Research on the Breakthrough "Homogenization" Phenomenon of Pedal-assisted E-bike Displays Design

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Abstract: *Pedal-assisted e-bike displays are an important part of e-bikes, which can provide users with various information and functions. However, there is a common phenomenon of "homogenization" of e-bike displays in the current market, i.e., there is a lack of differentiation and innovation among products in terms of shape, details, and connotation, which makes it difficult to satisfy the diversified needs and experiences of users. The purpose of this paper is to discuss the role and significance of generative design and user experience-centered design methods in solving this problem. This paper firstly analyzes the background, status quo, and causes of the "homogenization" phenomenon of pedal-assisted e-bike instrument design, and then proposes a design process based on generative design and user experience research. Through this process, the paper explores how to improve the serious "homogenization" phenomenon in the field of pedal-assisted e-bike instrument design, enhance user experience, and strengthen the brand image of the instrument. The paper provides relevant references for improving the current serious "homogenization" phenomenon in the field of pedal-assisted e-bike instrument design, enhancing the user experience, and strengthening the competitiveness of the product market and the brand image of the instrument.*

Keywords: *Pedal-assisted e-bike displays, product "homogenization" phenomenon, design innovation methods*

1. Introduction

Pedal-assisted e-bike displays are products that have developed with the advancement of microelectronics technology in the 21st century and are widely used in electric bicycles. With people's pursuit of a healthier lifestyle continuing to increase, sales of electric bicycles are also rising[1]. As the most important accessory on the electric bicycle, the display is also the focus of R & D and production for many companies. However, the electric bicycle displays have appeared a serious "homogenization" phenomenon, meaning that there is little difference and innovation among products in terms of shape, details, and functions. Many companies are also trying to find a way to break the "homogenization" phenomenon. This paper will also propose several design methods from the design point of view for the industry to refer to.

2. The Current Situation of Instrument Design of Domestic Pedal-assisted E-bikes

The pedal-assisted e-bike is a bicycle with a hub motor, controller, battery, lights, and instrumentation accessories added based on a traditional bicycle. Pedal-assisted e-bike instrumentation is a very important display and control unit in the pedal-assisted e-bike, which can provide users with various information and functions, such as speed, battery level, riding mode, navigation, etc. Pedal-assisted e-bike instrumentation can be divided into three kinds of instrumentation according to its assembly position: left instrumentation, center instrumentation and stem instrumentation. Please refer to Figue 1 for more details. The left meter is the meter installed on the left handlebar cross of the e-bike through screws or hooks, which can be operated with the left hand during riding. The center meter is the meter installed in the middle of the handlebar cross of the e-bike through screws, which is usually used with the left button. The stem meter is the meter embedded in the stem cross, which is perfectly fused with the e-bike.

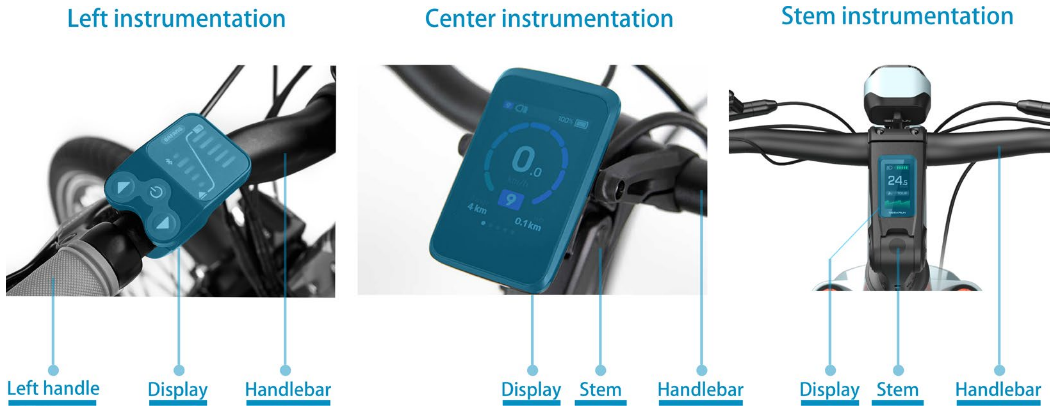
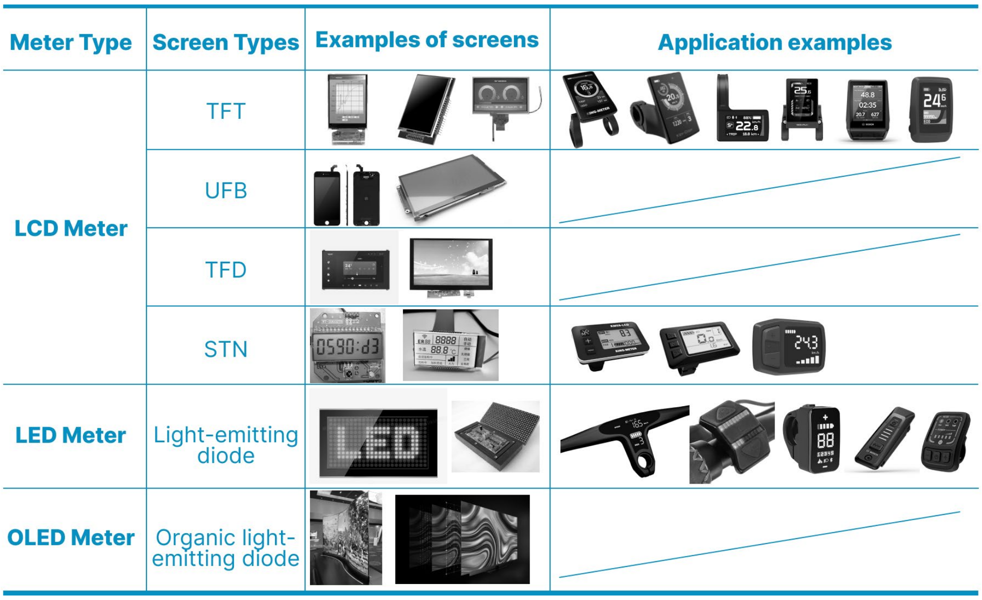


