Article

From Theory to Practice: An Adaptive Development of Design Education

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Abstract: This study aims to discuss the adaptive challenge, and bridge the gap between theory and practice in design education. From now on, navigating design communities through the new era is a significant issue facing global competition and pluralistic society. First, this study reviews the essential evolution of design theories in the past few decades on man-machine system design, user-centered design, and user experience design. Second, based on three case studies of the REACH toothbrushes, an IEF wearable computer, and a LINNAK twin-cup, the research findings are offered to witness the advancement and transformation from hi-tech to hi-touch. Furthermore, this study summarizes three paradigms to interpret the adaptive evolution in design education. Finally, the authors propose three directions for the advancement of the creative industry and design education. The contributions of this study are to (1) clarify the interrelations between the theory and practice of design via the three foci of the human factors, human actors, and cultural aspects; (2) demonstrate the transformation of the archetypal model of user–tool–task employing illustrative paradigms; (3) identify the evolution of design education with contextual stages in the past decades; and (4) propose orientated perspectives for the personnel and institutes of the design industry and design education.

Keywords: design theory; design practice; design education; adaptive development; cultural ergonomics

1. Introduction

Humans have always striven for a better life. Our ancestors created diverse tools, craftworks, objects, and products via the application of advanced technology of the time to face their challenges in the world. After the industrial revolution, intentions of chasing economic growth caused the blooming of mass production and machine manufacture. Later, for achieving the balance between aesthetic necessity and industrial production, the idea and action of integrating technology and arts and crafts turned into design theories and design practices in the sphere of education and industry. In other words, design education was triggered in the early 20th century because of the enlightenment from the Bauhaus school [1,2]. Across the Atlantic, the concept and implementation of design and design education spread to the United States, then carried forward and brought greater development to the world. Today a century later, as we face global competition and a pluralistic society, navigating design communities through the new era has become a significant issue.

Although humans have been pursuing advanced technology for a better life over long periods, we have perceived that the more high tech humans have, the more high touch humans want [3]. The association, balance, and interface between technology and humanity has become a well-known issue of design since Nokia addressed the concept of "human technology" and "connecting people" in the late 1990s [4–6]. People choose

products according to the benefits they obtain from both hedonic and utilitarian aspects. However, experiential enjoyment is more difficult to evaluate and quantify than practical functionality [7].

This study takes the approach of "from theory to practice" to explore the development of design education from an adaptive perspective. First, this study reviews the essential evolution of design theories on the man-machine system, user-centered, and user experience; second, the authors discuss three empirical cases of design practice as contrast with the corresponding literature review. These research findings witness the advancement from hi-tech to hi-touch and the transformation from human-computer interaction (HCI) to human-culture interaction (HCuI); and address that touch is associated with the symbolic meaning which is always beyond the technology once the functionality has been met. This article has limitations in including the wide-range, comprehensive, and chronicled literature review in design pedagogy. In this article, most discussions and presentations apply to college school, an advanced degree, or in-service design education; and focus on the interfaces and interrelations between artifact creations/products and human cognitions from ergonomic design to cultural product design. This study aims to discuss the adaptive challenge and bridge the gap between theory and practice in design education. The purposes of this study are to (1) clarify the interrelations between the theory and practice of design via the three foci of human factors, human actors, and cultural aspects; (2) demonstrate the transformation of the archetypal model of user–tool–task employing illustrative paradigms; (3) identify the evolution of design education with contextual stages in the past decades; and (4) propose orientated perspectives for the personnel and institutes of the design industry and design education. Finally, the authors hope that these study results will be of practical use and valuable reference for the creative industry and design education.

2. Literature Review on Design Education and Design Theory

2.1. The Challenge and Direction of Design Education

When people discuss the goals and development of design education, one of the efficient ways is to keep exploring the trends and requirements of practical design and innovative entrepreneurial as an essential consultation. As Schaefer et al. (2019) indicated in *Design Education Today* (2019), "good design is human-centered, commercially viable and technologically sound [8] (p. 5)." The experience of good design always delivers a desirable sensation and is inspirational. The design has a significant impact on individuals, societies, and cultures, and shapes the world around us. It is a technical discipline and art that facilitates people to realize their aspirations [8]. Therefore, design practice's challenges, principles, and ideals also become valuable references and guidelines for design education.

Meanwhile, the world faces new challenges; as Meyer et al. (2020) mentioned, "designers are entrusted with increasingly complex and impactful challenges [9] (p. 13)". The capability of designers, design students, and design teachers to develop creative solutions to complex issues is becoming increasingly important. Design is a complicated field; it often needs sophisticated cooperation with cross domains. How design education keeps up with the new demands of the 21st century will be a significant and profound inquiry. According to Ken Friedman's suggestions, Meyer and Norman extended the eleven design challenges in 2020. They divided these design challenges into four groups of performance, systemic, contextual, and global to define the future of design and design education [9]. They also indicated there are two very different types of educational institutions that teach design. A research university concentrates on research activities, theory development, scholarly work and increases general knowledge. Nevertheless, in stand-alone schools of design, the faculty and students emphasize practice. Some gaps indeed exist between the two different educational design institutions, and so too between design theory and practice.

