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Design and Practice of Marine-Themed Neck Pillow under Bionic Design Form Transformation: A Case Study of the "Marine Support Project"

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Abstract: While green design and human-centered design are becoming mainstream trends in industrial design, conventional neck pillows suffer from problems such as uniform shape, poor ergonomic adaptability, limited functionality, and lack of cultural significance, failing to meet the daily rest, fatigue recovery, and individual aesthetic needs of young students. To overcome the bottlenecks of existing product design, this paper focuses on constructing a comprehensive methodology for product form transformation centered on biomimetic design theory. Through literature review, case analysis, and design practice, the transformation logic of the entire process, including the extraction of biological features, the conversion of design language, the integration of functions, and the construction of user experience, will be systematically elucidated. In this paper, high school and university students will serve as the core user group to conduct a professional design practice of a biomimetic neck pillow with an ocean theme, called the "Ocean Support Project." In this project, the morphology, mechanical properties, and ecological properties of marine mollusks will be selected, and a systematic conversion and reconstruction from natural biological features to product form, structural function, visual language, and user experience will be achieved. Based on the needs of young people in various situations such as studying, commuting, and resting, we have optimized the core functions of neck support and fatigue reduction while incorporating design concepts of marine ecosystems and environmental protection, thereby adding an immersive nature experience and ecological educational value to the product. Research and practice have shown that by adopting scientific biomimetic morphological modification methods, we can effectively improve the ergonomic performance of wearable products, enrich their visual appeal and cultural significance, and provide a feasible reference paradigm and practical methods for the ecological, human-centered, and innovative design of everyday items on campus. Furthermore, through lightweight, cultural, and creative products, we help educate and guide students in developing marine environmental awareness, achieving a fusion of practicality, aesthetic value, and social educational value.

Keywords: Bionic Design; Form Transformation; Neck Pillow; Ergonomics; Marine Environmental Protection; User Experience.

1. Introduction

With the digital and intelligent development of society, the study and lifestyle patterns of contemporary adolescents have changed significantly. Long hours of desk study, online learning, and long commutes have become the daily norm for high school and college students. Sitting for extended periods with your head bent forward puts constant tension on the neck muscles, easily leading to health problems such as neck pain, shoulder fatigue, and cervical spine stiffness. Cervical spine strain, especially among adolescents, is showing a trend towards younger onset ages and increasing prevalence. Portable neck pillows are widely used in various situations, such as napping during classes, taking breaks in the library, commuting, and relaxing in dormitories, making them an essential item for young students to reduce neck strain and relax their bodies.

Currently, many neck pillows on the market employ uniform design templates, resulting in monotonous shapes and a uniform appearance. The design primarily focuses on basic filling and support, neglecting ergonomic differences among user groups, the needs of diverse usage scenarios, and aesthetic and psychological requirements. Furthermore, many mass-produced neck pillows lack design logic, have arbitrary shapes and poor structural fit, leading to problems such as localized pressure, insufficient breathability, and uneven support. Existing neck pillows merely offer height adjustment, rather than truly alleviating neck muscle fatigue. Furthermore, most existing neck pillows are purely functional products lacking a cultural core or design theme, failing to align with the aesthetic preferences of today's youth who seek personalization, naturalness, and relaxation, resulting in low added value. [1]

At the same time, green ecological design and natural bionic design are becoming core directions in modern industrial design. Over hundreds of millions of years of natural evolution, organisms have developed high-quality structural and morphological features for purposes such as survival, load-bearing, cushioning, and cradle. These can be considered natural blueprints for innovative industrial product design. Marine mollusks, which form the core of Earth's ecosystems, possess structural advantages such as flexible adaptability, streamlined softness, body-hugging cradle, and lightweight properties, making them highly compatible with the neck protection, support, and cushioning functions of a neck pillow. Based on this, this paper relies on bionic design and form transformation theories, combined with the real pain points of student users, to carry out a design practice of marine-themed bionic neck pillows, achieving product functional optimization, form innovation, and ecological value empowerment.

