Review on the Application of Interactive Design in the Design of Modern Furniture Products

Xinghua Xia and Ahmad Rasdan Ismail

Abstract Under the background of the digital age, with the development of information technology, the interactive design method is gradually introduced into the field of modern furniture design, which has good applicability and promotion prospects. The interaction design method shows advantages in exploring complex behavior and the relationship between humans, products, and the environment. Furniture interactive design aims to solve the connection and interactive experience of people, furniture and living space, follow the user-centered principle, emphasize the importance of user experience, and pay attention to solving user needs. This study makes a substantive comparison and analysis between furniture design and interaction design, summarizes the main characteristics of interaction design of modern furniture products, briefly classifies and summarizes the existing methods and practices of furniture interaction design, and then analyzes the existing problems, precautions, and development trend of interaction design in combination with the characteristics of the furniture market, It provides a reference for the in-depth practice and effective development of furniture interactive design in the future.

Keywords Furniture · Design · Interaction design

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1 Overview of Furniture Interactive Design

1.1 The Trend of Furniture Interactive Design Under the Background of the Digital Age

With the continuous development of social informatization and the continuous progress of process production technology, products are expected to provide more possibilities while having practical performance and practical benefits. Furniture has experienced the changes of handicraft age, industrial age, and information age, and its design elements and methods have also changed accordingly. From the perspective of industrial design, furniture design emphasizes the function and beauty of furniture, focusing on the unity of functionalism and formalism (Johnson and Abraham 2020), Designing comfortable and beautiful furniture products that meet the requirements of ergonomics is the concept of modern design. However, in the current digital era, with the rapid development of science and technology, more and more new technologies and materials are applied to furniture design. High-quality service is no longer the only requirement of modern users for furniture design, and furniture is no longer regarded as an isolated single product limited to the actual use function (Kesdi 2019), Modern furniture design should be integrated with people's living environment. People, as the main body, can obtain an interactive experience of high efficiency, comfort, pleasure, interest, and environmental protection in the living environment through the use of furniture (Seseni and Mbohwa 2021). In short, as the first element, user experience promotes modern furniture design to be user-centered and pays more attention to the interactive experience between users and furniture, which is also a process of interactive design.

Interaction design originates from the field of information. It is the product of the rapid development of computer technology in the 1980s. It is the information exchange process between man and machine (Nowakowski 2021). In recent years, interaction design has gradually developed from interface design to physical products. The expansion of the research scope and concept of interactive design makes the interactive design of furniture possible. Under this background, exploring the application of interactive design methods derived from information products to furniture design and creating efficient and pleasant life experiences for users has become a problem worthy of thinking and discussion.

1.2 Interactive Design of Furniture Products Based on User Experience

In the 1990s, the concept of interaction design was proposed by Bill Mogridge, one of the founders of IDEO company, to solve the problem of how to use products to connect people in design practice. Interaction design is essentially a system design, in which

the constituent elements include people, human behavior, product use scenarios, and technologies supporting interaction behavior (Zhao et al. 2016; Blomé 2015).

In the era of the experience economy, people pay more and more attention to the non-material attributes of products, hoping to feel care, mutual movement, and fun from the product itself and the use process (Nakazato et al. 2016). User demand has always been the situation that all designers want to understand, and the demand changes with society, science and technology, humanities, times, and so on (Gribbin et al. 2016). With the rapid development of society, user demand will no longer be "as long as you have it" or "as long as you can use it", but will put forward requirements for the attributes of the products used. Furniture design and interaction design are consistent in design essence and design objectives, pay attention to people's life behavior, and form design objectives based on behavior analysis (Hehn et al. 2019). In the process of planning and practice, we should fully consider the interaction process between users and furniture products, take the user's experience as the starting point, minimize complicated and useless interaction modes and methods, and deeply excavate people's interaction behavior to achieve the universal applicability of design (Wang et al. 2021). The concept of interaction design focuses on the target user, which directly affects the "design" of the target user. The user demand based on interactive design lies in the safety, fluency, efficiency, and comfort of the interactive process. The structural modeling function of furniture and the products integrated with science and technology has always changed according to the change of human interaction mode. Human needs are different in different times (Akita et al. 2015). Furniture design needs to meet the lifestyle and behavior characteristics of contemporary people, which puts forward new requirements for design methods. The application of the interaction design method also helps to find the potential needs behind the user behavior and create a healthier and better home life experience.

