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RESEARCH ARTICLE

The concept of usability in terms of universal design

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Abstract

Objectives. The paper discusses usability as the concept underlying many contemporary design trends and accompanying technological development in various industrial, graphic and digital contexts. A formulation of the concept of usability in digital design contexts is advanced based on the evolution of industrial design.

Methods. Using the historical research method, usability is shown to be characterized by unification of form as applied to the relationship between a person and a design object. This conclusion has been applied to digital design using the analogy method. Basic principles of usability assessment in design are outlined, along with impacts on further development. Requirements for a designed product in terms of usability analysis should be fulfilled taking into account the principles of universality that constitute a basis for a universal design system.

Results. When developing UI/UX design objects, the usability of a digital product is considered in terms of universality based on rational visual image principles of industrial design and taking contemporary requirements in graphic, digital, and website design into account. Examples of industrial and digital design developments carried out by students using the concept of universal design are presented.

Conclusions. The usability of a design object can be shaped by using universal principles applying in both industrial and UI/UX design.

Keywords: usability, shaping, industrial design, digital design, universal design

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НАУЧНАЯ СТАТЬЯ

Концепция юзабилити с позиции универсального дизайна

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Резюме

Цели. В статье представлено понятие юзабилити как основополагающей концепции многих направлений современного дизайна: промышленного, графического, цифрового и т.д. с учетом развития технологий. Целью статьи является формулирование концепции юзабилити в цифровом дизайне на основании эволюции юзабилити в промышленном дизайне.

Методы. Использование исторического метода исследования показало, что юзабилити применительно к взаимосвязи между человеком и объектом дизайна характеризуется унификацией формы. С помощью метода аналогии этот вывод был применен и по отношению к цифровому дизайну. В статье приведены основные принципы оценки юзабилити в дизайне, а также характер ее влияния на дальнейшее развитие дизайна. Требования к проектируемому продукту с точки зрения анализа юзабилити рекомендовано выполнять с учетом принципов универсальности, являющихся основой системы универсального дизайна.

Результаты. Принимая во внимание принципы проектирования в промышленном дизайне и современные требования в области графического, цифрового и веб-дизайна, авторами предложено формировать юзабилити цифрового продукта с точки зрения универсальности и искать наиболее рациональные визуальные образы при проектировании объектов UI/UX дизайна. В статье приведены примеры разработок промышленного и цифрового дизайна, выполненных студентами с применением концепции универсального дизайна.

Выводы. Использование принципов универсальности как в промышленном, так и в UI/UX дизайне, позволяет сформировать юзабилити проектируемого объекта дизайна.

Ключевые слова: юзабилити, формообразование, промышленный дизайн, цифровой дизайн, универсальный дизайн

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INTRODUCTION

A contemporary designer is confronted by a multilevel complex system of closely intertwined requirements, conditions, and frameworks, often involving contradiction and ambiguity. Today, one of the most important aspects of a designer's work involves developing products that have the property of usability. Usability is a property of a product's design that allows consumers to use it under specified conditions for achieving their goals with sufficient effectiveness, efficiency, and satisfaction. Since it allows an evaluation of the quality of the product design, the usability characteristic is of key importance. In industrial design contexts, usability is defined by the form of the designed object.

HISTORICAL BACKGROUND

Modern human beings perform many habitual actions, many of which have become second nature. As such, the nature of the household objects surrounding us

tends not to be reflected on. Whether we are considering a toothbrush, coffee cup, shoes, or comb, each of these objects has its own design history, which may not always be simple or uncontroversial (e.g., an ordinary table fork). The form of each everyday object perceived as a certain given has been shaped over time in accordance with various laws of evolution. Notwithstanding their multilevel nature and diversity, a certain regularity may be traced in the general principle of shaping material objects.

Many processes shaping human lives are cyclical in nature. In design contexts, the principle of shaping obeys the same laws as other processes occurring within the society. When analyzing the formal evolution of certain objects, relationships between historical eras—Gothic, Renaissance, Baroque, Classicism, and etc.—may be revealed. Along with features of scientific and technological progress in a given era, the nature of production is largely determined by the economic situation. Such historical changes result in the emergence of new art styles that influence the form of everyday objects.