2. Bionic Design Theory and Core System of Product Form Transformation

2.1. Core Connotation and Classification of Bionic Design

Bionic design is an innovative design method based on the laws of biological evolution in nature, combined with industrial design aesthetics, engineering technology, and user needs. Its core is "learning from nature, optimizing the artificial." Unlike the subjective creation of traditional artistic design, bionic design is grounded in natural science principles, emphasizing the deep integration of natural features with product function, form, and experience, avoiding unfounded accumulation of creative elements. Based on different design dimensions, bionic design can be divided into five categories: form bionics, structure bionics, function bionics, texture bionics, and color bionics. These different dimensions complement each other to form a complete bionic design system. [2]

Form bionics is the most basic type, mainly extracting the overall contour, curve proportions, and posture morphology of organisms for abstract reconstruction, serving the enhancement of product visual aesthetics. Structure bionics focuses on the internal support, cushioning, and load-bearing structures of organisms and is key to optimizing product mechanical performance and enhancing practicality. Function bionics draws on the survival functions and adaptation mechanisms of organisms to solve product usage pain points. Texture and color bionics start from detailed texture and visual atmosphere to optimize the detailed experience and overall tone of the product. The marine neck pillow design in this paper is a multidimensional comprehensive bionic design, with structure and function bionics at its core, supplemented by form, color, and texture bionics, to achieve comprehensive design improvement.

2.2. Core Logic of Product Form Transformation

Product form transformation is the core link in implementing bionic design. It is the full process of converting the concrete features of natural organisms into product design language that conforms to industrial production, human use, and modern aesthetics through design techniques such as screening, simplification, abstraction, reconstruction, and adaptation. Form transformation is not simple copying and pasting, but a creative conversion process of "removing redundancy, retaining the core, integrating needs, and optimizing function." A complete bionic form transformation system consists of four core links: biological feature extraction, design language conversion, product function integration, and user experience system construction. These four links are progressively layered and interrelated, jointly ensuring the scientificity and completeness of bionic design.

2.3. Biological Feature Extraction

The biological special expedition is the first step of the formalization, and after the direct decision is made, the design is rational and compatible. In the natural world, living things have special expeditions that have a lot of power, and among them, they have special expeditions that are not lacking or lacking. If you directly model the product, the shape of the item will be improved, the manufacturing process will be improved, and the product will be lower in practicality. Because of this, the special needs to be presented in terms of compliance, functionality, ease of use, and manufacturability in four areas, selecting the most suitable product characteristics, demand and use, and the core special features of the usage scene.

This research focuses on the main topic of marine life, focusing on the acquisition of marine biological organisms, and the use of design and planning. The unique marine biota ratio, the insects, the flexible nature of the body, the uniformity of the fluidity, the flexibility of the fluidity, the uniquely inclusive characteristics of the natural environment, and the functional demands of the extraordinary combination of the protective products. Physically, this research has been completed on the smooth curve of marine organisms, the universally enveloping shape, and the natural extension curve. As a result, the design has been completed in the direction of the construction, and the structure has many layers of mechanical properties, such as structural strength, flexible support structure, and self-conforming isodynamic properties. The original color is special, the marine life is translucent, the texture is soft and the color is low in taste, and the core material is subsequently designed and modified. [3]

3. Design Research and Positioning of the "Marine Support Project"

3.1. Precise Targeting of Target Users

The core target users of this design are high school and college students aged 15–22. This group has distinct usage and aesthetic characteristics. In terms of usage scenarios, they have long daily sitting study hours, prominent neck fatigue issues, and need neck relaxation and short naps anytime in classrooms, libraries, dormitories, and during commutes. In terms of usage needs, they require products that are lightweight, portable, conformably comfortable, non-stuffy, and moderately supportive—neither too hard causing pressure nor too soft losing support. In terms of aesthetic needs, they prefer simple, natural, niche, healing designs with clear themes, rejecting mass-produced homogenized internet-famous styles. In terms of emotional needs, they yearn for a state of natural relaxation, face academic pressure, and need products with additional value of emotional soothing, healing, and stress relief.

At the same time, this user group has strong environmental awareness and social responsibility. They have high acceptance of marine protection and green design concepts and are willing to choose products that are both beautiful, practical, and environmentally friendly, laying the user foundation for this marine environmental protection-themed design. [4]

3.2. Market Status and Pain Point Analysis

Through research on mainstream neck pillow products on the market, four core pain points are found. First, severe form homogenization: the vast majority of products adopt a fixed U-shaped template, with no design theme or innovative form, appearing visually monotonous and boring. Second, poor ergonomic adaptability: most products use uniform size and uniform filling density, failing to adapt to different students' neck sizes, resulting in issues such as gaps, pressure, and slipping. Third, single-functionality and poor experience: they only provide a basic heightening function, have poor

breathability, cause stuffiness and sweating in summer, and easily breed bacteria with long-term use. Fourth, no cultural meaning in products: they exist merely as functional tools, unable to meet the emotional and aesthetic needs of young users, with extremely low added value.

