Changing Terminology of Definition and Design of Wearable Technology Products

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ABSTRACT
While technology is becoming the most important part of daily experiences, the concept of the Internet of Things IoT, has been one of the most important factor in the transition of industrial to information society. When we examine this concept of IoT, that has the potential to offer a wide range of changes especially in daily life, it can be seen that among others, consumers are being presented to wearable technology products. Wearable technologies are implemented in products that are integrated into the human body in different ways, usually connected to a network. These products, such as jewellery, glasses, clothing, or any other similar item include sensors or other technologies. New features are either added to the existing products in the market or new product products categories emerge by wearable technologies. There are many definitions of wearable technologies and/or wearable technology products in the literature due to both the variety of products available in the technology market and lack of standards in the field of wearable technologies. This makes it difficult to classify products throughout the history of wearable technologies. In this study, it is aimed to make a review of existing wearable technology definitions and to explore to what extent the products meet the requirements of these definitions**.** The main objective is to make clear and suggest wearable technology product requirements to the designer, engineer and researcher. It is important to determine the boundaries of stakeholders in the process of new product development of wearable technology products which are products of interdisicplinary studies.

Keywords: Wearable technologies, wearable technology products, wearable technology history, wearable technology terminology

INTRODUCTION
Wearable technologies are products that are integrated into the human body in different ways, usually connected to a network (Thierer, 2015). These products, which are often referred to as wearable computers in the literature, have a structure that enriches the user's daily life experiences Sensor accessories such as smart watches, bracelets, rings and necklaces, virtual reality glasses, smart glasses such as the Google Glass project and similar, as well as smart optical lenses and headphones can be shown among wearable technologies (Sezgin, 2016).

Especially with the development of technology after 2000s, the studies in the field of wearable technologies are increasing day by day. One of the main reasons for this rapid progress both in the academic field and in the market has been the fact that people today show interest in wearable technology rather than portable technology and send information analysis and communication of these products directly to the body from smart phones (Pala and Timur,2018). There is a strong competition in the technology market. As a result of this competition, either new features are added to the products produced; the existing products are completely renewed or completely new product categories emerge. The race of companies to adapt to changing and developing

technology greatly affect the integration of wearable technology products in the health, textile, education, entertainment and tourism sectors (Kılıç,2017).

In addition to diversified products as a result of the development of technology, the lack of standardization in wearable technology have led to differences in the definition of wearable technology. There are many definitions of wearable technology and / or wearable technology products in the literature. Some researchers have made broader and more inclusive definitions, while others have defined the boundaries of wearable technology and wearable technology products. These differences in definitions have also changed the scope of the wearable technology product. When the history of wearable technology literature is examined, the products determined for the beginning and following periods of wearable technology history differ according to the studies. This has caused confusion in introducing product requirements and product architecture. While the process of creating wearable technology products is an interdisciplinary field that requires a high technical know-how, it is necessary to cooperate with experts from many different fields such as textile, electronics, fashion and design in reaching the end user (McCann and Bryson,2009). The starting point of this study was to determine the scope of wearable technology products that emerged as a result of the collaboration of many different fields and to reveal the product requirements for other disciplines, especially the product design discipline.

In this study, it is aimed to make a review of existing wearable technology definitions and to explore to what extent the products meet the requirements of these definitions. For this reason, three the definitions of wearable technology in the literature were examined, the most used words were revealed by word cloud analysis the relationship between these words were made visible by Graph Commons platform (URL-5) and the important products found in the history of wearable technology were analyzed using these word groups. As a result of this analysis, current definition of wearable technology products and product requirements are determined.

INTERNET OF THINGS AND WEARABLE TECHNOLOGY
Internet of Things
Technology, which has become an important part of daily experiences, is constantly evolving as a decisive factor in people's lives (Marangoz and Aydın,2017). Technological developments starting with the industrial revolution are progressing rapidly and it is inevitable to come across technology products in almost every field (Lamkin, 2016). In the process from the first Industrial Revolution to the present, significant changes have been made in materials, production, methods and products with the change of technology. The developments in the industry are shown in Table 1.

Table 1. Developments in Industry (URL-1)

Industry 1.0	This period began in the 1760s and continued until the 1830s. In this process, production has generally changed from hand and body labor to machine power. The machines, which showed an increase in quality and quantity, functioned with steam power. Manufacturing innovation in the First Industrial Revolution: water and steam power, factories, mechanical tools.
Industry 2.0	II. Industrial Revolution also known technology revolution, covers the period 1840 - 1870. In the II. Industrial Revolution, the development of the transportation network, especially in the railways, and therefore the ease of transportation, greatly facilitated the supply of raw materials. It is possible for products to reach new and distant markets with developing transportation. In the Second Industrial Revolution, production innovation took place in the form of assembly lines, division of labor, electrification and mass production.

