices using Android has been sold more than the sum of devices using Windows, iOS and Mac OS. Besides the Android, we also plan using other mobile operating systems while developing applications.

Android application was developed using the Java language. Java is a very popular programming language developed by Sun Microsystems (now owned by Oracle).

3. RESULTS AND DISCUSSION

We evaluated the performance of the system using the Brook's SUS [48,49] questionnaire, a simple, ten-item attitude Likert scale, covering a variety of aspects of system usability, such as the need for support, training, and complexity.

Sauro stated that a translated version was shown to have similar internal reliability to the original English version [51]. Since our system was developed in Turkish and for Turkish customers we translated the questionnaire into Turkish language.

All tests were performed on a group of 60 textile companies located in Istanbul. One worker from each company participated in the trial. Each company required to have at least one computer, one Android smartphone and an internet connection. Participants were requested to download and install the QR Code Fabric Tag mobile application. All the operations and steps were explained to all participants. Each participant was requested to use all the facilities of the QR Code Fabric Tag system for a week.

Each participant was requested to connect to the QR Code Fabric Tag web site through their office laptops to:

1. register into the system
2. login into the system
3. enter information about the company
4. update the information about the company
5. enter transactions related to each fabric used by the company
6. update transactions related to each fabric used by the company
7. print the QR code tag/label containing the link to the information about the fabric
8. enter data related to cost calculation of the company
9. calculate costs specific to that company by using their own data
10. log out of the system.

Each participant was also requested to use the QR Code Fabric Tag mobile application to:

1. login into the system
2. scan the QR code tag/label containing the link to the information about the fabric
3. view the information about the fabric after the QR code has been scanned
4. log out of the system.

After performing the tasks each participant were asked to fill a form, which asked to provide information about their age, gender and computer skills. It was followed by a SUS questionnaire.

Computer skills of the participants were classified as follows:

Level 0 - No Computer Skills
Level 1 - Fundamental Skills (Typing, Mouse)
Level 2 - Basic Computing and Applications
Level 3 - Intermediate Computing and Applications
Level 4 - Advanced Computing and Applications
Level 5 - Proficient Computing, Applications, and Programming

3.1 SUS Questionnaire

Question items included in the SUS survey has a five-scale Likert scale ranged from strongly disagree (1) to strongly agree (5): [51,52]

1. I think that I would like to use this system frequently.
2. I found the system unnecessarily complex.
3. I thought the system was easy to use.
4. I think that I would need the support of a technical person to be able to use this system.
5. I found the various functions in this system were well integrated.
6. I thought there was too much inconsistency in this system.
7. I would imagine that most people would learn to use this system very quickly.
8. I found the system very cumbersome to use.
9. I felt very confident using the system.
10. I needed to learn a lot of things before I could get going with this system.

3.2 SUS Calculation

To scale all values from 0 to 4, 1 is subtracted from the participant's response for odd items, while for even-numbered questions the participant's response is subtracted from 5 [51,52].

The converted responses should be added up for each user and multiplied the total by 2.5. This converts the range of possible values from 0 to 100 instead of from 0 to 40 [51,52].

The SUS score success threshold is 80.3, which is the point where users are more likely to recommend the application to a friend and is the minimum acceptable score. If the overall mean SUS score is above the success threshold, then the application is considered satisfactory and usable overall [51,52].

3.3 SUS Results

We evaluated the performance of the system based on the computer skills of the participants. We created the following groups:

Group 1 - No Computer Skills
Group 2 - Fundamental Skills (Typing, Mouse)
Group 3 - Basic Computing and Applications
Group 4 - Intermediate Computing and Applications
Group 5 - Advanced Computing and Applications
Group 6 - Proficient Computing, Applications, and Programming

SUS score distribution for each participant in a group with no computer skills is presented in Figure 3. The mean SUS score for the group is 80.50.

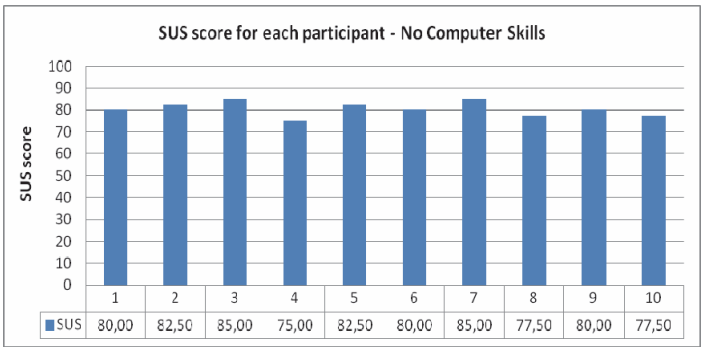

Figure 3. SUS score distribution for each participant in a group with no computer skills.