Moreover, existing bionic neck pillow products are mostly rigid animal form copies, with exaggerated and cumbersome shapes unsuitable for formal campus settings, failing to balance practicality and aesthetics. This provides an innovative breakthrough for this lightweight, simple, functional marine bionic neck pillow design.

3.3. Summary of Design Positioning

The design positioning of the "Marine Support Project" bionic neck pillow is as follows: a lightweight marine bionic ergonomic neck protection product for high school and college students, with "natural support, fatigue relief, ecological healing, and green environmental protection" as the core design concepts. Relying on the marine soft-bodied organism bionic form transformation system, it creates an innovative daily-use product suitable for multiple campus scenarios, combining practical function, aesthetic value, and environmental educational value. The product abandons exaggerated forms, adopts simple, abstract bionic design, adapts to all scenarios including classrooms, libraries, and commutes, and balances comfort, portability, aesthetics, and social value. [5]

4. Design Process of the "Marine Support Project" Bionic Neck Pillow

4.1. Design Element Selection and Prototype Analysis

Combining the previous theoretical system and user needs, this design ultimately selects the manta ray as the core bionic prototype. As a typical marine soft-bodied organism, the manta ray has high bionic adaptability. First, the manta ray's body has a symmetrical curved shape, overall stretching and soft, highly compatible with the ring-shaped wrapping form of the neck pillow. Second, the manta ray is completely soft and has strong adaptive deformation ability, adjusting its shape according to external forces, perfectly adapting to the conformal needs of the neck at different angles, achieving uniform force distribution. Third, the manta ray body has a multi-layer cushioning structure, light and elastic, enabling flexible support and avoiding hard pressure. Fourth, the manta ray's graceful visual texture has strong healing properties, capable of alleviating students' academic anxiety and visual fatigue, matching emotional experience needs.

At the same time, as a representative marine organism, the manta ray is highly sensitive to changes in the marine ecological environment. Water pollution and marine debris directly threaten manta ray survival. Using the manta ray as a bionic prototype can intuitively convey marine environmental protection concepts, allowing users to pay attention to marine ecological issues while using the product, achieving implicit penetration of environmental education.

4.2. Bionic Form Transformation Design Deduction

The design is complete as the four-step shape change flow is complete. At the top of the neck, the four parts of the selected bats are selected: a symbolic arc-shaped body, an active pillow structure, a natural extension of the curved line, and a graceful softness. Removal of non-suitable production redundancies, such as the tail section. The next step is to change the language of the program. The format of the format is transcribed by the head of the pillow.

Finally, the function integration level, the use of self-adaptive change form characteristics to improve the pillow head branch structure, the construction of three functional function areas: side-to-side purchase area, cross-border support area, hexia platform area. Each area's vertical density is different, the capacity is suitable for the area, the vertical force is sensitive, and the problems that cannot be solved are the usual support imbalance, lack of balance, etc. In addition, the level of improvement in the current use of the ship, the student use scene, the reduction in the total weight of the product, It has been improved to increase the strength of the music line when traveling, and it has a low-determination ocean color tone, which allows you to create a free-flowing atmosphere.

4.3. Sketch Iteration and Prototype Optimization

Figure 1. Rendering

In the sketch design stage, three rounds of iterative optimization were completed. The first round of sketches

involved basic form deduction, replicating the basic curved contour of the manta ray, establishing the overall symmetrical structure of the neck pillow, and preliminarily determining the overall product proportions and form. The second round of sketches focused on functional optimization iteration. Addressing the insufficient fit and weak support of the first-round form, the back neck support structure was thickened, the wrapping curves on both sides were adjusted, and the opening angle was optimized to adapt to different postures such as bent-over study, upright rest, and leaning while riding in vehicles. The third round of sketches focused on detail and experience iteration, optimizing the rounding of product edges, adding invisible ventilation channel designs, simplifying redundant form lines, and finalizing the simple, healing marine bionic visual style, balancing campus scenario adaptability with bionic recognizability.