In the context of globalization, Lysenko et al. (2020) addressed the essential factors of modern higher education in quality and competitiveness, "they depend not only on technical achievements, inventions, and knowledge creation but also on organiza-

tional changes [10] (p. 13)." Jardim (2021) mentioned that "cognitive and technical skills are not sufficient to face the professional challenges of the current digital and global world [11] (p. 1)". They also pointed out the new generations' challenges in innovative entrepreneurial education.

The strategies through the efficient and stable symbiotic interface achieving the evolution of symbiosis, are a new direction for educational improvement. Wang and Yu (2019) discussed the value of collaborative innovation, which significantly promoted industry and university cooperation. There are many good cases of university collaborative innovation, and they argued that "the synergy between ordinary universities creates much bigger value than the total value that each individual university can provide [12] (p. 12)". Ruoslahti (2020), based on the European Union (EU) case study of promoting collaboration to explain the value of co-create knowledge, indicated that "complexity characterizes the co-creation of knowledge in innovation projects in various ways [13] (p. 228)".

When creative education is surrounding the concern of human-centered designs, Metallo et al. (2021) also suggested that "the psychoanalysis of individuals' unconscious representations, such as deeper fantasies, wishes, and desires, allow us to understand behaviors including the dreams and ambitions of entrepreneurs in the organizations [14] (p. 40)". In addition, Ali (2019) was concerned with how personality traits affected innovativeness among individuals and satisfaction with life perceptions and proposed an approach to studying an important gap in the body of knowledge. The core values of personality traits, individual innovativeness, and satisfaction with life, are worth in-depth study in design education [15]. The points of the concept are discussed shortly in subsequent research. Lin et al. (2021) pointed out the value of design thinking and situation in design education, "in the past, the primary concern of design education was about designers' competency rather than the power of design. Design thinking has become increasingly popular over the years because it is proven to be the right approach for the success of design problem-solving and daily activities [16] (p. 7)". According to the root cause analysis (RCA) report, Cross (2011) summarized the nature of the design. It indicated that design research should focus on the design process, which achieves the task via understanding design cognition and the way of knowing and thinking [17].

When realizing the increasing complexities of design issues, this study tries to illuminate the appropriate approach and find the potential direction for design education. Learning from experiences is one of the essential principles of experiential learning in pedagogy [18]. However, learning to educate from experience is one of the concerns of this study [19]; how does the theory and practice in design education make the balance in harmony. In other words, the cognition and understanding of the interrelation between the design theory and design practice can be the significant guidelines of design education. This study tries to retrospect the archetypal model in the design educating experience. It takes the user–tool–task paradigm as an example to explore its adaptive transformation in the design process to pursue sustainability. In the following paragraphs, the authors review the essential theories of ergonomic design on man-machine system design, user-centered design, and user experience design to highlight the evolution and challenges of three foci on the human factors, human actors, and cultural aspects in the changing design education.

2.2. Man-Machine System Design: Human Factors

In the early days of the 20th century, machine systems were built. The initial human factors concern was the development of principles of machine guarding to ensure worker safety. This was followed by time-motion studies to improve worker productivity. The Second World War with its introduction of high-performance airplanes and machinery necessitated the study of their designs so as not to exceed the human capabilities of their operators. This led to man-machine design with its emphasis on mathematical modeling of the human operator as a "manual controller" component in such systems. These all pertained to military and industrial environments confronting the human. The automobile industry began application of anthropometry for increasing safety and comfort

of drivers. In the early 1970s, concern arose for "consumer product design": the application, modification and extension of human factors principles developed in military and industrial contexts to the design of everyday products for the ordinary human so that they would be satisfying to the consumer and profitable to the manufacturer. The development of the first commercial computer systems in the 1950s and their introduction as consumer products in the 1960s launched research into the user interface [20]. When the "mouse" was invented by Douglas Engelbart in 1968, it fostered the next innovative waves of graphical user interface (GUI) in the 1970s and 1980s.

Those innovations allowed information to be manipulated in a more flexible and friendly way [21]. Norman proposed the direct manipulation interface, which has been well-received by users, as a good form of interface design. He identified two basic phenomena that led to the feeling of directness: one deals with the distance of information processing between the user's intentions and machine's facilities, another phenomenon relates to the relation of interface languages between the input and output; he also mentioned that distance and engagement are the two major aspects with landmark values, especially when the system provides the representation of objects as if they are the objects themselves [22]. Direct manipulation provides the feeling of directness and friendliness, just as WYSIWYG what you see is what you get (WYSIWYG) became one of the important principles of product design [23,24].