Starting with the analysis of the characteristics of modern furniture product interaction design, this paper summarizes the existing furniture interaction design methods, and puts forward opinions and suggestions for the existing problems in the research of furniture interaction design, to provide a further research direction for furniture interaction design.

2 Interactive Design Features of Modern Furniture Products

2.1 Personalized User Needs

Different social roles and work roles will have different levels of needs. The design should fully consider the needs of users from the aspects of usability, ease of use, experience, and value creation (Honan 2017). Maslow's hierarchy of needs theory divides human needs into five levels, which are expressed in a pyramid-like way from low to high: physiological, security, social, respect, and self-realization needs.

Because the user's behavior in different scenes is affected by many uncertain conditions such as scene, emotion, human factors, and social factors, it is emphasized that interaction is the ontology of design, and the application of interaction design is based on the process rationality of specific tasks and user feelings (Azevedo 2020). The user needs of furniture interaction design can be divided into sensory, human–computer interaction, interpersonal interaction, social and self needs (Oygur 2017). User needs have strong sociality, and people will present different needs under the reflection of different social forms. With the rapid development of science and technology, economy, and society, people's living rate is faster and faster. On the basis of enjoying the peace and functional convenience brought by furniture, they gradually pay attention to their personalized needs. More and more advanced scientific and technological achievements add more and more experiential bonuses to different zones so that users can feel the high efficiency and fun brought by design while living, which is also the significance of interactive design. After meeting the sensory, human–computer interaction, interpersonal interaction, and social needs, due to individual differences, each user's self needs are also different, and its ultimate goal is to realize self-worth.

2.2 Cultural Attribute

Culture is hidden in every piece of furniture, which affects users' judgment on the practicability, safety, and value of furniture products (Kampermann 2021). Culture includes multiple levels of spirit, behavior, and material culture. First of all, furniture is the carrier of material culture. As a material appliance, furniture must form a solid form and use function through specific materials and processing technology (Bekiroglu et al. 2021). Secondly, furniture is the medium of behavior culture. Furniture is closely related to people's life. Furniture design must take the observation and understanding of life behavior as the starting point, and take life as the origin and main driving force of design. Thirdly, furniture is the expression of spiritual culture. As a display art, furniture has imperceptibly cultivated people's aesthetic taste and embodied the philosophical concepts and religious beliefs in a specific cultural situation in the long-term use process of people. The cultural context has a great impact on people's lifestyles. For example, people from different regions have very similar working styles, but the differences in their daily lifestyles are very significant. Furniture products are indispensable supplies in daily life (Liu et al. 2014). It shapes and carries people's life behavior and the unique living culture of all races and nationalities. Therefore, in the process of designing furniture products, we should fully consider the cultural colors and attributes of material culture, behavior, and spirit. Furniture products should adopt specific processing technology and materials to form corresponding use functions and solid modeling, which have significant material and cultural characteristics. Secondly, furniture is closely related to people's social and life behavior, and the cultural characteristics of behavior are very significant. The Interaction Model is mostly Human–computer Intelligent Interaction.

2.3 Most Human–Computer Intelligent Interaction Modes

Human–computer interaction only exists in high-tech furniture, which is also the development trend of the intelligent and multifunctional modern furniture product system (Huarng et al. 2020). Many furniture designers have begun to adopt the relevant design concept of operation feedback behavior to provide users with secondary design opportunities in use and make people feel interesting and novel interactive experiences. At the same time, the functions of various modern furniture products are changeable and the sources of materials are rich. A dynamic operation interface is adapted to allow users to fully participate in the design process. Furniture products have personalized colors and can meet the needs of diversified life in various cultural situations.

Now more and more furniture products are integrated into intelligent and interactive design through computer vision, machine learning, speech recognition system, robot technology, and so on. The development of intelligent furniture not only conforms to the trend of the era of industry 4.0 but also conforms to the design principle of people-oriented and user-centered (Gunther et al. 2015). In traditional furniture design, it is necessary to fully express its functional utility, while intelligent interactive furniture focuses on human–computer interaction, which is different from the direct physical operation and operated experience. People are not so much using furniture as having a conscious dialogue with furniture. Adding human–computer intelligent interaction design in furniture design can shorten the distance between people and furniture and facilitate the communication between people and furniture. When furniture is not just a simple functional product, but a comprehensive product that can communicate and interact, the sense of user experience and happiness will be enhanced.