Industry 3.0	In the 1950s, digital technology began to develop and foundations of the III. Industrial Revolution were laid in this way. The production of the Z1 calculator, which runs on mechanical electricity, followed by digital advances that have extended to the computer, has brought a new dimension to the production processes. In III. the Industrial Revolution, production innovation was created with digital information technology systems, leaving behind digital technology, analog and mechanical technology.
Industry 4.0	IV. Industrial Revolution has emerged when machines in industry started to manage themselves and their production processes without the need for manpower. Machines include these top-level and up-to-date structures; computer, communication and internet technologies. This highly developed structure, referred to by the concept of the Internet of Things, extends almost to the self-management of a manufacturing factory. In the last stage, production innovation has been manifested in the form of automatic production, cyber-physical systems, internet of objects and smart factories.

Due to the rapid development of technology, the most important element in societies that have passed from the industrial society to the information society is to have knowledge and to use this information in the most effective way (Kılıç,2017). IV. The concept of the Internet of Things that emerged with the Industrial Revolution (Industry 4.0) accelerated this transition.

Internet of Things (IoT) is used to hold individual and environmental data that can support individuals' daily activities in a variety of ways. Most of these data processing processes are performed with the help of smart products. The development of technology is also a major factor in this. One of the main requirements of a device to be considered intelligent is to be able to establish a wireless connection to that device, it contains sensors (Sezgin,2016). IoT has the potential to present a wide range of changes in the whole of human life, especially in everyday life (Atzori et.al,2010). When the existence of internet technologies of objects is examined, it is seen that the most common products on the end user are wearable technology products .

Wearable Technology Products
Daily objects have been enriched with gears such as sensors, microchips and software and completely changed the product concept with the development of computer technologies. Thus, products have become intelligent structures that can perceive the environment and users in which they are located, and can move according to this environment (Pamir,2010).
With the developing technologies, the perception of the built-in computer in the minds of the users has left itself to desktop computers, then to smart phones, tablets and finally wearable technologies (Moar,2014).

Among the wearable technology products; jewelery, glasses, clothing, or any other product that is worn by the person can be counted (Aydan and Aydan,2016). These products include sensors (sensors) or other technologies.

The rapid progress of these products in recent years is that people today are more interested in wearable technology than portable technology and these products send information analysis and communication directly from smart phones to the body (Pala and Timur,2018). As a result of this development, both academic and research and development related studies on wearable technology and wearable technology products increased. Wearable technology is becoming more and more developed in the market and

wearable technology products have become a part of everyday life (Kılıç,2017). Due to the competition in the technology market, new features are added to the existing products in the market or these products are completely renewed (Kılıç,2017). However, there are also predictions that the development in wearable technologies will be realized more rapidly. Lamkin (2016) states that in 2020, 411 million wearable devices will be sold, worth $ 34 billion (Lamkin,2016).

In addition to the variety of products in the technology market, there are many definitions of wearable technology and/or wearable technology products in the literature. Researchers who approach the concept of wearable technology from different sides have caused different definitions in this field.

While some researchers have broader and more inclusive definitions, some researchers have defined the limits of wearable technology and wearable technology products. The definitions in the literature and the definitions made by the companies regarding wearable technology are shown in Appendix-1.

HISTORICAL DEVELOPMENT OF WEARABLE TECHNOLOGY PRODUCTS

Especially after the 2000s, technological developments have changed the balances in the market and these changes have contributed to the participation of new products and services in the market. One of the products that took its place in the market due to the changes in technology is wearable technology products. The purpose of these products is to incorporate functional, portable electronic devices and computers into daily life. Wearable devices have a major impact on the military and health sectors when examined before entering the consumer market (Tehrani et. al,2014). Over time, the use of wearable technology products in different areas has increased. For this study, the history of wearable technology has been examined in two periods, taking the year 2000 as a breaking point, considering the rise of Industry 4.0 in 2010 (URL-1).

Wearable Technology Products Before 2000s

Although the concept of wearable technology sounds like a new concept, it has a long history in literature. Different studies have recognized different products as the beginning of the history of wearable technology. The wearable technology products that emerged before 2000s are shown in Table 3. Information about the products are given in chronological order in this section briefly.