Figure 1: Diagram of pedal-assisted e-bike instrumentation by assembly location (author's own drawing, bicycle image from the Internet)

According to the display mode, it can be mainly divided into LCD (Liquid Crystal Display) meter and LED (Light Emitting Diode) meter categories, as shown in Figure 2. LCD meter refers to the instrument that uses a liquid crystal display screen to display information. The current liquid crystal display screens mainly have several types, such as TFT, UFB, TFD, STN, etc. LED meter refers to the instrument that uses the light emitted by the light-emitting diode through a specific shape of the hole to display information. Such instruments have lower manufacturing costs and technical requirements, and are widely used in various types of vehicles. OLED (Organic Light-Emitting Diode) screen is a kind of screen with higher manufacturing costs and technical difficulties than the current screens. It is less used in the instrument of electric bicycles at present, but there are quite many instrument manufacturers trying to improve the production, and it is expected that it will be applied in the design of the instrument of electric bicycle soon.



Meter Type	Screen Types	Examples of screens	Application examples
LCD Meter	TFT		
	UFB		
	TFD		
	STN		
LED Meter	Light-emitting diode		
OLED Meter	Organic light-emitting diode		

Figure 2: Diagram of pedal-assisted e-bike instrumentation by type of display (Author's own drawing, instrumentation images from the Internet)

In terms of interaction, the location and display type of the instrument have a great impact on the interaction. From the point of view of the installation position, the left instrument and the center instrument generally use mechanical buttons to control the corresponding functions. Mechanical buttons can give the user the most direct sensory feedback, and the relevant information will also be displayed on the instrument, giving the user the most intuitive visual feedback. On the contrary, if the touch screen is used for operation, because the user can't keep looking at the screen during the riding process, the user and the car interaction can only be reflected by the speed of the car, and the user can't receive the most direct interactive information. Left-mounted instrumentation generally combines mechanical buttons and instrumentation, reflecting the characteristics of an integrated design. When the user interacts with it, they can view the information displayed on the instrumentation in the most intuitive way. The center-mounted instrument is mainly installed on the left side of the handlebar cross, and the instrument is installed in the middle of the handlebar cross, which can provide users with the best information presentation angle when riding at a faster speed. Therefore, the left-mounted instrument is generally chosen to be used with city bikes, and road bikes, which have a higher speed, generally choose the center-mounted instrument as a way of presenting information. This can be understood by referring to Figue 3. The difference between LCD and LED meters in interaction is that LCD meters can display more interface information, with a very rich form of information presentation, such as different levels of interface display, diversified information interaction, and cell phone APP, to bring users a different experience. While LED meter is relatively simple in information presentation, generally only using fixed lights through a fixed shape of holes to present different information. The LED meter displays a more fixed information style, and the interaction between the user and it is also more fixed.

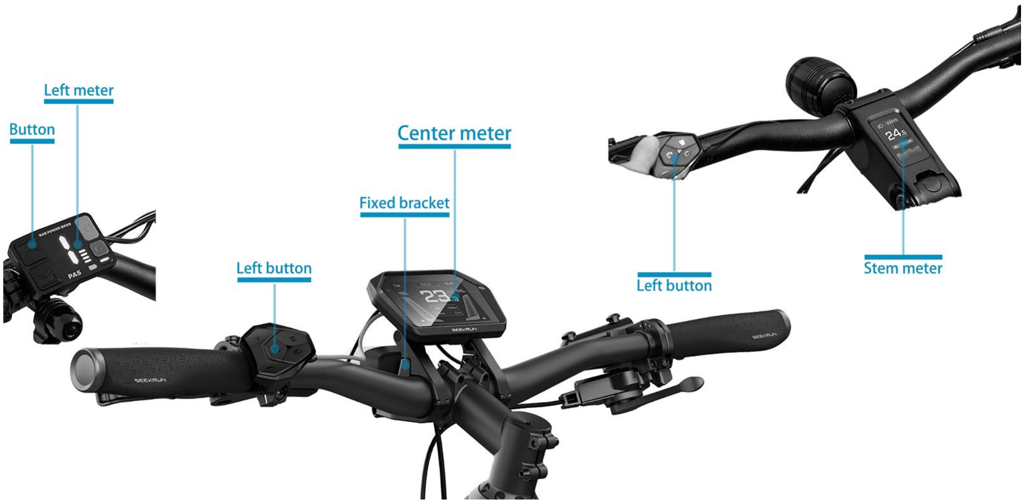


Figure 3: Diagram of how different pedal-assisted e-bikes' instruments interact with each other (author's own drawing, bicycle image from the web)