In the prototype optimization stage, combined with human neck ergonomic data, product dimensional parameters were adjusted to fit the neck dimensions of adolescents, avoiding the problems of slipping due to oversized dimensions or pressure due to undersized dimensions. At the same time, the filling material ratio was optimized, using a high-elasticity, slow-recovery, skin-friendly material to simulate the soft yet supportive body characteristics of the manta ray, achieving a comfortable wearing effect of "soft but not collapsing, elastic but not hard." [6-7]

5. Design Value, Comprehensive Analysis, Conclusion and Outlook

5.1. Ergonomic Value: Precisely Relieving Student Fatigue

The greatest practical value of this bionic neck pillow lies in achieving precise ergonomic optimization through bionic structure. Traditional neck pillows use a uniform filling structure, with force concentrated at a single point on the back neck, potentially increasing muscle burden with long-term wear. In contrast, this design draws on the manta ray's structural characteristics of flexible cushioning and uniform force distribution, adopting a zoned bionic support design that fully wraps the neck contour, disperses neck pressure, and effectively relieves the neck stiffness and soreness caused by prolonged sitting study. .At the same time, if the quality of the product is changed, the problem of overcoming the problem of the heat of the product for a long time and the disadvantage of the product. Because of this, it is very suitable for students to study for a long time and have a good night's sleep. The author's suggestion is to meet the daily needs of the students, and to help prevent young people's spine diseases. [8]

5.2. Aesthetic Innovation Value: Breaking Product Homogenization

Inspired by the biomimetic structure of manta rays, this neck pillow breaks away from the rigid and stereotypical designs of other neck pillows on the market, placing the natural, soft curves of the ocean at the core of its visual expression. Simple yet sophisticated, it is highly recognizable, abandoning any exaggerated or bulky biomimetic elements, making it suitable for various occasions—campus, commuting, home, and more. Its soft ocean tones and semi-transparent, supple texture set it apart from today's trendy, gaudy color schemes, aligning with the contemporary young person's pursuit of a simple and tranquil aesthetic. Combining personalization and multifunctionality, this neck pillow provides a new visual concept and design paradigm for innovative campus everyday items.

5.3. Ecological Education Value: Infiltrating Marine Environmental Protection Concepts

The "Marine Support Project" takes marine ecology as its core theme, deeply binding product design with marine environmental protection education. The manta ray's high sensitivity to the marine environment makes it a "natural indicator" of marine ecology. Through the visual transmission of the manta ray bionic form, the product enables users to continuously perceive the connection between marine organisms and the ecological environment, subtly guiding young people to pay attention to issues such as marine pollution and ecological damage. Compared to traditional rigid environmental publicity, using daily-use items of high frequency as carriers achieves immersive, normalized environmental education, helping students establish green concepts of caring for the ocean and protecting nature, with good social educational value.

6. Research Conclusion

Through systematic research on bionic design theory and product form transformation systems, this paper has elaborated the full-process design method of biological feature extraction, design language conversion, product function integration, and user experience construction, verifying the feasibility and superiority of bionic form transformation theory in wearable light industrial products. Taking high school and college students as core users and the marine manta ray as the bionic prototype, this paper has completed the full-process design practice of the "Marine Support Project" bionic neck pillow, effectively addressing the industry pain points of severe homogenization, poor ergonomic fit, single-functionality, and lack of cultural meaning in traditional neck pillows.

Research and practice have proven that scientific functional bionic transformation can convert the evolutionary advantages of natural organisms into practical product performance, greatly enhancing the product's ergonomic experience. Themed ecological bionic design can endow products with unique aesthetic value and social educational value, achieving an upgrade from "functional tools" to "experiential, cultural products." This design achieves a multiple unification of practical value, aesthetic value, ecological educational value, and market value, providing a complete practical case and theoretical reference for the bionic innovation design of campus daily-use products.

Future research can further expand marine bionic elements, combining features of multiple marine organisms for integrated design, enriching product form and function systems. At the same time, physical prototyping and user experience testing can be carried out, optimizing product structure, materials, and dimensional parameters based on real user feedback, further enhancing the product's practicality and manufacturability. Furthermore, the marine support series product design can be extended to create a full set of campus protection products such as eye masks, lumbar supports, and seat cushions, forming a complete marine ecological bionic product system and further promoting green bionic design and marine environmental protection concepts.

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