The most important wearable technology products that emerged in the period of Industry 1.0 were Nuremberg Egg- the first portable time measuring instrument- (1510) and Abacus Ring (1600) (Karamehmet,2019).

The industry had been upgraded to 2.0 with electrical technology and this change in technology had led to changes in products. The most important product which was created in 1884 by adding led lamps to ballerina clothes and named as Electric Girls, is accepted by some researchers as the first wearable technology product (Çakır et.al,2018). The pigeon camera which can be counted as the ancestor of the drones used today in 1907 is an important example of the period (Karamehmet,2019).

The Industry 3.0 is defined digital advances that have extended to the computer and has brought a new dimension to the production processes. First wearable technology product of this period is the first modern wearable computer is a shoe-based timing device designed by Edward O. Thorp in 1955 and invented in 1961 with the participation of Claude Shannon (Thorp,1998). Pulsar Calculator (1975) watch can be regarded as one of the most common wearable technology products to reach today. Seiko UC 2000 Wrist PC (1981), 6502-based wearable text, graphic and multimedia system with a backpack-mounted system (Camera and other photographic systems) (1981) -is designed by Steve Mann- are important products of this period (Sağbaş et.al,2016). In 1984, Nelsonic Space Attack Clock began to build the portable digital gaming market. In 1989 PrivateEye was a

pioneer for augmented reality technologies. At the beginning of the 1990s, the wearable technology product called Sneaker Phone that was both a shoe and a phone was released (Bal,2017).

One of the important names among wearable technology developers: Steve Mann developed a wearable wireless webcam, in 1994, which can be considered as one of the first examples of Lifelogging (Sağbaş et.al,2016). In 1994, the aim of Forget-me-Not, one of the leading products in the history of wearable technology is to record and store communication between people and the device [14]. In 1998, again Mann designed EyeTap Digital Eye Glass. This design of Mann has come up to the design of Google Glass in 2012 with various improvements (Özgür et. al,2018).

Wearable Technology Products in 2000s and After
The 2000s are seen as a period of significant developments in wearable technology products. One of the most important developments of the industry 4.0 period is the frequent use of the Internet in our daily lives, especially the Internet of Things, which has led to a change in the scope of wearable technology products and a variety of products. During these years, both academic studies and commercial products have emerged. The wearable technology products that emerged in the 2000s and after are shown in chronological order in Table 4. Information about the products is given in this section briefly:

In 2000 and after, many products were launched with the cooperation of brands. ICD + Jacket was produced by Levis in cooperation with Philips in 2000s is accepted as one of the important products of this period. Thanks to the conductive fibers and fabrics inside, the product enables communication between mobile phone, music player and headphones (Özgür et. al,2018). The Nike + device, which was designed in 2006 with the collaboration of Nike and Apple, is a health-fitness measuring instrument (Karamehmet,2019). Designed in 2016 in collaboration with Levi's and Google, the Commuter jacket includes a sensor that detects users' hand movement (Pala and Timur,2018).

Developments in the field of wearable technology have attracted the attention of many technology companies. With the introduction of bluetooth technology in 2002, the Nokia introduced Bluetooth headsets (Karamehmet,2019). Scientist of Intel Research Seattle designed a wearable RFID-based device called iGlove in 2007 (Sağbaş et.al,2016). Fitbit Classic designed in 2008, is an example of wearable technologies in the health sector (Karamehmet,2019). In 2013 Samsung Galaxy Gear, in 2014 Samsung Gear Live and LG G Watch smart watches were introduced (Sağbaş et.al,2016). Also Google Glass were launched in 2013 (Kılıç,2017). In 2014 solar jacket was produced by Tommy Hilfiger. In 2015, Apple Watch was launched. This watch with a wearable phone indicator is considered a major breakthrough in wearable technology products (Karamehmet,2019).

Academic studies in the field of wearable technology also accelerated in this period. In 2000, a smart ring was designed to continuously monitor patients' health status due to the sensors placed on the ring (Özgür et. al,2018). Also in 2002, a product called sociometer was developed to measure the user's interaction with people face to face (Choudhury and Pentland,2002). In 2006, Giansanti aimed to prevent falls with the help of kinematic sensors (Sağbaş et.al,2016). In 2007, Bourke et al. Aimed to determine the fall of individuals with accelerometer sensors placed on the trunk and leg (Bourke et.al,2007). In 2011, an application was made using wearable technology in the field of electrocardiography data monitoring by Özkaraca et al. (Özkaraca et.al,2011). In an academic study conducted in 2011, SUN wearable devices were used to detect the actions of brushing teeth, cycling, running at a light tempo, standing, walking, stair climbing, climbing stairs and writing on the board (Sağbaş,et.al,2016). In 2013, Trabelsi et al. Estimated the physical action of individuals with three wearable sensors (accelerometers) placed on the left ankle, chest and leg (Trabelsi et.al,2013).