Despite the technological paradigm, various craftwork skills still relevant today have been honed over the period of many centuries. During this time, significant attention has been focused on improving the forms of the most popular household items. Nevertheless, few attempts have been made to comprehend, scientifically justify, and describe the laws and principles according to which objects are shaped. Since craftwork does not generally involve explicit design, the centuries-old process of shaping of products has occurred more or less spontaneously. Behind each craft masterpiece lies the experience of generations preceding the master, involving lots of trial and error, unexpected findings, as well as inevitable failures. Thus, a more or less randomly obtained form combining convenience, functionality, and aesthetics "catches-on" in daily life, while inappropriate analogues gradually disappear in a process of evolution resulting in the unification of the form of the household object.

For primitive man, who lacked a variety of materials, the emergence of each new one has been a significant event; thus, the epochs of that time have the following distinctive names: "Stone Age," "Iron Age," and "Bronze Age." With a piece of clay accidentally falling into the fire, the previously mastered wood and stone have been supplemented with ceramics; seeing sparkling droplets emerging from a piece of ore in a fire, man discovered metal. Each time, the emergence of new materials and their processing technologies established a new development vector for artists, craftsmen, and architects. New materials and technologies gave rise to previously unseen objects and forms along with a rethinking of previous forms. Eventually, these processes again resulted in the unification of form within a new style, quite often involving a return to previous developments in the new round of progress (Fig. 1). However, the form is always strongly related to the production process.

(a) (b)

Fig. 1. Evolution of the mug form from antiquity (a) to the present day (b)

Among the many world-changing events associated with the historical period known as the Renaissance is the emergence of design as a discrete activity. While the difference between an idea and its realization may now be quite obvious, this approach represented a real innovation for the time; with the understanding that form exists separately from its material embodiment, craftwork started to lose its preeminent role in production. Scientists, artists, and architects—the precursors of modern engineers—invented various mechanisms, conducted experiments and calculations, as well as keeping records to build on the achievements of medieval science. Nevertheless, since form was not yet comprehended as an independent phenomenon, these changes in consciousness did not influence the shaping of traditional household items.

Although the first attempts to systematize principles of shaping were made during the period commonly referred to as the Industrial Revolution, this phenomenon in human history is also cyclical and obeys the same laws as all previous changes in the way of thinking.

The start of the Industrial Revolution has been associated with the invention of the steam engine during the late 18th century. This period has been described in textbooks on history, sociology, economics, and design as one of the key moments shaping the trajectory of modern society towards a global reorganization of the world. With the stealthy displacement of craftwork by the industrial paradigm, traditional forms typical were lost along with the elegance of lines, functionality, and convenience. In their attempts to conceal obvious shortcomings of new products in terms of their form, manufacturers resorted to so-called ornamentation, which involved decorating products to obscure the clumsiness of exterior forms and conjunctions with embossed overlays and coffers. This process coincided with the crucial shift towards

designing the form at a separate pre-primary stage rather than during the process of manufacture. Thus, it was necessary to develop a scientific understanding of the principles of shaping and identify its regularities based on a systematic approach. Here manufacturing was informed by design principles that had developed in architecture. The formation of the industrial design discipline is associated with such names as Gottfried Semper (German architect, 1803–1879) and Henry Cole (English artist and social activist, 1808–1882). By the end of the 19th century, design was already established as a discipline in its own right.

The transition to the 20th century may be characterized by a shift in industrial production to a new level. Household objects produced according to this paradigm have already become inexpensive, convenient and widely accessible to the public. The replacement of steam and water engines by electric equivalents, the invention of conveyor belts, as well as the development of transport, telegraph, telephone and radio gave rise to the Second Industrial Revolution.