The man-machine system also known as human engineering or ergonomics in product design, particularly explores the categories of "human factors", based on the study and analysis of engineering psychology on the mental and physical capabilities and limitations of people to solve complex problems. Kreifeldt (1974) [25] proposed the analysis paradigm of the user–tool–task system as shown in Figure 1 for later discussion with exemplified case studies. This model presented the interactions and adaptive feedbacks, and in particular emphasized the three objects of design: user (human), tool (product), task (goal); the two interfaces: manipulation (user–tool) interface and engagement (tool–task) interface in the human system design [26–28]. Human factors are the major concerns of the manipulation interface, while mechanical engineering tends to be the essential feature of the engagement interface. This prototype model outlined the interrelations and influences between the user–tool, tool–task, and user–task. In other words, the user solves the problem and completes a task via the tool control which usually involves and employs two interfaces of manipulation and engagement. In the following, the user–tool–task model was reproduced and transformed into a more comprehensive system for the application of product design.
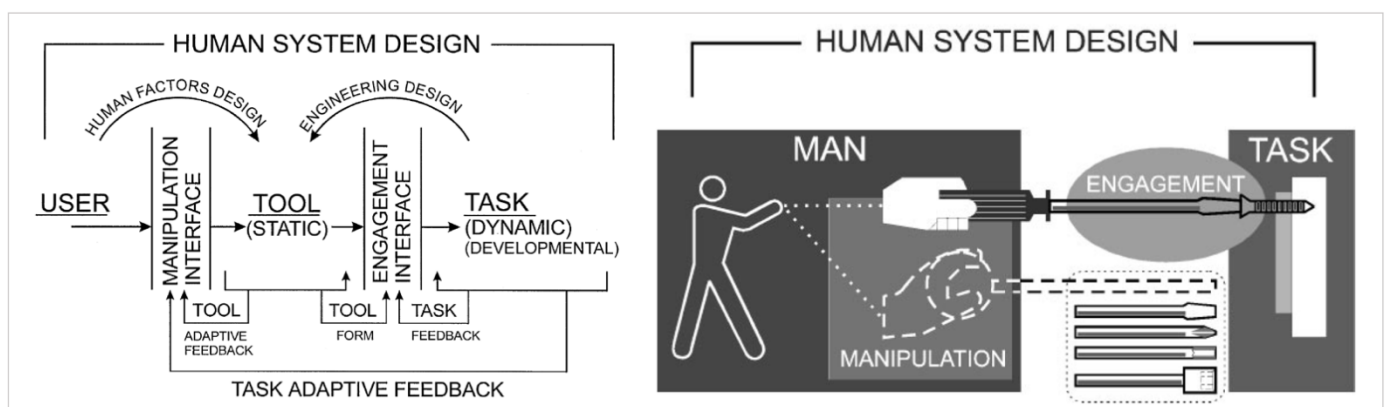

Figure 1. A symbolic framework of user–tool–task paradigm (**left**) and an analogic representation of the user–tool–task system (**right**). (adapted from [28]).

2.3. User-Centered Design: Human Actors

As a distinct species, human beings have two special characteristics. One is the ability to modify the living environment through artifact creation. The other is the corresponding ability to transmit the modifications to the next generations through human language which codifies the precept and procedure [29]. The invention of artificial devices enhances our speed, power, and intelligence. Tool making and usage also define our characteristics as human beings. Many artifacts make us stronger, faster, and smarter, increasing cognitive capabilities [30]. Artifactual tools are generally regarded as extensions of human physical agility. Nevertheless, the psychic situations effect the cognition and operation of such artifactual products. Consequently, the research of user-centered design (UCD) was inspired by the concept of the concerns for human nature and user needs [31].

In 1986, Norman not only proposed the new perspectives on human-computer interaction (HCI) but also engaged in cognitive engineering and tried to apply cognitive science to the design and construction of machines. In addition to computers, many complex devices are difficult to use because of fundamental difficulties in understanding their operation. He addressed some application problems and discussed a few issues which focus on the way that people interact with machines. He also proposed a conceptual prototype of mental models which comprise design model, user's model and system image as providing predictive and explanatory power for understanding the interaction [31]. Designers can communicate with the eventual users only through the system image of a product. Thus, a good designer will make sure that the system image of the final design conveys the proper user model. Norman aimed to facilitate bridging the gap between the gulf of execution (from goals to system state) and the gulf of evaluation (from system state to goals) which provided an orientation for issues of user-centered system design, and moving the user and system closer to each other [22,31,32].

It has become increasingly clear that the interaction between people and task affects the artifact and its usability and performance. When the artifact is combined with the informational and processing structure of human and task, the expansion of cognitive capabilities of the total system of human, artifact (tool, product), and task become an enhanced issue [30]. Designers sought to understand the underlying principles behind human action and performance, and devise systems that were pleasant and fun to use. For achieving "pleasurable engagement", researchers sought new ways of understanding the relationships and constraints between people, technology, and environment. The design communities stressed the research interests of user-centered design and departed from "human factors" to "human actors". At the same time, a larger role was given to the users who are not simply passive objects but active and centered agents within the design process [33].

2.4. User Experience Design: Cultural Aspects

Norman (1985) discussed that when user experiences directly interact with the objects, direct engagement occurs synchronously [22]. In order to deepen its understanding in the core value of user-centered design, Norman proposed the advanced concept of user experience (UX) design. As he suggested in "emotional design" (2004), each of the three processing levels of brain mechanism: Visceral, Behavioral, and Reflective, properly plays a different role in the functioning of human attributes [34]. The visceral level starts affective processing via making fast judgments and sending signals to the muscles and warning the rest of the brain. The behavioral level is more often referred to the practical and functional aspects of usability. The reflective level is the highest level which represents conscious thought and extracts the information to allow people to react intellectually and rationally [35]. Norman's three levels of design all combine to form the entire user experience.

User experience is a major concept in HCI dealing with "a person's perceptions and responses that result from the use or anticipated use of a product, system or service." The perceptions and responses in particular include the user's emotions, beliefs, preferences, accomplishments, physical and psychological responses that occur before, during, and

after use [36–38]. In other words, research of user experience concerns the user's feelings when using a product. User experience can be anything from sad to happy, from hate to love, from apathetic to passion, and so on [36]. Norman also explains the factors and states what affects the user's feelings. People cannot escape from affecting, positive or negative affection changes the way of thinking. Positive affection makes brain learning effective and arouses curiosity and creativity: someone who is in a pleasant mood is more creative. As he stressed, if the product is enjoyable and fun, designers and users will certainly benefit [34].