Another important products in this period;Ringly eliminates the need for continuous phone checking by notifying users of the phone with vibrations and light in 2013. Launched by the Quell in 2015, the product not only detects upcoming chronic pain but also stimulates the nerve endings of the user and sends pain prevention signals. In 2015, the bPay launched the wristband, which allows users to make contactless payments (Karamehmet,2019). Adrenaline Dress is a technological garment that can measure the wearer's body temperature and adrenaline and stress levels , designed in collaboration with Intel and Chromat (URL-2). HoloLens was introduced in the first quarter of 2016 by Microsoft as a smart wearable device that can integrate high quality holograms into the user's world (URL-3). Again in 2016, OculusRift's virtual glasses for augmented reality was released. With these glasses, users see virtual games as more realistic thanks to the motion-sensing headpiece (Bal,2017).

METHODOLOGY

In the field of wearable technology, due to lack of product variety and standardization, researchers have defined the wearable technology with different definitions [Godfrey et.al,2018). This situation has caused complexity in the literature especially in the products before 2000 when we look at the history of wearable technology. While some researchers started the history of wearable technology with the first portable device Nurenberg Egg (Karamehmet,2019), which appeared in 1510, some researchers considered Electric girls as the first wearable product in 1884 as a result of the addition of leds to the ballerina's tutus (Çakır et.al,2018). Shoe-based timing device, which was designed in 1955 and invented in 1961 and accepted as the first wearable computer in modern sense, has been mentioned in the literature as the first wearable technology product by many researchers (Yang and Rhee,2000). The Pulsar Calculator has been recognized by some researchers as the first product to achieve global success (Karamehmet,2019). It is thought that this confusion in the classification and identification of products is caused by the existence of more than one definition of wearable technology and wearable technology products in the literature.

The study consists of four parts. In the first part, studies in the field of wearable technology were examined using the keywords 'wearable technology' and 'wearable technology products'. 'Wearable Technology Definitions' table was created by using wearable technology definitions obtained from both literature and internet searches (Appendix-1).

In the second part of the study, word cloud method was used (URL-4). The word cloud method is a visual representation of word frequency. The more common the keywords appear in the text, the larger they appear in the image. The word cloud method is a widely used method for determining the focus of written material. Although politics is used frequently in business and education, it is also used in different disciplines. In this study, definitions of wearable technology and wearable technology products in literature have been examined and most repetitive keywords have been revealed by word cloud method. The definitions in Appendix-1 include the definitions of wearable technology found in literature and internet resources. Word Art program was used for word cloud analysis and its accuracy was confirmed with word clouds and Tagcrowd programs.

In the third step of the study, the most repetitive keywords are presented and grouped according to finding in the text. Graph commons program was used for this stage (URL-5).

In the fourth and last step of the study, a table was created with the groups obtained in the previous step. This table examines whether the wearable technology products found in the literature before and after 2000 coincide with the emerging keywords. The aim is to show how much the products can match the most mentioned words in the definitions.

RESULTS

If we examine the results of the method applied in four different steps, firstly, 'Wearable Technology Definitions' table is created by using the definitions of wearable technology obtained from both literature and internet searches (Appendix-1).

In the second step, the word cloud method is used to obtain frequently used words. The definitions are obtained by scanning the definitions used in the literature and on the web pages of various companies are shown in Figure 1.

Figure 1. Word Cloud Analysis (URL-4)

When we examine the word cloud analysis, the most commonly used words in the visual are 'worn', 'device', 'technology', 'sensor', and 'body. Although all words were analyzed by word cloud method, n: 18 and n: 3 word groups were used for this study. Other frequently recurring keywords are shown in Table 2.