The principle of shaping in design, encapsulated by the famous formulation "form follows function" by the architect Louis Sullivan in 1896, established the main direction for shaping in the 20th century. In industrial production, this brilliantly simple approach to shaping led to the establishment of industrial design schools based on Sullivan principle of functionalism (e.g., Bauhaus, Vkhutemas). Thus, the search for forms that maximize the function of products became the main strategy associated with the Second Industrial Revolution. Items produced during this period can be characterized a certain delicate elegance in terms of their functional simplicity and style. Therefore, the design concept of usability was defined by the relationship between form and function.

The end of World War II is associated with the third round of the industrial revolution. This period is marked by the more rapid pace of scientific and technological development with multifunctional electric devices moving from highly specialized areas of industrial production into the everyday lives of ordinary people. Private automobiles became widely available, electronics was actively developed and new materials based on polymers became widely used in production. The variety of forms produced in the 1960s–1980s is amazing.

During this time, the role of design in production significantly increased along with several trends in design associated with a rejection of functionalism as the ground for usability and based a post-modernistic rejection of the established principles of shaping. New trends in art-design were encapsulated in the slogans "form follows style," "form does not follow function," and "function is form," giving rise to a profusion of forms and products. Much of these have lost their relevance falling out of fashion with time. Again, there has been a trend towards the unification of form based already on the quality of the design concept rather than on the development and improvement over centuries.

Today, the unification of forms produced by the Second and the Third Industrial Revolutions may be witnessed. Here, we may cite the example of the automobile. Since the dawn of the automobile industry during the Second Industrial Revolution, the automobile form was dictated by its design and function, while the variety of these forms is limited by production capacity. With the development of material processing and assembly technologies, as well as improvements in aerodynamic and ergonomic testing during the third industrial revolution, the variety of forms employed in automotive engineering has increased significantly. Manufacturers have used all available means in an effort to impress the customer and increase sales; as a consequence, cars of various shapes, sizes, colors and versions have been rolling off the automaker assembly lines. An analysis of styles in car design for the second half of the 20th century should be the subject of a separate study. By the beginning of the 21st century, the design of the overwhelming majority of cars produced worldwide had been sufficiently unified enough to differ from each other by separate design details only: headlights, radiators and trunk shaping lines (Fig. 2). The overall shape has been reduced to the unified image dictated by the balance between aerodynamics, economic characteristics and ergonomics rather than by function. Thus, it is in a balance of characteristics that usability parameters are ultimately provided.

The late 20th century may be characterized by an emerging crisis in design. Having already come under attack during the second half of the 20th century, Sullivan's principle of form following function has become increasingly irrelevant in the production of objects functioning beyond the objective world. Today, humanity is in the midst of the Fourth Industrial Revolution placing an even heavier burden of responsibility on designers. This revolution is associated with formation of new expectations of quality of life, as well as with digitalization, development of artificial intelligence, and the replacement of conventional production technologies with the mass customization paradigm. Since there is insufficient time for unifying form in a natural manner, designers are obliged to shape the usability of objects guided by preferences that are yet to be manifested. For example, while the unification of automobile design took half a century, the unification of cell phones or computer mouse design occurred within 20 years (Fig. 3).

Fig. 2. Evolution of the car shape:
(a) 1958 Chevrolet Bel Air; (b) 1969 Ford Mustang Shelby GT500; (c) Toyota Auris 2008; (d) FORD Fiesta 2009

Fig. 3. Shape evolution of the computer mouse:
(a) sample devices from the 1990s;
(b) modern computer mice

In this event, shaping in the context of usability requires a new approach to be considered not only in terms of function, but also the trend towards future unification due to the demand and quality of design. The development of modern usability in design may be characterized most thoroughly by the "form follows ergonomics" principle. Modern digital products are often no longer intended to be directly manipulated. For example, the function of modern headphones is not essentially different from the function of those in the past; however, their operation principle and the human-computer interaction technology have changed dramatically. Their shape may vary now within a very wide range, from familiar to bionic ones [1–6].