Material use. These instruments generally use a black plastic shell (ABS) as the main body of the instrument, the screen display area is more transparent PC material, the material of the keys are mainly rubber buttons, acrylic buttons, and ABS and other plastic buttons. Rubber buttons are widely used because of their good feel of the press, as a hard button acrylic material combined with the human-computer morphology can usually have a good aesthetic effect visually, resulting in a better interactive experience. In addition to the keys, the claw hand used to fix the instrument is also a more important part of the material selection. Many of the claw hands in the case of thicker strength will use ABS materials for manufacturing, because the ABS material can meet the requirements of the claw hand in terms of injection molding process and structural strength. In the case of thinner and lighter design, PP or PE materials are generally used for manufacturing, because these two materials have good elasticity and flexibility. In the case of relatively thin and light, they can also meet the structural strength requirements. Details can be seen in Figue 4.

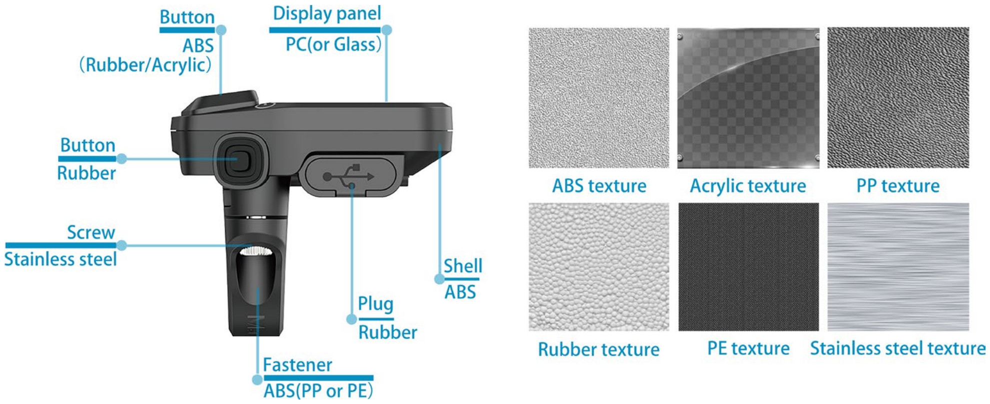


Figure 4: Material diagram of pedal-assisted e-bike instrumentation (self-painted by the author, instrumentation and material texture images from the Internet)

Color and process. The current market of major manufacturers of instrumentation use black sand grain plastic shell as the main shell of the instrument, followed by screen printing and spraying ink to print the brand logo on the instrument, such as in Figure 2 where the product image of each brand of instrumentation shows this feature. The plastic shell is usually manufactured by the injection molding process. The current instrument is more monochrome injection molding process, LCD instrument in order to bring a better user experience, many instruments are now beginning to use the full lamination gluing process for manufacturing, eliminating the sense of division caused by the existence of gaps between the screen and the appearance of the sense of the split.

Through the analysis of the above instruments, a very obvious feature can be found: that the major brands of the same type of instrument from the installation, display, interaction, and CMF have greater similarities. Installation mostly adopts the screw fixing method; the display mainly adopts LCD and LED two display screens to present information; the interaction method has a high similarity; CMF also has a strong similarity. As the standard equipment of pedal-assisted e-bikes, it has accounted for an increasing share in the entire pedal-assisted e-bike market in recent years, because of the meter, as a terminal for direct dialogue with the user, is being paid attention to by more and more consumers through the information displayed and the good user experience. From the above analysis, it is not difficult to find that different brands of products show the phenomenon of "homogenization" in various aspects.

3. Electric Assisted Bicycle Instrumentation "Homogenization" Phenomenon Causes

This is an era of serious homogenization, not only product homogenization, information homogenization, business model homogenization, and even cultural homogenization. According to Gao Feng and others, the phenomenon of product "homogenization" refers to the strong similarity of product appearance, structure, function, service, price and brand, etc., and the strong substitutability of products of the same level[2]. The phenomenon of product homogenization will lead to the loss of the enterprise's characteristics, loss of the original market share, and thus put them in a disadvantageous position in the commercial competition, or even cause them to be eliminated. At present, some pedal-assisted e-bike enterprises have greatly improved the appearance and image of instrument accessories and UI design in the past, but remain at a superficial level, lacking in-depth and detailed excavation of the potential value and innovation of their products.