Table 2. Word frequencies obtained by word cloud analysis

Key Word	f	Key Word	f	Key Word	f	Key Word	f	Key Word	f
Worn	18	Clothing	8	Bluetooth	5	Embedded	3	Advanced	3
Device	15	Connected	8	Include	4	Powered	3	Items	3
Technology	13	Smart	7	Track	4	Via	3	Comfortably	3
Sensor	13	Integrated	7	Smartphone	4	Internet	3	Activity	3
Body	12	Wireless	7	Seamlessly	4	Small	3	Top	3
Computer	12	Use	6	Wearable	4	Wear	3	Self	3
Accessory	11	Access	6	Interaction	4	Take	3	Digital	3
Information	11	User	5	Incorparate	4	Sync	3	Exchanging	3
Data	10	Human	5	Relevant	4	Mobile	3	Time	3
Electronic	9	Collect	5	Product	4	Transmit	3	Test	3

In the third stage of our study, how to use the frequently used keywords that we have obtained from the definitions in the literature to analyze the products before and after 2000 in the history of wearable technology, and the relationship with each other was put forward and grouped.
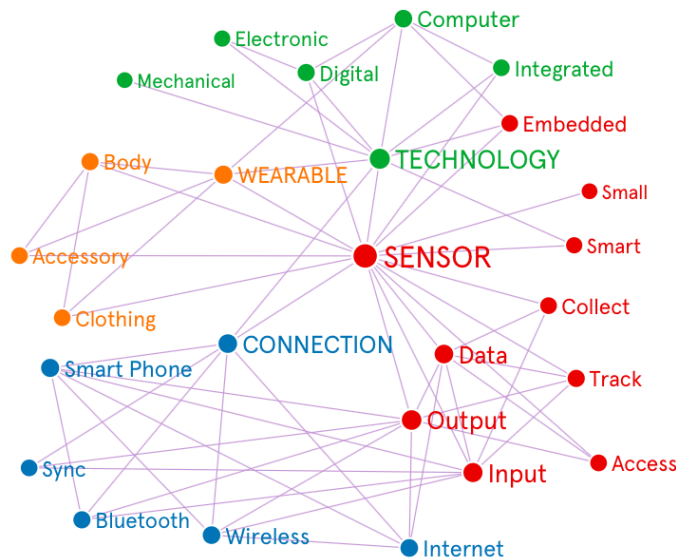

Figure 2. The relationship between words created by Graph Commons platform (URL–5)

When we examine Table 2, we can see the frequency of the keywords we get from the definitions. The relationship between the most frequently repeated words and how they are used in definitions are shown in Figure 2 . The words with the highest frequency are grouped to analyze existing products as used in definitions in below.

• Worn (f:18) is expected to occur at the highest frequency. Body (f:12), wearable (f:4) and wear (f:4) can be added to this group. Worn, wear and wearable are grouped as accessory (f:11) and clothing (f:8).

• Technology (f:13) is a frequently used word. Three types of wearable technologies are mentioned in the literature. Mechanical (f:1), electronic (f:9) and digital (f:3). Computer (f:12) is mostly used with the word integrated (f:7) and refers to the transition to digital technologies. Electronic (f:9) is also defined as embedded electronics. In this grouping, it is important to show which technology type is important for the evaluation of products. A product that includes digital technologies may also include electric technology, but is only marked as digital technology in the evaluation.

• Sensor (f:13) is one of the frequently encountered words. It is also the word that makes an important distinction between products in the history of wearable technology. When we look at the definitions, the word sensor is usually used with the words smart (f:7), Small (f:3) and embedded (f:3). When we look at the definitions of wearable technology, it is ensured that data is received, processed, stored and transferred with the sensors in the products. When the words Information (f:11) and data (f:10) are examined, both meet the meaning of the data received by the sensors. The most commonly used words with these words are Access (f:6), collect (f:5), collect (f:5), track (f:4). This group was used to analyze data exchange with sensors.

• Connected (f:8) refers to the transmission of the collected data and the commonly used words are wireless (f:7), bluetooth (f:5), smartphone (f:4), internet (f:3), mobile (f:3), sync (f:3).

Product analysis tables formed by grouping the words obtained from frequencies are shown in Table 3 and Table 4.

Table 3. Analysis of products in the history of wearable technology before 2000

PRODUCT	YEAR	Wearable		Technology			Data Exchange with Sensors		Connected with Internet or etc.
		Accessory	Clothing	Mechanical	Electrical	Digital	İnput	Output	
INDUSTRY 1.0									
Nuremberg Egg	1510	✓	-	✓	-	-	-	-	-
Abacus Ring	1600	✓	-	✓	-	-	-	-	-
INDUSTRY 2.0									
Electric Girls	1884	-	✓	-	✓	-	-	-	-
Pigeon Camera	1907	✓	-	-	✓	-	-	-	-
INDUSTRY 3.0									
Roulette Shoes	1955 / 1961	✓	-	-	-	✓	-	-	✓
Pulsar Calculator	1975	✓	-	-	-	✓	-	-	-
Seiko UC 2000 PC	1980	✓	-	-	-	✓	-	-	✓
Backpack with multimedia computer	1981	✓	-	-	-	✓	-	-	✓
Nelsonic Space Clock	1984	✓	-	-	-	✓	-	-	-
Private Eye	1989	✓	-	-	-	✓	-	-	✓
Snaker Phone	1990'lar	✓	-	-	-	✓	-	-	✓
Lifelogging	1994	✓	-	-	-	✓	-	-	✓
Forget me not	1994	✓	-	-	-	✓	✓	-	✓
Eye Tap Digital	1998	✓	-	-	-	✓	-	-	✓