RESEARCH RESULTS

In industrial design, the concept of usability is intimately associated with form evolution and product shaping. However, universality principles should be considered when designing and constructing industrial facilities. In contrast to industrial products, the development of digital technology has resulted in the creation of digital products depending to a greater extent on usability. Shaping in digital design implies a search for harmonious color combinations, defining the style of elements (including defining the form of these elements) to create a harmonious composition. However, the most important criterion in digital design is usability (ease of use). Therefore, developers carry out thorough pre-project research before starting developing a website or mobile application design. Usability in user interface (UI) design is related to user experience (UX)

design research, implying the development of user interface designs that combined user convenience with a harmonious interface appearance.

Digitalization in the contemporary world accompanies the transformation of socio-technical structures previously provided by non-digital products and relations into structures mediated by digital products and relations with embedded new digital capabilities. While the development of digitalization and digital technologies has influenced the creation of new so-called "non-digital" products, since this involves the creation and development of digital products, the contemporary designer is required to master digital competencies and skills in order to create them.

Digital skills involve mastering a set of capabilities for digital devices, communication applications, and networks for accessing and managing information. Thus, digital skills and competencies should be mastered in the following areas: programming and web development, application development, digital design, project management, digital marketing, and data analytics.

The main advantages of creating digital products are the following:

1. *Low overhead costs*. Digital designing certainly involves the cost of purchasing computer hardware and licensed professional software. However, in contrast to the industrial production, the creation of each unit of a digital product (digital identity, landing page, etc.) does not imply purchasing raw materials for their creation.
2. *High profitability*. Since there are no recurring costs for materials when developing a digital product, profit can be made without use of consumables. Nevertheless, costs must be allocated to payments for labor, electricity, etc.
3. *Automated development process*. When developing various digital products, many processes may be automated to accelerate the process of completion.
4. *Flexible digital product transport*. Advanced cloud and associated technologies allow the storage and transportation of digital products to consumers without involving their physical transportation.

Thus, ergonomics, ease of use, and usability come to the fore in creating successful and competitive digital products. In digital design, the product—e.g., developing the design of website or its mobile version—undergoes a rather long process of UI/UX design testing. Although this process has common roots with evolutionary shaping in industrial design, web designers try to obtain maximum user feedback on each element of the digital product performance. Then, an analysis of user experience is carried out along with troubleshooting of the website or mobile application.

Before starting the layout, the user route for "wandering" within the developed graphical user interface should be plotted to provide a framework for the work (Fig. 4). After the route has been discussed, the development of architecture along with layout is performed (Fig. 5). The interface visualization is an important outcome of the work (Fig. 6) [7–9].