Those feelings that occur before, during, and after use influence the user's experience; however, the cultural factors rooted in environment, society, community, belief, religion, custom and so forth subliminally affect the user's emotion and cognition. Bruner's overview in *Studies in Cognitive Growth* (1966) stated that "man is seen to grow by the process of internalizing the ways of acting, imagining, and symbolizing that 'exist' in his culture, ways that amplify his powers. He then develops these powers in a fashion that reflects the uses to which he puts [them]" [39] (pp. 320–321). However, Cole and Griffin pointed out in their article "Cultural Amplifiers Reconsidered" (1980), that the different notions that artifacts enhance or amplify may be natural [30,40]. Nevertheless, despite the intertwining and dissension about the process of amplification, some cultures push or affect cognitive growth, and the varieties of cognition change a user's experience consciously or subconsciously.

As Kaplan (2004) mentioned, ergonomics is a continuously evolving field; Helander predicted the extension of cultural ergonomics in the 2000s. Since ergonomics adds cultural to human factors, cultural ergonomics emerged as a new sub-discipline [41]. Immediately, those cultural factors are incorporated into the design considerations. Moalosi et al. (2010) discussed an experimental design approach which was conducted at the University of Botswana, and proposed a model to integrate socio-cultural factors in the design process [42]. The research of Kreifeldt et al. focused on the aboriginal weaving box's appearance, cultural meaning, operational interface, and tried to create a new interface for examining the way of design and culture in the design process [43]. Kolus et al. (2018) proposed empirical evidence to remind that the decisions that impact design go beyond a conventional health and safety perspective [44].

3. Case Study on Design Practice

This study reviews the essential concepts of man-machine system design, user-centered design, and user experience design; also examines the development of adaptive design from "human factors" to "human actors" then "cultural aspects". Following, the authors adapted the user–tool–task paradigm (Figure 1) as an analysis framework for discussing three practical design cases corresponding to the empirical approach from theory to practice. Based on the discussion in adaptive development of an archetypal model of user–tool–task, this study chose three case studies across the 1970s to the 21st century, demonstrating its long-term applicability and transformation.

3.1. Case A: REACH Toothbrush

Toothbrushes are one of the most common and familiar products used in daily life since early childhood. A 17th century Chinese literature once mentioned tools for cleaning the teeth. In 1780, the British William Addis fixed the mane of a hog to an animal bone and created the first toothbrush. In 1857, the first American-designed toothbrush was patented in the United States, and to this day, there are hundreds of patents for manual or electric toothbrushes in design, appearance, function, or operation. Another important milestone in modern toothbrush design occurred in 1938 at the DuPont manufacturing company in Massachusetts, USA, when the first nylon fiber replaced the hog-mane bristle, greatly increasing the production of toothbrushes [45].

The design team of Percy Hill and John G. Kreifeldt of Tufts University is one of the best examples of integrating human factors with design. They accepted a design commission from DuPont in 1971 to develop a statistically supportable improved "teeth cleaning

device" which would be better than those of the competitors. They used scientific research methods and advanced production technology to solve the problem when brushing teeth of reaching the most difficult areas to brush inside the mouth. This project successfully conveys the core values of toothbrush design and demonstrates the coaction for engineering and design principles for which it was awarded the 1976 IDEA Award for excellence of design. As shown in Figure 2, the REACH toothbrush design, which changed the design of toothbrushes, is a successful design in line with human factors principles and is also a well-known and a typical example of man-machine system design and human engineering applied to product design. The technology was then transferred to Johnson & Johnson for mass manufacturing [2,45].
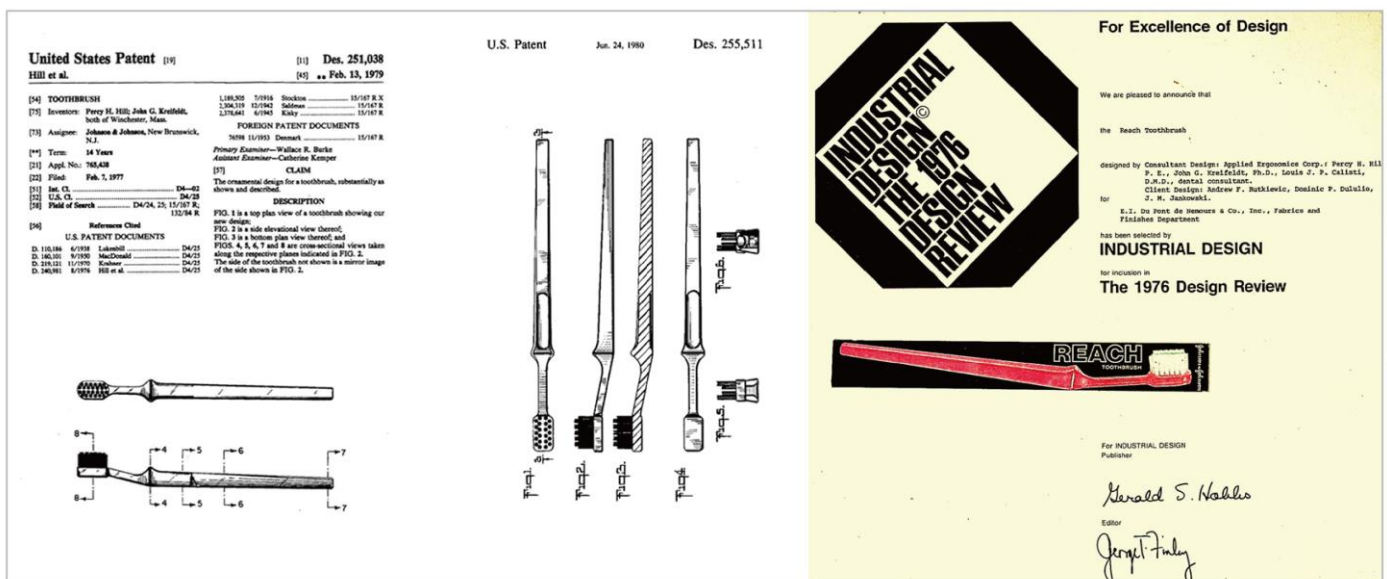