2.4 Diversification of Interaction Design Elements

Interaction design pays attention to the research and analysis of user behavior, and is good at capturing continuous and complex behavior over time; He is good at summarizing individual behaviors into group characteristics and forming a persona model representing the target user group (Robert and Beata 2014). Due to the limitation of use space, the interactive behavior of furniture can be further divided into the interactive behavior between users, furniture and living environment in cooking and dining, living and receiving guests, resting and sleeping, reading and office, cleaning bathroom, fitness and entertainment, and other activities, as shown in Fig. 1. The elements in furniture interactive design can be replaced by user, activity, context, product, UACP. Among them, the user (U) is still in the center position; However, compared with information products, furniture users are more changeable and uncertain, and many users are using the same furniture products together (Hyun et al. 2021). Therefore, in the analysis of user elements in the design, not only the behavior of a

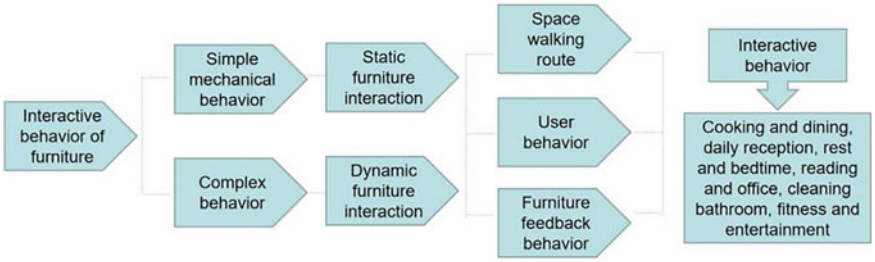

Fig. 1 Interactive behavior among users, furniture and living environment *Source* Tang Lei and Lin Zuoxin and Zhang Yachi (Tang 2014)

single user but also the social relationship between users and users, ethical order, and so on should be considered. In space scene (c), the user behavior is different from the static and dynamic behavior, the production behavior, and the entertainment behavior because of the difference of the spatial function.

3 Interactive Design Method and Practice of Furniture Products

3.1 Traditional Furniture Design Method and Practice

Traditional furniture products emphasize the needs of users from appearance design to structural design and process design. The traditional user experience mainly focuses on the hardware interface and software interface between users and products. When designing products in the interactive design method, we should not only make the products comfortable and easy to use, but also enhance the interactivity of products, and pay attention to the behavior and information interaction between users and products (Macaranas et al. 2015). The design process includes user research, user requirements, product conception, interactive scheme analysis, and design plan confirmation. The interactive scheme analysis stage mainly takes consumers as the reference object to analyze them, modify consumer needs, and provide feedback to the product conception stage. Through multiple iterations, the final design plan is formed. According to the final design plan, production and processing can be carried out. At the 2014 Seattle Design Festival, there was a group of interactive street furniture in the architectural environment design. The inspiration of the project is to create an opportunity for users to enjoy the free collocation and create their own space in the public environment. As shown in Fig. 2, these pieces of furniture are composed of simple movable modules. Through movement and combination, users can create a temporary place for communication, observation, and rest. At the same

Fig. 2 Interactive street furniture in Seattle *Source* www.archdaily.com© Trevor Dykstra

time, these modules were designed as projects suitable for user types. During the two-week Music Festival, these wooden blocks were maximized and successfully created a new interactive space for the public. After the music festival, this interactive furniture is still kept in the streets. By creating an interactive space, designers solve and eliminate the problem of interaction obstacles.

3.2 Design Method and Practice of Intelligent Furniture

Under the background of intelligent trends, furniture is also transforming to intelligent direction. Traditional interaction design processes and methods are based on user experience (Endert et al. 2014). Before planning and designing products, it is necessary to establish user behavior and cognitive models to ensure that the display and operation of products can meet the expectations of users. The interaction between users and products is multi-channel and all-around. For interesting and intelligent furniture, the simple operation may lead to too direct and traditional interaction between users and furniture products, which hinders users from obtaining a rich experience. Furniture is not only a simple functional material product but also can make people produce some aesthetic pleasure and rich associations in the process of contact and use. The interface is the basis of interaction between users and products and a necessary condition for interaction. Intelligent design is to simulate human thinking activities through computers according to modern information technology, so as to improve the intelligence level of computers so that computers can better undertake a variety of complex tasks in the design process, and become an important auxiliary tool for designers. Aesthetic interactive design is a method of designing a product aesthetic experience (Maria 2018). Take the interaction process of the stir kinectic desk as an example, as shown in Fig. 3. This extremely simple intelligent desk has a built-in intelligent system that can analyze the height most suitable for

Fig. 3 Stir kinectic desk
Source www.stirworks.com

users. Then, the function of intelligent height adjustment can be realized by double-clicking the touch screen on the desktop to simplify the user experience. The desk can also display the user's heat consumption level with an intuitive chart, so as to remind the user to stand in time and reduce the sedentary.