From the electric bicycle instrumentation industry in the countrys more than 10 years of development time, the industry's products show a more serious "homogenization" phenomenon. The causes of this phenomenon are mainly composed of market factors, manufacturing factors, and consumer culture factors.

First of all, there is the market factor. With the rapid development of the green economy and sharing economy, electricity becomes the most important way of clean energy supply. at the beginning of the 21st century, when electric energy and bicycles meet, they result in more energy-saving than the traditional pedal bicycle, more convenient electric bicycle. The surge in market demand leads to the corresponding development of the instrumentation R & D as one of the accessories of electric bicycles. There are many companies that supply the same electric power-assisted bicycles, and most of them are founded by the former employees of instrumentation industry with a history in instrumentation industry. This results in a continuous research and development and production of same type of products, which leads to the homogenization phenomenon in instrumentation industry design.

Secondly, there is the same manufacturing model that causes the design homogenization phenomenon. The current manufacturing mode of electric bicycle instrumentation is that the design and development personnel complete the design of the program and send it to the relevant suppliers for the trial production of products, which are then tested for the instrumentation production process and product performance, and approved after meeting the standard, and then large-scale production and manufacturing is done. Based on production technology stagnation, the convergence of production processes and product development market feedback and other issues will often overthrow the realization of the previous design innovation, so that the instrument design continues to converge to homogenization.

Analyzing the aspect of consumer culture, Baudrillard believes that consumption in a consumer-oriented society is a process of acquiring a commodity symbolic system of identity and symbolic beliefs. An item is not only the product's nature with its use value, when it is exchanged as a commodity it can bring consumers a higher level of connotation such as identity and taste, at this time the product becomes a symbol with symbolic significance endowed with cultural connotations and added value [3]. At present, the instrument production industry is still in the stage of pursuing the practical functions and use values of value for their products, rather than the price, and the cost, resulting in the lack of cultural value-added power in the design of the electric bicycle's instrumentation, resulting in the further deepening of the homogenization phenomenon in the industry.

In addition to the above reasons, there are many other reasons for the phenomenon of "homogenization" of electric bicycle instruments, such as the product life cycle and market standardization proposed by Zhu Boyu in his thesis [4] Other reasons are shown in Figure 5. To break the current "homogenization" phenomenon, we need to explore the third stage of consumer culture proposed by Baudrillard in the context of electric bicycle and related accessories. As a travel tool, pedal-assisted e-bikes are more efficient, environmentally friendly, and sustainable than bicycles and electric vehicles, and can bring users a healthier lifestyle and a different travel experience. As an important accessory of the E-bike, the instrument is not only a material carrier for displaying information but also a product symbol with cultural connotations to symbolize the user's healthy lifestyle, personality characteristics, and unique taste in life. Based on this, this paper will propose an innovative method of E-bike instrumentation in the process of exploring the third stage of consumer culture from the design point of view, to provide a reference for E-bikes to reduce the phenomenon of "homogenization".

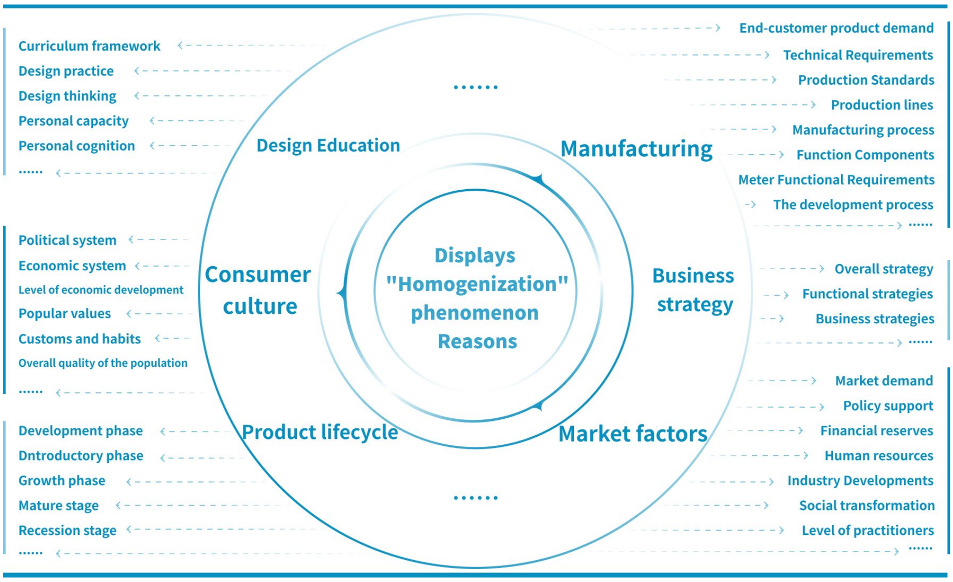
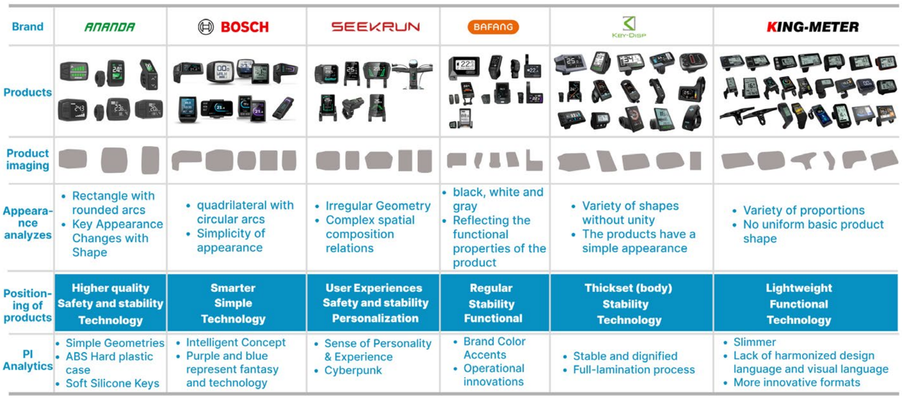