Figure 2. Design draft of REACH toothbrush prototypes (**left**) and the certification of INDUSTRIAL DESIGN for excellence of design in the 1976 design review (**right**) (adapted from [45]).

The design team of the REACH project, in conjunction with the analysis framework of the user–tool–task paradigm formulated by Kreifeldt, was used to conduct a series of studies on the details of people's brushing actions. After time-motion research and human factors analysis, the design team obtained many results about the interrelationship between brushing methods, toothbrushes, and hands [45,46]. This study also applied the user–tool–task paradigm to discuss and realize the final toothbrush design, explain the interaction and feedback among three objects of user (various people), tool (toothbrush), task (dental cleaning) and illustrated the processing factors which exist in the manipulation interface (comfort, operability, safety, user-friendly, etc.) and the engagement interface (brush shape, handle curve, neck angle, material, sensation, etc.) as shown in Figure 3.

The toothbrushes of the REACH series have been popular in the market for nearly 50 years. Today, in order to respond to the concerns and demands of sustainability, REACH also produces the eco-friendly toothbrush with a bamboo body (Figure 3f) [47]. This example explains how product design conveys the core values of the product and humanity through human engineering thinking to affect consumers. This design case of the REACH toothbrush not only shows the perfect combination of man-machine system design and human nature, but also carries out the consequences of "from function to feeling", which is an important strategy to achieve impressive product design and ensure successful marketing in order to return a substantial profit to the manufacturer.
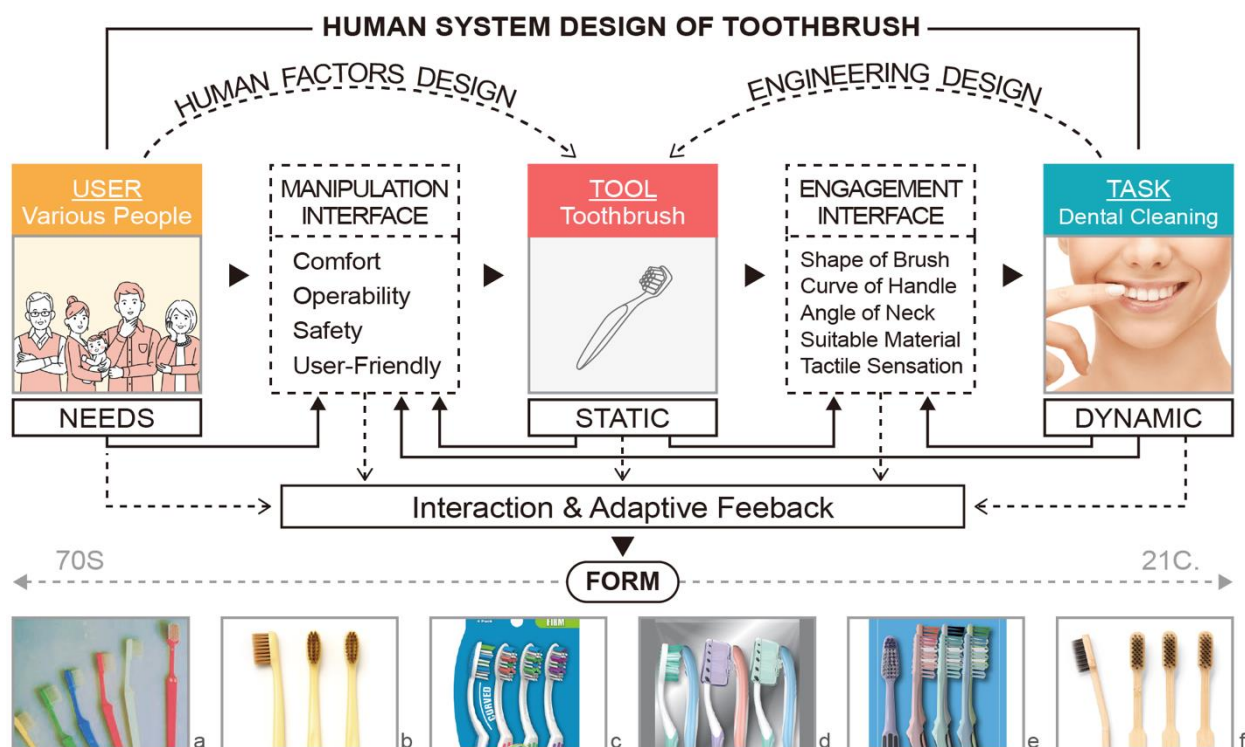
Figure 3. The analysis framework of user–tool–task paradigm as a toothbrush design (adapted from [26]. Bottom image (**a**): adapted from [45], (**b**–**f**): retrieved from [47]. Redrawn for this study).