4 The Development Direction of Furniture Product Interaction Design

4.1 Differentiated Research on the Diversity of User Experience

The user experience of furniture has obvious uniqueness, which needs more targeted exploration and research (Cockburn et al. 2017). At present, there are the following problems in relevant research fields:

The user groups of furniture products are more diversified and widely distributed from multiple dimensions such as gender, age, and region. Furniture design needs to face the diversified use needs of different target groups (Nassar et al. 2019). The usage and behavior preferences of different user groups for furniture are largely affected by their cultural environment.

Traditional product evaluation pays more attention to the user's early interactive experience (Oblak et al. 2020). However, furniture products mainly focus on service use and emphasize understanding the user's long-term user experience. During the initial use of the product, users usually pay more attention to the usability and ease of use attributes of the product, but after a while, users may reduce their attention to these attributes and increase their attention to other attributes.

In the process of furniture product design, the understanding user model is the most basic design principle. Designers build and design application products based on the interpretation of user needs (Dong et al. 2021), however, many studies point

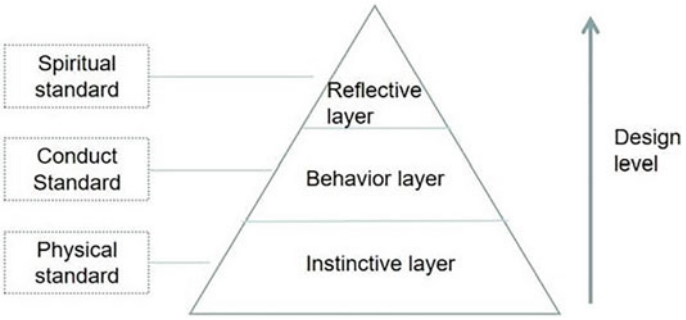

Fig. 4 Furniture design level *Source* YU Ji-hong and FU Tong WU Xiang (Ji-Hong et al. 2019)

out that designers often can not accurately predict users' needs and preferences, and there are some differences between designer models and user models based on target products. In view of the above problems, we can refine and analyze the model from the three different levels of design, instinct level, behavior level, and reflection level integrate the triple standards of furniture interactive design, shape furniture products rich in function and aesthetic experience, and meet the needs of users' interactive behavior and experience, as shown in Fig. 4. It can study the cognitive differences of different cultural user groups on furniture product design. Based on the user's cognitive model, this paper makes a comparative study on the attention superiority of user groups with different cultural backgrounds. Based on the experience behavior, this paper makes a comparative study on the initial experience and later experience of users using furniture products. We can also study the experience differ based on emotional preference.

4.2 Furniture Unconscious Interaction Design

At present, simple interaction design is "the behavior of redesigning man-made systems, which requires users to operate according to instructions or guidelines".The unconscious interaction design is to mine and reproduce the existing interaction behavior between users and products, not to create new, but to present the old, not to redesign people's behavior, but to show the existing unconscious interaction behavior in an appropriate way (Andrei 2015). Unconscious interaction can reduce the user's thinking and reduce the cognitive burden of user interactive learning. The operation of interactive behavior is like preset in the user's brain. You can skillfully use the operation without redundant guidance, hint, and learning.

Interaction design is moving towards time-saving and labor-saving, and pays more and more attention to users' emotional factors (Bhattacharyya et al. 2019), However, the establishment of emotion takes time, and under the background of rapid renewal, the establishment of human and material emotion is very difficult. Unconscious

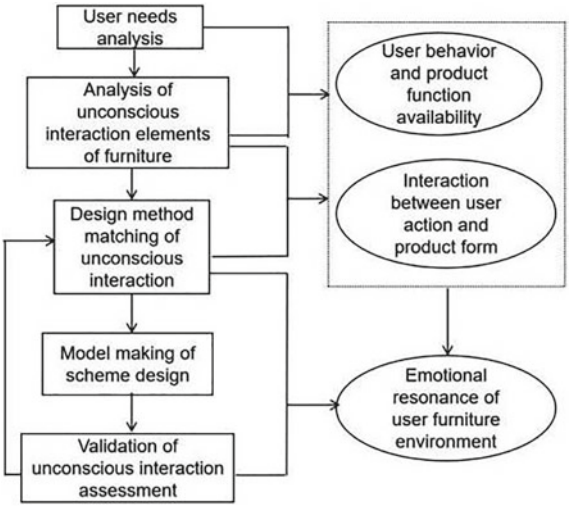

Fig. 5 Unconscious interaction design method *Source* Liu Bin and Zhu Jiangang (Liu 2020)