Figure 5: Analysis table of the causes of "homogenization" phenomenon of pedal-assisted e-bike instrumentation (authors' own drawing)

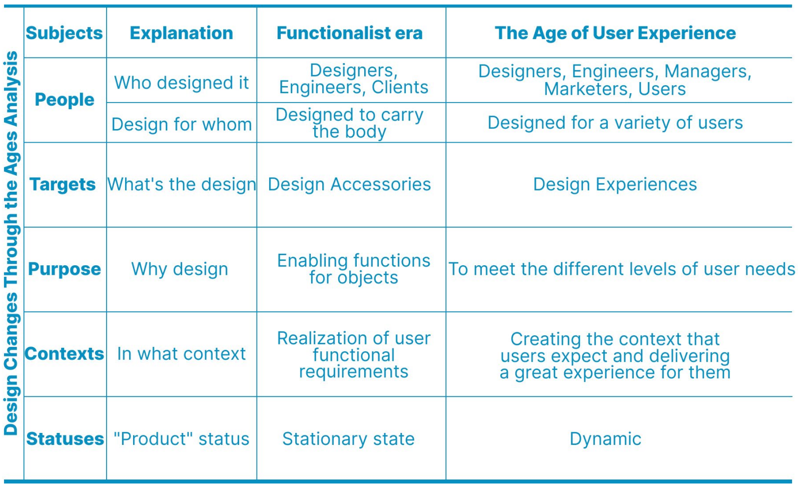
4. The Current Stage of Product "Homogenization" Solutions

Although the current instrumentation industry is seriously homogenized, there are pioneering companies that put innovation first and continue to introduce differentiated products, for example, SEEKRUN, although it started late, it aims to create products that are perfectly integrated with pedal-assisted e-bikes, enhance the user's ride experience and promote a harmonious partnership between humans, mobility and the environment. In a comparison of the SEEKRUN meter and other companies' meters, as shown in the content of Figure 6, it can be found that the company has entered the era of user experience, and the design and production of its meter is to provide a more perfect integration of pedal-assisted e-bikes, focusing on bringing a better sense of the travel experience for the user, as shown in the details of Figure 7.



Brand	ANANDA	BOSCH	SEEKRUN	BAFANG	KEY-DISP	KING-METER
Products						
Product imaging						
Appearance analyzes	• Rectangle with rounded arcs • Key Appearance Changes with Shape	• quadrilateral with circular arcs • Simplicity of appearance	• Irregular Geometry • Complex spatial composition relations	• black, white and gray • Reflecting the functional properties of the product	• Variety of shapes without unity • The products have a simple appearance	• Variety of proportions • No uniform basic product shape
Positioning of products	**Higher quality Safety and stability Technology**	**Smarter Simple Technology**	**User Experiences Safety and stability Personalization**	**Regular Stability Functional**	**Thickset (body) Stability Technology**	**Lightweight Functional Technology**
PI Analytics	• Simple Geometries • ABS Hard plastic case • Soft Silicone Keys	• Intelligent Concept • Purple and blue represent fantasy and technology	• Sense of Personality & Experience • Cyberpunk	• Brand Color Accents • Operational innovations	• Stable and dignified • Full-lamination process	• Slimmer • Lack of harmonized design language and visual language • More innovative formats

Figure 6: Comparative analysis table of meters by brand (Self-drawn by the author, meter images from the Internet) instrumentation (authors' own drawing)