When the products before 2000 are examined, it is seen that all products are wearable. Only the costume that is designed for the Electric Girls stage performance is in the form of an outfit, while all other products are in the accessory category. When the technologies were examined, mechanical technologies were used for products until the illuminated outfit for the Electric Girls that appeared in 1884. Electrical technology was introduced with the Electric girls product in history of wearable technology products. Similarly, in 1955, the first Roulette shoe designed for the first time made the transition to digital technologies. This product, which is called the first wearable computer in the literature, is important for the definition of wearable technology. In this period, digital technology was used in all products except Eye Tap Digital.In addition, the Roulette shoe is an important product for the history of wearable technology in terms of transmitting the received data and communicating with a different vehicle. Before 2000, sensor technology was not used in any product. The products before 2000 coincide with the periods of II., II., III. Industrial Revolution.

Table 4. Analysis of products in the history of wearable technology in 2000 and after

PRODUCT	YEAR	Wearable		Technology			Data Exchange with Sensors		Connected with Internet or etc.
		Accessory	Clothing	Mechanical	Electrical	Digital	İnput	Output	
INDUSTRY 4.0									
ICD	2000	-	✓	-	-	✓	-	-	✓
Smart Ring	2000	✓	-	-	-	✓	✓	✓	✓
Sociometer	2002	✓	-	-	-	✓	✓	✓	✓
Bluetooth Headphone	2002	✓	-	-	-	✓	-	-	✓
Smart Shirt	2004	-	✓	-	-	✓	✓	✓	✓
Anti-fall Device	2006	✓	-	-	-	✓	✓	✓	✓
Nike +	2006	✓	-	-	-	✓	✓	✓	✓
Fall Detection Device	2007	✓	-	-	-	✓	✓	✓	✓
iGlove	2007	✓	-	-	-	✓	✓	✓	✓
Fitbit Classic	2008	✓	-	-	-	✓	✓	✓	✓
SUN	2011	✓	-	-	-	✓	✓	✓	✓
Monitoring of electrocardiography data	2011	-	✓	-	-	✓	✓	✓	✓
Google Glass	2013	✓	-	-	-	✓	✓	✓	✓
Physical Actions Predictive Device	2013	✓	-	-	-	✓	✓	✓	✓
Samsung Galaxy Gear	2013	✓	-	-	-	✓	✓	✓	✓
Samsung Gear Live-LG G Watch	2014	✓	-	-	-	✓	✓	✓	✓
Tommy Hilfiger-Solar Jacket	2014	-	✓	-	-	✓	-	-	-
Apple Watch	2015	✓	-	-	-	✓	✓	✓	✓
Ringly	2015	✓	-	-	-	✓	-	-	✓
Quell	2015	✓	-	-	-	✓	✓	✓	✓
bPay	2015	✓	-	-	-	✓	-	-	✓
IntelCurie	2015	-	✓	-	-	✓	✓	✓	✓
Hololens	2016	✓	-	-	-	✓	✓	✓	✓
Oculus Rift	2016	✓	-	-	-	✓	✓	✓	✓
Levi's Commuter X Jacquard	2016	-	✓	-	-	✓	✓	✓	✓

When the products in the year 2000 and after were examined, the number of the products that appeared as clothing increased with the developments in the textile industry. With industry 4.0, all products have shifted to digital technology. Unlike before 2000, products other than ICD, Bluetooth Headphone, Solar Jacket and bPay, have now become the structures that receive, process and transmit data through sensors. One of the most important features of wearable technology products in the industry 4.0 period, and the ability to connect with other products that we frequently encountered in the definitions, has appeared in all products except Solar Jacket.

CONCLUSION

The most important element in societies that have passed from industrial society to information society is to have knowledge and to use this information in the most effective way due to the development of technology (Kılıç,2017). The concept of the Internet of Things that emerged with the Industrial Revolution (Industry 4.0) accelerated this transition. The internet of objects provides the opportunity to see, hear, think and speak to each other by sharing information with each other, such as embedded devices, sensor networks, communication protocols, and so on. the transformation of basic technologies from a traditional system to an intelligent system (Aktaş et.al,2016). The future conditions offered by the Internet of Things can be called the smart environment (Gubbi et.al,2013). The gradual shrinkage of smart devices has paved the way for these devices to be used as wearable technologies in these smart environments (Sezgin,2016).