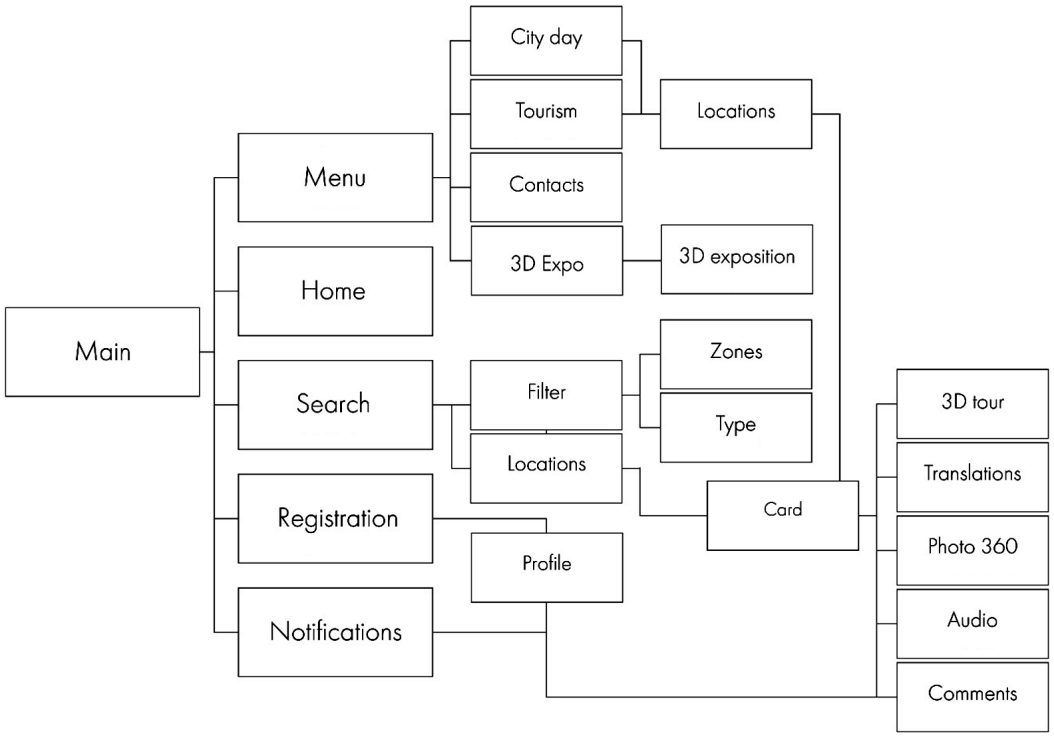

Fig. 4. Developing the user route for the exhibition website

Fig. 5. Designing the website layout

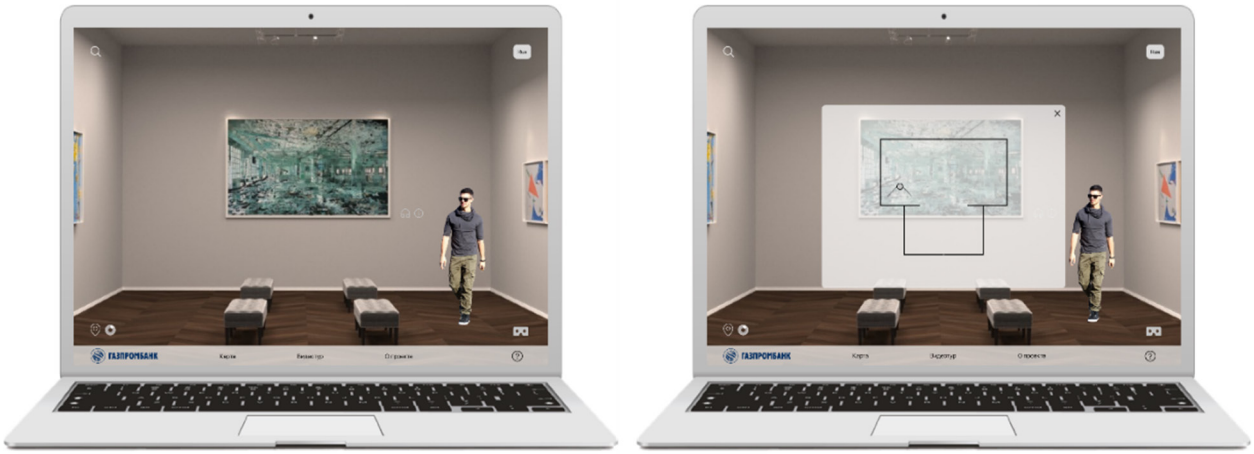

Fig. 6. Visualizing website design

In today's world, principles of universality are referred to in industrial design and architecture. Universality of design allows designers to navigate rapidly changing trends. This trend, which originally involves the development of projects taking ergonomics requirements into account, is based on inclusivity principles and intended for a wide range of users. Universal design shapes the object-spatial environment accessible to people with different abilities and physical traits [10–14]. Products designed according to versality principles should be adapted to a wide range of individual preferences and capabilities, as well as being easy to use and intuitive. Object design transmits information to the user as well as minimizing risks and the adverse consequences of accidental or unintended actions. Universal design ensures that objects may be used efficiently, comfortably and with minimal fatigue. The focus on ergonomics specifies sizes for objects and environments to ensure their usability regardless of the user's body size, condition, or mobility. Due to the original universality of such objects, their shape does not require unification.