3.2. Case B: IEF Wearable Computer

This case treats a wearable computer: designing the computer as an Intimate Electronic Friend (IEF) based on the concept of user-centered design in order to explore the human factors and user interfaces of high-technology products design. The case was proposed in 2001, so the following discussions are based on the technological, humanistic, and social contexts of the time [2]. At that time, wearable computers were being developed by many companies because of the rapid advances in technologies [28]. Unfortunately, many consumer products were not suitable for wearing, being either uncomfortable or bulky, causing annoying interference or unexpected disturbance with normal activities. As a result, most of the products rarely reached acceptable performance.

Many wearable attributes which effect the system appropriately belong to the research category of human factors. Therefore, the IEF design team, led by Rungtai Lin the ex-president of the Taiwan Design Center, not only analyzed the correlation and usability between the interfaces and accessories worn by people (Figure 4–left), but also proposed eight checking questions for the referential criteria of wearable computer design [28]. The IEF consists of three objects: helmet mounted display, right upper arm processor, and left forearm input device (Figure 4–right). All three devices are designed to be flexible and suitable for users with various body shapes, and can be worn in different situations comfortably. The main purpose of this case is to show how the designers combined the concepts of human engineering with design thinking under the contextual concepts of technology and design at that time [2,28].
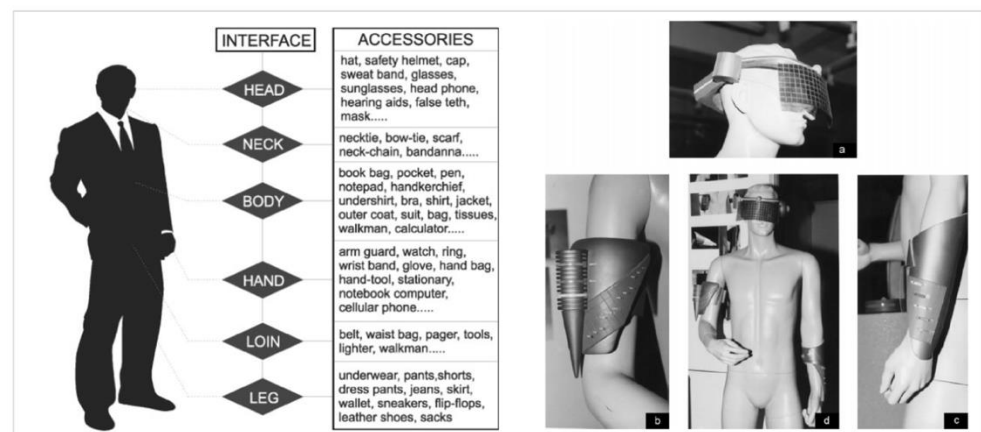
Figure 4. Wearable analysis for human (**left**) and prototype design of the Intimate Electronic Friend (IEF) (**right**) (adapted from [28]).

In order to define the design issues, guide development, evaluate usability, and finalize the wearable computer design, this design case applied the user–tool–task paradigm to analyze human factors in the manipulation interface and explore the engineering matters in the engagement interface as shown in Figure 5. Based on the concept and pursuit of "user-centered design", this practical case of wearable computer design not only focuses on the analysis of human factors, but also stresses the implementation of human actors that concern the user's participation as well as anticipation.
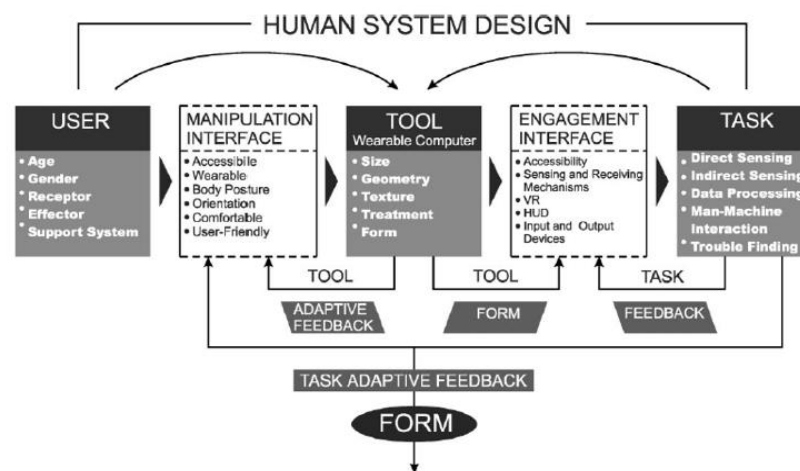

Figure 5. The analysis framework of the user–tool–task paradigm as a wearable computer design (adapted from [28]).

Today, in the world of high-tech ubiquity, we find that high-tech products are becoming smaller and lighter, but they contain more and more fuzzy features and are becoming more and more confusing to consumers. Therefore, how to use ergonomics to fill the gap between the user and the product should be the designer's durative focus [28]. This design case applied the user–tool–task paradigm to achieve the objectives of adaptive product design. This model describes the objects, interfaces, and interactions in the system and aims at fulfilling the wants of humanity as well exploring products that conform to the human nature of human engineering. It can serve as both an organized conceptual framework for user-centered design and a guide to the design process.