interaction design reduces the emotional establishment process, directly extracts the user's past unconscious emotional memory, and integrates it into the product. At first glance, it may not feel it. Once it is actually operated, it will have physical, spiritual, and emotional resonance. When a single familiar product segment is connected to form the whole warm and harmonious home environment, that atmosphere will really relax and enjoy the busy day outside. Unconscious interaction design is to find out the most primitive contour relationship between environment, product, and human in the whole human product environment. When thinking about the interaction process between users and furniture products, we need to take the user's instinctive response as the starting point, minimize complex interaction modes and methods, find and excavate people's unconscious interaction behavior and achieve the general design of all kinds of users, as shown in Fig. 5.

4.3 Furniture Interactive Design Focusing on User Participation

The traditional furniture design belongs to the rigid design mode. The designer holds the leading power in the design process and puts limited products on the market. This way is difficult to meet the diversified life needs of different consumers. Although mass customization realizes the richness of terminal furniture products with standardized parts, it partially meets the personalized needs of users; however, it is still difficult to adapt to the changing needs of users with time, environment, and family communication. Interactive design advocates a highly participatory design process and provides users with more flexible furniture forms and richer furniture functions through user research, the user "secondary design" and "DIY" assembly

Table 1 Design patterns of different types of furniture products *Source* Tang Lei and Lin Zuoxin and Zhang Yachi (Tang 2014).

Design pattern	Design process
Traditional design	Designer → Popular products → Meet users' basic living needs
Custom design	Designer → Standardized furniture parts → Personalized combination mode → Meet diversified user needs
Interactive design	Designer → User → Furniture prototype → User test → Furniture products → User secondary design → Furniture supplies → Designer

(Ludwig and Welch 2019). Furniture products can change flexibly with the changes of users' life, communication mode, and living environment in the process of use, which is more in line with users' personalized and diversified life needs. As shown in Table 1.

Compared with the traditional furniture design mode, the interactive design of furniture products gives users the leading power of creativity, so that they can reshape the layout, form, and function of furniture according to their understanding of life. Putting products on the market is not the end of furniture design, but the beginning of user re-creation. Users are highly involved in all stages of the design process, and their life behavior, cultural habits, and emotional experience are constantly given to the improvement of products (Barcellini et al. 2015). With the process of use, the emotional connection between the product and users is gradually established. User participation is reflected in all stages of furniture product interactive design. In the concept stage, the designer uses observation, situational interview, and other methods to fully understand the user's life behavior, form the design goal, and make the product prototype on this basis. In the design evaluation stage, I used prototype testing in the laboratory or use situation to understand the problems of users in the use process and modify the product scheme. In the use stage after users purchase the product, they can also adopt the way of "secondary design" to change the function and form of the product, to truly meet the personalized needs of users. By providing feedback information to designers, users can also stimulate the design team to carry out a new round of product improvement, forming a repeated iterative design process.

5 Conclusion

With the development of modern science and technology and the improvement of living standards, people are no longer satisfied with the basic functions of household products but hope that household products can bring a healthy and interesting life (Hooper 2015). Modern furniture interaction design is still in the basic stage of research, and most research methods focus on the intelligent furniture interface interaction design similar to information products. On the basis of scientific search, analysis, and expression of users' life behavior, it is necessary to further explore the cognition and behavior of furniture users from multi-disciplinary fields such as

culture, sociology, psychology, and design According to the differences of behavior and emotional characteristics, personal behavior is summarized as a typical user model, and clear design objectives are formed. Finally, these design objectives are further reflected as the expression form of furniture. Through interaction design, reveal the potential needs behind user behavior, help designers analyze user life behavior and create products that meet the needs of target users. Therefore, the research of furniture interaction design can be further developed in the direction of user diversity, unconscious design, user model evaluation, and so on. However, the complexity of contemporary furniture user interaction behavior and the change of home lifestyle put forward higher requirements for furniture designers. How to use appropriate interaction methods for furniture product interaction design is a big test for design researchers, and will become the focus of future research. In the future, there will be more intersection and integration between interactive design and furniture design, so as to create a more efficient, comfortable, and pleasant living experience for users, and achieve the perfect harmony and unity among people, product, and the environment.

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