Wearable technologies can be defined as the general name of technological equipment worn on body [URL-6]. But not every product or every technological product used in daily life is a product of wearable technology. In order for a product to be a wearable technology, it must process and/or directly transfer the data that is allowed with the help of smart sensors and collected for a particular purpose to the technological product developed by bluetooth or any wireless device (Çakır et.al,2018).

However, when the literature on wearable technology is examined, there are many definitions of wearable technology products. Especially in the history of wearable technology, the starting and breaking points of wearable technology products have been expressed with different products. The reason for these breaks is technology. With the development of existing technology, product form and functions have differentiated for each period. With this situation, there are some problems regarding the formation of product architecs and determination of product requirements. This confusion that arose in wearable technology products, which provided researchers with an interdisciplinary field of study, revealed that the roles of stakeholders such as engineers and designers in the product development and innovation process could not be clearly determined. Incorrect distribution of tasks weakens the relationship of products with the user and leads to situations such as reducing cultural and sociological effects.

Importance of this study in terms of product design discipline; the main role of product design and designer in New Product Development projects is the formation of product concept and idea at the beginning of the process, visualization of this idea in two and three dimensions (sketches, drawings and modeling methods) and communication between team members from different disciplines involved in product development activities in the whole process. and ensuring integration (Er and Er,2000). In order to visualize the product in two and three dimensions, product requirements must be established. In this study, it is revealed that wearable technology products include digital technologies, sensors and data exchange with industry 4.0, and connection to a mobile device or internet. This has clarified the issues for product designers such as product definition, determination of usage area, determination of product requirements and how much free space technology provides to the designer and the limits of the designer in wearable technology products have been determined. In this way, the main problem in wearable technology products is to keep the relationship with the user weak and as a result, to prevent the problem of non-commercialization.

As a result of the study, it is clear that the definition and product requirements of wearable technology products have a dynamic structure. As technology evolves, product boundaries change constantly and product definition changes. The definition of wearable technology products made before the 2000s has lost its validity due to the rapid development of the concept of digital technologies and the internet of objects. In the past, mechanical or electrical technology and wearable products are included in the scope of wearable technology products today, these products are receiving, processing and transmitting this data is desired to be smart products. Due to the dynamic nature of the

products, these definitions and requirements will change over time and the number, roles, areas of action of the stakeholders in the new product development process will also change accordingly.

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Appendix-1

- **Definitions from literature research**

YEAR	DEFINITION
1998	Wearable technology can be described as an open and accessible computer. (Mann, 1998)
2001	Self-powered, fully functional and self contained computer that provides access to information and interaction with human body at anytime and anywhere. (Barfield and Coudell, 2001)
2003	A shift from digital simulation to digital augmentation. (Viseu ,2003)
2013	Wearable technologies record user's movements, physical data, location or status, habits , psychological data by using various sensors.(MacLean, 2013)
2013	Wearable technology can be defined as those products worn on the body of the user for extended periods of time with experience of significant enhancement as a result of the product being worn. The definition is subjected to two test. Test 1, assesses whether the product is wearable, questioning the length of time being worn and significant user experience enhancement. Test 2, for wearable technology assess whether the product is smart; questioning advanced circuity, wireless connectivity and independent processing capability.(Walker, 2013)
2014	Accessories or clothing that incorporate advanced electronic techniques and incorporate computer, which can be worn on the body. (Tehrani and Andrew, 2014)
2014	Wearable devices that merge wireless connectivity for the aim of seamlessly accessing, interacting with and exchanging contextually relevant information. (Nyan et. all, 2008)