SUS score distribution for each participant in a group with fundamental skills is presented in Figure 4. The mean SUS score for the group is 85.00.

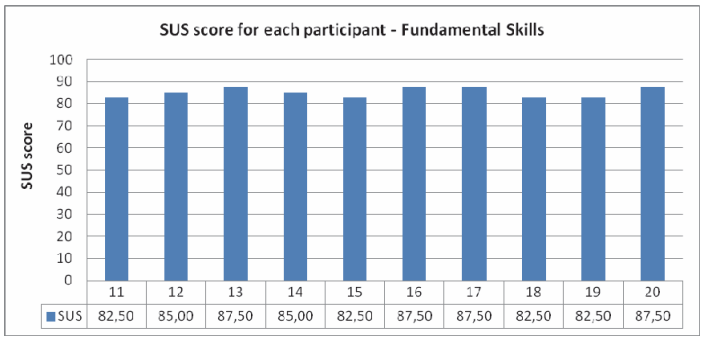

Figure 4. SUS score distribution for each participant in a group with fundamental skills.

SUS score distribution for each participant in a group with basic computing and applications skills is presented in Figure 5. The mean SUS score for the group is 89.25.

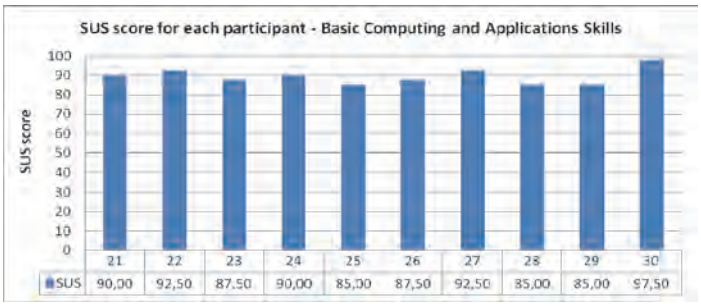

Figure 5. SUS score distribution for each participant in a group with basic computing and applications skills.

SUS score distribution for each participant in a group with intermediate computing and applications skills is presented in Figure 6. The mean SUS score for the group is 91.50.

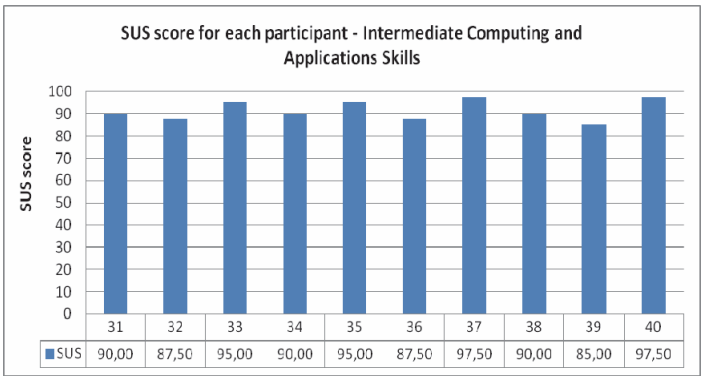

Figure 6. SUS score distribution for each participant in a group with intermediate computing and applications skills.

SUS score distribution for each participant in a group with advanced computing and applications skills is presented in Figure 7. The mean SUS score for the group is 93.75.

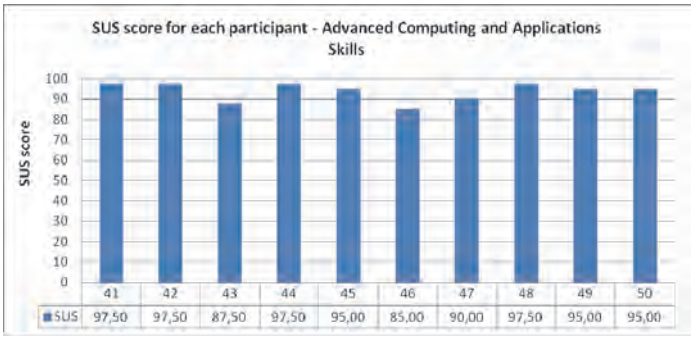

Figure 7. SUS score distribution for each participant in a group with advanced computing and applications skills.

SUS score distribution for each participant in a group with advanced computing and applications skills is presented in Figure 8. The mean SUS score for the group is 97.00.