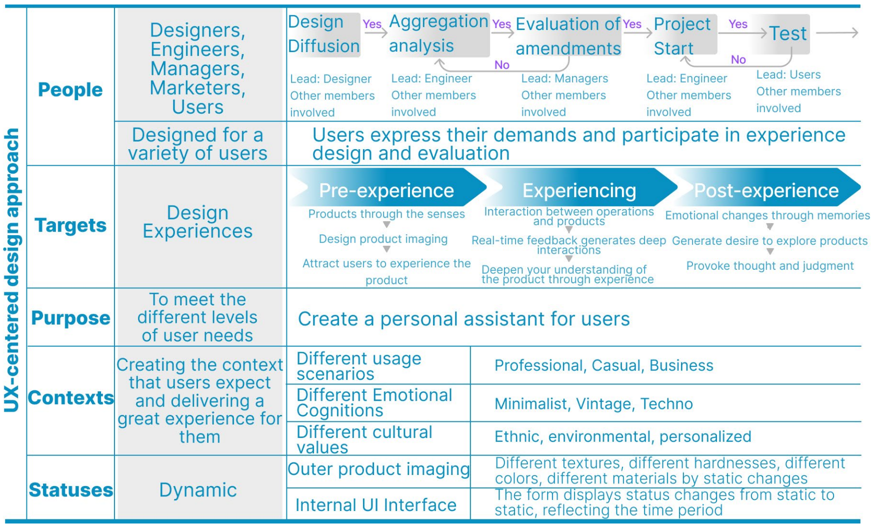


Design Changes Through the Ages Analysis

Subjects	Explanation	Functionalist era	The Age of User Experience
People	Who designed it	Designers, Engineers, Clients	Designers, Engineers, Managers, Marketers, Users
	Design for whom	Designed to carry the body	Designed for a variety of users
Targets	What's the design	Design Accessories	Design Experiences
Purpose	Why design	Enabling functions for objects	To meet the different levels of user needs
Contexts	In what context	Realization of user functional requirements	Creating the context that users expect and delivering a great experience for them
Statuses	"Product" status	Stationary state	Dynamic

Figure 7: Analysis of design changes over time (authors' own drawing)

4.1 A User Experience-centered Design Approach



UX-centered design approach

People	Designers, Engineers, Managers, Marketers, Users	Design Diffusion Yes → Aggregation analysis Yes → Evaluation of amendments Yes → Project Start Yes → Test → No No Lead: Designer Other members involved Lead: Engineer Other members involved Lead: Managers Other members involved Lead: Engineer Other members involved Lead: Users Other members involved	
	Designed for a variety of users	Users express their demands and participate in experience design and evaluation	
Targets	Design Experiences	Pre-experience Products through the senses Design product imaging Attract users to experience the product Experiencing Interaction between operations and products Real-time feedback generates deep interactions Deepen your understanding of the product through experience Post-experience Emotional changes through memories Generate desire to explore products Provoke thought and judgment	
Purpose	To meet the different levels of user needs	Create a personal assistant for users	
Contexts	Creating the context that users expect and delivering a great experience for them	Different usage scenarios	Professional, Casual, Business
		Different Emotional Cognitions	Minimalist, Vintage, Techno
		Different cultural values	Ethnic, environmental, personalized
Statuses	Dynamic	Outer product imaging	Different textures, different hardnesses, different colors, different materials by static changes
		Internal UI Interface	The form displays status changes from static to static, reflecting the time period

Figure 8: A user experience-centered design approach (author's own drawing).

As shown in Figure 8, in addition to designers, engineers and managers, design innovators, product-related marketing personnel, marketers and users enjoy the same power of innovation. However, big data, blockchain, and artificial intelligence technology will continue to play an important role in innovation and design, especially in the product design phase, such as product function positioning, product image innovation, and other aspects, the application of various artificial intelligence tools to product innovation will bring great vitality to product innovation.

The change of the design object is an important feature of the change between the functional era and the user experience era. The design object in the functional era is simple, consisting of the design object in the user experience era is more complex, involving the experience that the product brings to the user. User experience includes three phases: pre-experience, which is the the expectation and anticipation of using the product; experience, which is the actual use of the product; and post-experience, which is the reflection and evaluation of using the product. The design of the experience should not only show the transmission of functional information of the product itself but also provide timely feedback on the operation made by the user, to improve the interactive experience between the product and the user. After the operator has experienced the product, a good experience will leave the user with good memories, prompting the user to produce more interaction with strong emotions.

The purpose of design serves as both the inception and a pivotal component of user-experience-centered design methodology. During the era of functionalism, instrument design merely aimed to exhibit device information and showcase product functions. However, in the age of user experience, instrument design has evolved beyond the mere display of functions; it now seeks to establish a profound connection between users and the presentation of functional information while addressing users' diverse needs. For instance, it provides real-time feedback to users based on their riding status, empowering them to make timely adjustments. Consequently, the instrument's identity transforms from a simple product into that of a riding assistant.

In the user-experience-centered design methodology, the design context assumes a paramount role. Users exhibit distinct positioning and requirements for a product across various contexts. For instance, when designing instrumentation for pedal-assisted e-bikes, one can consider different usage scenarios, such as professional, leisure, and business. Alternatively, designers can take into account users' sensory perceptions, emotions, and cognitive responses to create instrumentation with distinct styles and attributes, ranging from simplicity to vintage to a scientific and technological aesthetic. Furthermore, designers can delve into users' cultural backgrounds, values, beliefs, and other aspects to explore the development of instruments with diverse connotations and symbolism, embracing themes like ethnicity, environmental consciousness, and individuality. The shift in design context can impart unique styles to the product, representing a highly practical means of establishing a design identity.