3.3. Case C: Linnak Twin-Cup

Aboriginal arts and crafts are always full of energy and passion. In particular a fund of cultural treasures offers great potential for transforming creativity, enhancing design value

and becoming recognized globally [48]. This design case chose the Linnak, an aboriginal "twin-cup" object of the Paiwan tribe in south Taiwan, as a meaningful culture carrier and focused on analyzing its art appearance, cultural meaning, operational interface, and use scenarios. After studies, the usage behavior and meaning of the Linnak was identified as "sharing with each other" [49]. According to three cultural levels [50], the Linnak design team finally accomplished three cross-cultural product designs (Figure 6) to correspond with the design features in each culture layers (outer, mid, and inner).
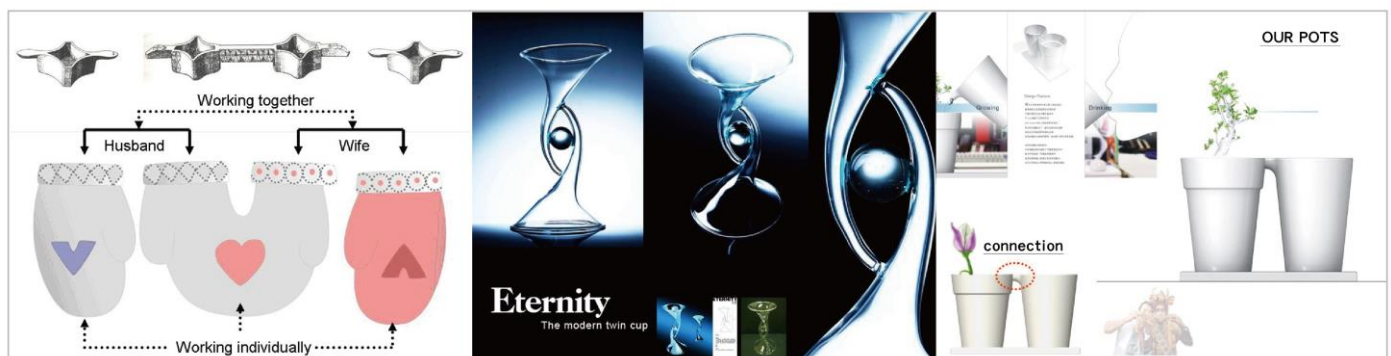

Figure 6. Our glovers: design from the outer level of the Linnak (**left**); our cups for lovers: design from the mid level of the Linnak (**middle**); our pots: design from the inner level of the Linnak (**right**) (adapted from [48]).

The design team of the Linnak project, led by Rungtai Lin, extracted cultural elements of the Linnak and transformed design attributes into modern products that meet the needs of the current market. Designers noted the significance of enhancing product value by associating products with local culture features [48]. The set of "our glovers" (Figure 6–left) extracts the cultural element from the outer level of the Linnak and transfers the meaning to "working together". It was designed for couples to express their relationship. The work of "our cups for lovers" (Figure 6–middle) is a pair of symmetrical cups joined inversely to show the intimate relationship of the drinkers as lovers, its cultural element and behavioral feature are extracted from the mid level of the Linnak. Another design is "our pots" (Figure 6–right). It connects two small pots with each other for cultivating and watering plants together. The spiritual concept of respect and harmony between humans and nature at the inner level is inspired and extracted from the symbolic patterns on the Linnak.

Cultural product design is an acculturation process of reviewing, rethinking, redefining, and redesigning [51]. The strategy of "from denotation to connotation" as used in these three cases for cultural product design emphasizes the analysis and application of "cultural aspects". As discussed in the literature review, cultural affection may amplify the user experience [39,40]. This study adapts the framework that combines the user–tool–task paradigm proposed by Kreifeldt (1974) [25] with the spatially classified cultural scaffold suggested by Leong and Clark (2003) [50] and the three levels of design posited by Norman (2004) [34], to explain the complex interactions and interfaces among human factors, human actors, and cultural aspects as shown in Figure 7 [48–50,52].