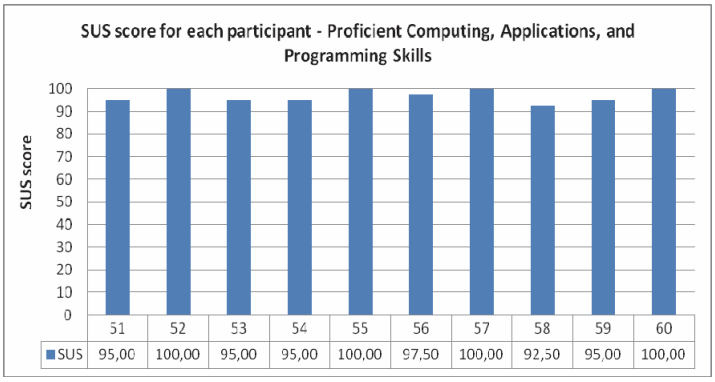

Figure 8. SUS score distribution for each participant in a group with proficient computing, applications, and programming skills.

Mean SUS scores for the groups with various levels of computer skills are depicted in Figure 9.

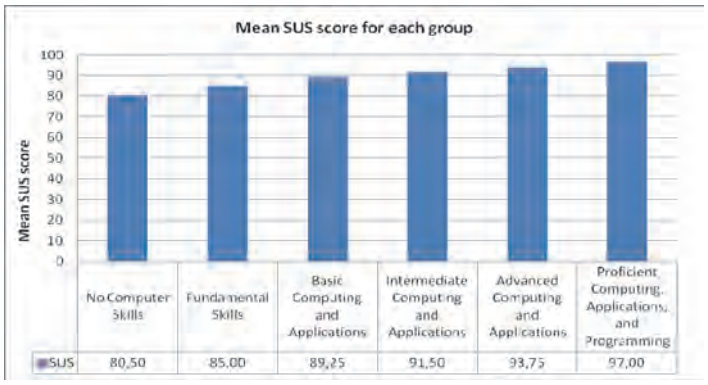

Figure 9. Mean SUS scores for the groups with various levels of computer skills.

As shown in the figure, the mean SUS score values increase as level of computer skill increases. The mean SUS score for the group with No Computer Skills (80.50) is the lowest and the mean SUS score for the group with Proficient Computing, Applications, and Programming (97.00) is the highest, as expected. This is due to the fact the first group had no computer experience, so they needed the support of a technical person to be able to use this system, and they felt they needed to learn some things before they could get going with this system. While the participants with more experience felt compitent using the system. Although participants with no computer skills had some difficulties using the system, mean SUS scores for all of the groups are above the success threshold (80.30).

The mean SUS score for all participants is 89.50, which is above the success threshold (80.30); this makes the developed system usable and satisfactory [51,52].

4. CONCLUSIONS

In this paper, we proposed a QR Code Fabric Tag system for textile companies in Turkey, which provides an online archive for the companies to keep detailed information about the fabrics and transactions related to them. In order to provide easy way to access the information stored by the companies in the online archive, each fabric cartel used by the company should be labeled with a unique QR code label. These QR code labels can be printed through the QR Code Fabric Tag web site. Textile companies will have to install a QR Code Fabric Tag mobile application on their smartphones. When the QR code label is scanned by the installed application all the information available on the QR Code Fabric Tag web site related to the fabric will be displayed on the smartphone. Moreover, the amount of single-plate knitted fabric in kg/h and all the costs per kg of that fabric in TL currency can be automatically calculated by the QR Code Fabric Tag web site. Every company can calculate a standard cost specific to that company by using their own data.

We evaluated the performance of the proposed system using the System Usability Scale. SUS has been shown to effectively distinguish between unusable and usable systems as well as or better than proprietary questionnaires. The mean SUS score for

QR Code Fabric Tag (89.50) system was above the success threshold (80.30), which means that the users were satisfied with the product and likely to recommend it to their friends. 60 volunteers from different textile companies in Istanbul with various computer skills were able to use the system effectively.

The developed system has many advantages. Firstly, it does not require any special hardware; the only hardware it requires is most likely already available in any office, which makes this system cost-efficient and easily installed. Moreover, customers will not have to deal with the problems of maintaining the server, developing/maintaining the web site and maintaining/protecting the database. All of these can be expensive and time consuming and difficult for the companies with no computer experience. Companies will not need to hire any additional personnel to manage the system. Since the system is maintained by the administrators of the QR Code Fabric Tag web site. Furthermore, customers may be mobile and access the system from anywhere; they do not have to be in their offices.

Some shortcomings of the system are as follows. Currently, mobile application works only on Android smartphones. In the near future, applications for other operating systems will be developed. Finally, currently the system is only available in Turkish, official language of Turkey. In the future, it will be extended to support some other languages like English, German and Russian.

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