2014	Computer and electronics that are integrated into textile or clothing and other accessories that can be worn comfortably on the body.(Wright and Letrina, 2014)
2014	The terms wearable technology , wearable device and wearable are electronic or computer technologies representing the body's wearable accessories and clothing. (Baş, 2011)
2014	Wearable technology or wearables are small electronic devices embedded into items that attach to the body and passes computational capability. Devices can be integrated into clothing, recognizable personal accessories or additional devices. (Shants and Veillette, 2014)
2014	Wearable technology and wearable devices are phrases that describe electronics and computers that are integrated into clothing and other accessories that can be worn comfortable on the body. (Wright and Letrina, 2014)
2014	Wearable technologies typically have several distinct, but connected, components. The hardware itself consists of a combination of sensors, o display, a processor and storage memory, as well asa means of communicating with another internet-enabled device or the internet directly. In addition , software including algorithms is necessary for the filtering , ,interpretation organization and storage of the collected new data. Finally, a mobile phone or computer application is often employed to present the data to the use in real time or as a retrospective report(Shants and Veillette, 2014)
2015	The target of wearable devices are exchanging and interacting relevant information through seamlessly access by wireless connectivity.(Bower and Sturman, 2015)
2015	Wearable technology products are the general name of technological and mechanical products can be worn by people.(Raj and Bookshire, 2015)
2015	Wearable technologies are generally connected to a network which can be integrated into the human body in different ways by users and is often used invidious accessories. (Thierer. 2015)
2015	Wearable digital devices that incorporate wireless connectivity for the purposes of seamlessly accessing, interacting with and exchanging contextual relevant information. (Bower and Sturman, 2015)
2015	Wearable technology is the general name of technological equipment worn on top. However, there is a clear distinction. For a product to be called wearable technology the product must transmit information from smart sensors to smartphone via wireless or bluetooth. (Kılıç, 2017)
2016	Wearable technology is the general name of technological equipment worn on top. However, there is a clear distinction. For a product to be called wearable technology the product must transmit information from smart sensors to the smartphone via wireless or bluetooth. Wearable devices, is defined by six basic features; monopolization, non-limiting,

	observable, controllable, rigorous, and communicative. (Ching and Singh, 2016)
2016	Wearable technology or called wearable is a computing technology device that can be worn on the human body , either a computer that are incorporated as an accessory or as part of material used in clothing. (Tehrani and Andrew, 2014)
2016	Wearable technology offers new opportunities to monitor human activity continuously with the miniature wearable sensors embedded. (Ching and Shing, 2016)
2017	The concept of wearable technology is the integraton of technology into everyday wear and accessories.(Yetmen, 2017)
2017	Wearable technology refers to digital devices that can be worn by users, taking the form of an accessory such as jewelry, eyewear or even actual items of clothing , such as shoes or a jacket to closely track data that is relevant to their daily activities through the use of wearable technologies. (Johnson et. all, 2017)
2017	Wearable technologies are mechanical and technological devices that can be worn by people (Raj and Bookshire, 2015)
2018	Not every product used in daily life is capable of wearable technology. In order for a product to be wearable technology it is required to transfer the data that is allowed with the help of smart sensors and collected for a certain purpose to the technological product developed by bluetooth or any wireless device. (Çakır et. al. , 2018)
2018	Wearable technology products created with sensors integrated into fabrics collect and record the data that are allowed to collect and fulfill the defined task assigned to it. (Çakır et. al., 2018)
2019	Wearable technology encompasses electronics that can be worn and integrated with it as part of accessory of the garment. (Değerli, 2019)

- **Definitons of Market Research**

Wearable technology is a category of electronic devices can be worn as accessories, embedded in clothing , implamented in the user's body or even tattooed on the skin. The devices are hands-free gadgets with practical uses, powered by microprocessors and enanced with the ability to send and receive data via internet (URL-7)
A wearable device is a technology that is worn on the human body. This type of device has become a more common part of the tech World a companies have started to evolve more types of devices that are small enough to wear and that include powerful sensor Technologies that can collect and deliver information about their surroundings (URL-8)
Wearable technology is a category of technology devices that can be worn by a consumer and often include tracking information related to health and fitness and also include sensors to take photos and sync with your mobile devices (URL-9)
In order to call a product wearable technology , the product must transmit information from smart sensors to your smartphone by connecting it wirelessly or bluetooth (URL10)
A small computer or advanced electronic device that is worn or carried on body (URL-11)

The vision of wearable technology is one in which information will flow seamlessly to and from the wearer, enabling invisible monitoring of medical conditions, instant Access to online data an deven superhuman physical and sensory abilities (URL-12)
Wearables are electronic technology or devices incorpareted into items that can be comfortably worn on a body. These wearable devices are used for tracking information on real basis They have motion sensors that take the snapshot of your day to day activities and sync them with mobile devices or laptop computers (URL-13)
Wearable technology refers to gadgets you can wear but gadgets such as headphones maybe wearable, but aren't technically classed as wearable technology. Wearable technology usually incorparates smart sensors that measure the wearer's personal data (URL-14)
The new age of wearables top into the connected self- they are laden with smart sensors that track our movements and biometrics , often using bluetooth to sync wirelessly to a smartphone (URL-15)