In the era of user experience, the nature of products undergoes profound transformations. Products are no longer static snapshots of a single moment but rather represent an evolving state over a defined period. This evolving characteristic is referred to as a dynamic product in this context. The dynamism of a dynamic product primarily manifests in two key aspects: the external aesthetics of the product and real-time changes in the user interface (UI). These UI alterations bring forth the most intuitive and aesthetically appealing experiences for users. Achieving this necessitates a focus on material and technology-related elements. Exploring various textures, degrees of hardness, and color palettes within the materials used is pivotal. Leveraging diverse manufacturing techniques enables users to seamlessly engage with the product without having to consciously navigate the physiological and psychological nuances. Furthermore, in the user's interactions with the product, the immediate feedback provided by the UI enhances the overall user experience, making it more chic and engaging. Designing for changes in the product's state elevates the interaction experience between the product and the user to a significant degree.

The user experience-centered design methodology finds practical application in the realm of pedal-assisted e-bike instrumentation, and its relevance extends to fostering design innovation across various accessory product domains. Implementing this methodology can trigger a sequence of organizational adjustments, necessitating interdisciplinary collaboration to achieve the most favorable outcomes.

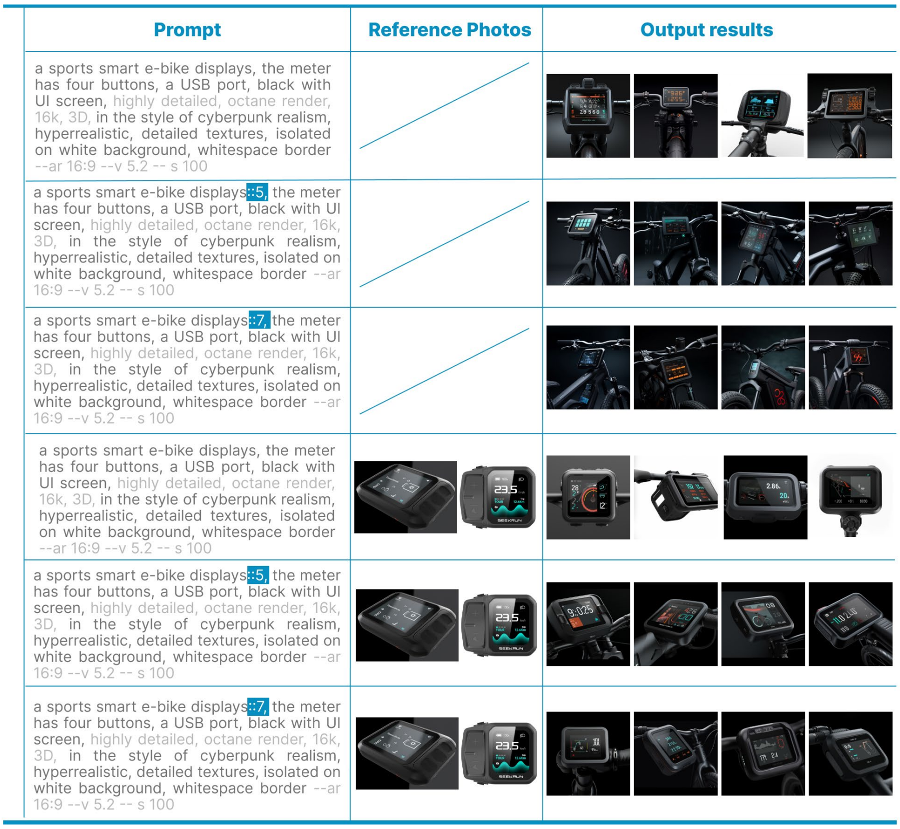
4.2 Generative Design Approach

Generative design, at its core, involves revisiting the fundamental aspects of a product its purpose, demand, essence, and underlying meanings and then innovating and optimizing based on these foundational principles. This process generates a multitude of potential solutions for existing products. When viewed from an object-oriented perspective, generative design shares striking similarities with Master Kenya Hara's REDESIGN design concept. Both approaches share a common goal of returning to the roots of a product, reevaluating its essence, and breaking away from established product models to create designs that better align with real-world needs. Master Kenya Hara, a renowned Japanese industrial designer, introduced the concept of REDESIGN, which involves the examination, deconstruction, reorganization, and recreation of existing objects to uncover hidden or overlooked values and imbue these objects with new functions, forms, or meanings. For instance, Hara transforms discarded or obsolete electronic products like televisions, phones, and radios into novel and artistic installations. He incorporates materials from traditional Japanese culture, such as bamboo tubes, fans, and paper, into the design of contemporary objects like stereos, lamps, and furniture. Hara also manipulates, reorganizes, enlarges, and reduces everyday items such as chairs, tables, and chopsticks to create new shapes, functions, or interpretations. This transformation of ordinary objects results in works that evoke surprise and humor. Master Kenya Hara's REDESIGN design approach epitomizes the essence of generative design. Both methods involve returning to the core of an object, rediscovering and redefining its value and significance, and ultimately creating something entirely new. Applying generative design techniques to the field of pedal-assisted e-bike instrumentation allows for a reevaluation of these products from their origins, prompting a reconsideration of their functions, forms, and underlying meanings. By repositioning these products and constructing logical frameworks, generative design can lead to the development of products that better align with the genuine needs and experiences of users.