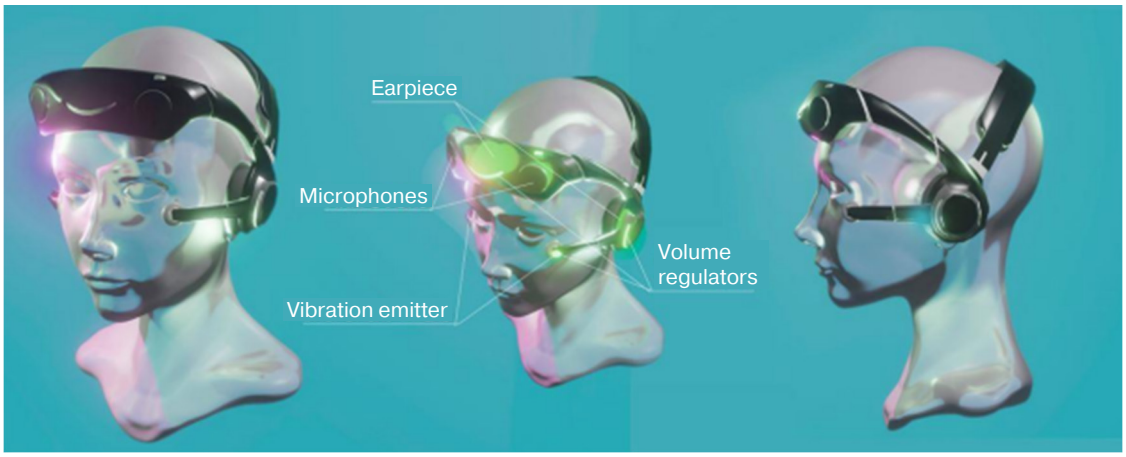

Fig. 7. The concept of a bionic helmet phone for people with disabilities

Digital product usability also requires universality principles to be considered since people with disabilities actively use digital technologies. Therefore, for example, whether developing a desktop or mobile version of a website, a version for blind or visually impaired individuals should be developed.

The possibilities of universal design are the research area being developed by the Department of Computer Design at the Institute for Advanced Technologies and Industrial Programming, MIREA – Russian Technological University [13–15].

Since the design of objects and environments based on universal principles is an essential aspect of training students at the department, students of the Department of Computer Design are actively involved in researching universal design possibilities.

The design of a helmet phone comprising a hearing device with air and bone conduction capabilities may be mentioned as an example of the developments of the department considering the universal design principles in both industrial and digital spheres (Fig. 7). This device facilitates the enhanced perception of sounds for people with hearing loss. The distinctive feature of the device consists in its design based entirely on professiographic methods for the ergonomic study of the human body. Studies have shown that vibration emitters intended for perceiving sounds through bones are located in the cheekbone area having maximum bone conduction. In order to keep the device on the user's head, a system of fastening arcs has been developed [15].

A scientific and practical conference "Universal Design – Equal Opportunities – Comfortable Environment," which examines various trends in modern design in terms of inclusiveness and universality, has been hosted at the University since 2016.

CONCLUSIONS

The evolution of usability is cyclical in nature. Each stage of scientific and technological progress produces a lot of new objects and forms, most of them losing relevance over time to be perceived as archaic and obsolete. Those passing the test of time are reduced to a single form and typically used for decades. Principles of versatility considering primarily ergonomics, safety, and usability help to avoid errors in product design. The evolution of digital design and web technologies define the developed product usability (ease of use). This promotes the transition from complex forms to simpler ones in design and shaping of digital products for a wide range of users and people with disabilities.

Authors' contributions

I.Yu. Mamedova—concept development, literary analysis, and writing the text of the article.

A.E. Dryukova—conducting a historical and comparative analysis of the usability development in design.

N.E. Milchakova—formulation of the concept of usability in the field of UI/UX design taking into account the historical context and principles of universality, drawing conclusions.

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