The concept of Crowd Intelligence Innovation, as proposed by Professor Luo Shijian, involves harnessing the potential of big data, blockchain, and artificial intelligence technology to break down disciplinary barriers and leverage the collective intelligence of the public to accomplish complex innovation tasks. Crowd Intelligence Innovation is characterized by its emergent and synergistic qualities. Emergent, in the context of Crowd Intelligence Innovation, implies that each individual within the system possesses talents that can benefit the entire organization. These individuals exhibit diverse, independent, and equal communication, along with decentralized and deauthoritative characteristics. Synergistic pertains to the collective intelligence and multidimensional innovation that emerges across the entire field. This approach promotes universal innovation[5]. The rapid advancement of artificial intelligence has introduced new avenues for design. The generative design methodology leverages big data, cloud computing, and artificial intelligence to transcend disciplinary boundaries. It dismantles centralization and authority that often exist within real-world design decision-making processes. Generative design employs robust algorithms to offer designers an extensive array of program possibilities, aligning well with the concept of crowd intelligence innovation. Presently, there are several artificial intelligence software solutions available on the market, such as Midjourney and Stable Diffusion. These tools are well-equipped with extensive data training capabilities, providing designers with a wealth of inspiration and design possibilities.

The generative design method can be approached through two distinct paths. The first path involves designers using keywords or scene descriptions to encapsulate the products they intend to design. These keywords are then inputted into AI tools as prompts. By adjusting the emphasis and weight of specific keywords within the design context, the AI tool can generate an array of limitless possibilities, offering designers an abundance of fresh ideas and inspiration. The second path complements the use of prompt words by supplementing them with relevant product images. This approach provides the AI tool with additional design context, enabling it to more precisely identify the products that align with the designer's vision. Consequently, this method leads to a more efficient output of design innovations. Following the generation of innovative ideas, designers must translate these concepts into engineering files for subsequent processing and production. To illustrate this approach, consider Midjourney as an example. Figure 9 depicts the results of two controlled experiments conducted under the same cue words. In one experiment, no reference pictures were added, and adjustments were made to the weighting of specific words. In the other experiment, the same cue words were employed, but reference pictures were included. It's evident that while the generative design method's outcomes may not always align perfectly with reality, they often prove more efficient than the original approach. This method opens up numerous avenues for designers to explore innovative ideas.

The application of the generative design methodology in the design of pedal-assisted e-bike instrumentation serves a dual purpose. Firstly, it facilitates a profound understanding and reconstruction of these instruments at their core, enabling designers to gain deeper insights into their functionality and purpose. Secondly, it widens the scope of innovative design ideas, offering a solution to counter the prevailing issue of "homogenization" in pedal-assisted e-bike instrumentation. The generative design methods are poised to become increasingly prevalent across various industries in the era of large-scale models. This approach not only enhances the understanding and creative potential within these industries but also holds the promise of breaking new ground in design innovation.



Prompt	Reference Photos	Output results
a sports smart e-bike displays, the meter has four buttons, a USB port, black with UI screen, highly detailed, octane render, 16k, 3D, in the style of cyberpunk realism, hyperrealistic, detailed textures, isolated on white background, whitespace border --ar 16:9 --v 5.2 -- s 100		
a sports smart e-bike displays::5, the meter has four buttons, a USB port, black with UI screen, highly detailed, octane render, 16k, 3D, in the style of cyberpunk realism, hyperrealistic, detailed textures, isolated on white background, whitespace border --ar 16:9 --v 5.2 -- s 100		
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Figure 9: Example of generative design methodology content (author's own drawing, design solution generated by Midjourney)

5. Conclusion

User experience-centered design and generative design indeed have distinct differences in their focus and objectives. Generative design is primarily geared towards creating entirely new products, pushing the boundaries of innovation, and infusing products with unique personality and cultural elements. On the other hand, user experience-centered design centers around enhancing and innovating existing products, often drawing inspiration from current products or competitors. Each of these design approaches comes with its own set of advantages and limitations, making it essential to choose and apply them judiciously based on specific situations and objectives. This paper contends that in the pedal-assisted e-bike instrumentation industry, both design methods hold intrinsic value and necessity. In this industry, combining the strengths of generative design and user experience-centered design can yield mutually beneficial outcomes. These approaches can learn from and complement one another, fostering the development of the pedal-assisted e-bike instrumentation sector as well as other accessory industries. The synergy between these two methods can result in more innovative, user-friendly, and culturally relevant products, ultimately driving progress and competitiveness in the market.

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