This study adds a cultural dimension (interface) to the analysis and discussion of ergonomics for exploring the interaction and experience in product design. Besides the participation in cultural contexts, cultural ergonomics is an important approach that helps designers to extend a better understanding of cultural meaning in the design process and exert the ability to utilize such understanding for designing and evaluating products, and greatly developing interactive experiences for users [52].
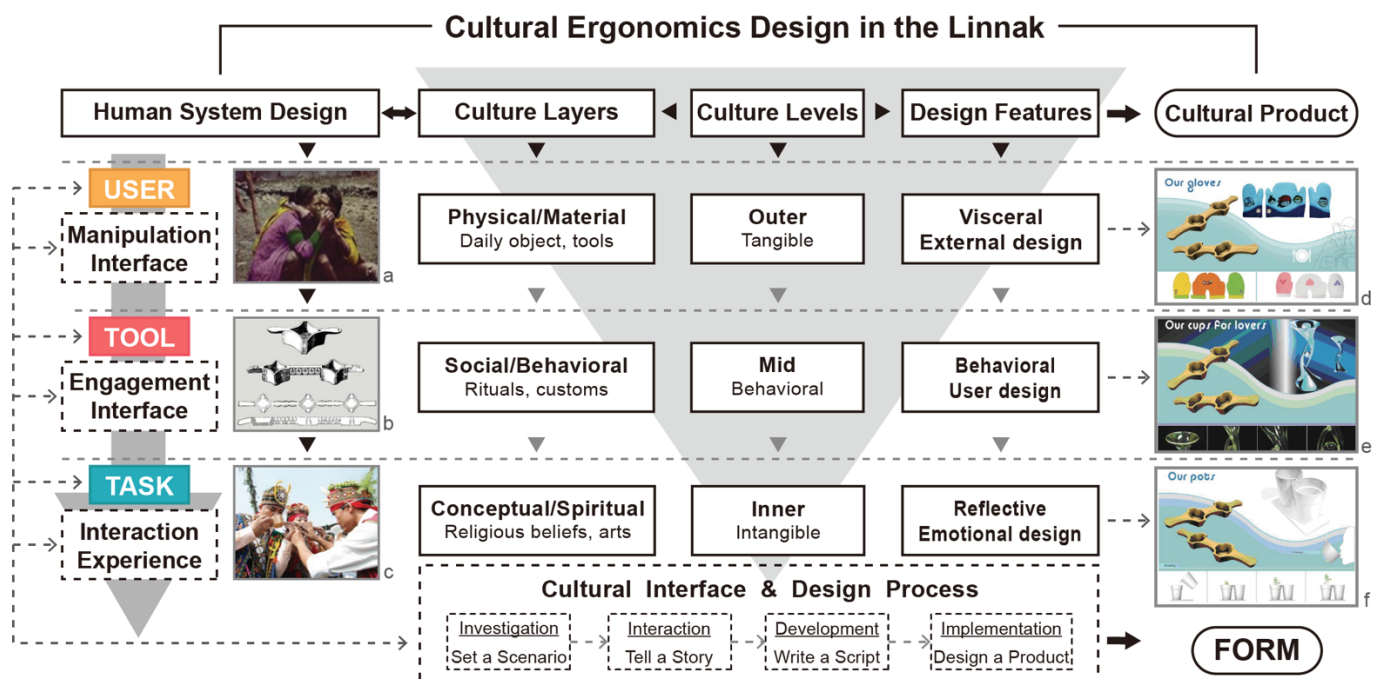
Figure 7. The analysis framework of the user–tool–task paradigm as transforming cultural features into product design (adapted from [48,52–54]. Redrawn for this study).

4. Discussion

4.1. Interrelations of Design Education between Theory and Practice

By reexamining man-machine system design, user-centered design, and user experience design, this study intends to clarify the interrelation of shifting between design theory and empirical practice from human factor, human actor, toward cultural aspect as shown in Figure 8. This approach consists of three stages: (1) At the first stage, design theory is focused on the discussion of man-machine system design about the Human Factors that affects the practical needs of quality design. This study selected the design case of the REACH toothbrush as an example to validate the analysis system of the user–tool–task paradigm. (2) At the second stage, user-centered design is the major topic with the concern for human actors that affects the symbolic wants of adaptive design. This study chose the IEF wearable computer as a design case to inquire further into the established system of the user–tool–task paradigm. (3) At the third stage, based on the vital concept of user experience design, this study explores the culture aspects that touch the aesthetic desires of qualia design in subjective conscious experience. The authors elected the Linnak twin-cup as a meaningful case study to demonstrate the integration of the typical system of user–tool–task paradigm into the spatially classified cultural scaffold and three levels of design as a new perspective of cultural ergonomics.

This study argues that the advancements from quality design to adaptive design and qualia design requires a hybrid of theory and practice which can work harmoniously without dilution of each but may successfully accomplish and strengthen each other when working toward a sustainable future. In fact, the more earnestly cooperation is blended when applying theory and practice towards the ends of design, the more likely it is that the product will have a tractive stimulation for future design paradigms.
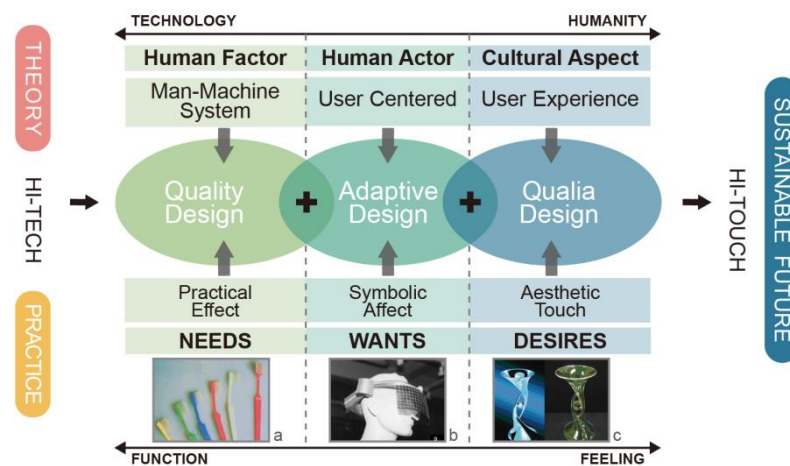
Figure 8. Interrelation and evolution of design education between theory and practice.

4.2. Transfromation of the Archetyhpal Model

One of the purposes of this study is intended to extract the timeless features and adaptive transformation of archetypal paradigms in the interaction between the discussion of design theory and design practice. The authors take the user–tool–task paradigm for example (Figure 9) to illustrate the sustainability of an archetypal paradigm in design process.
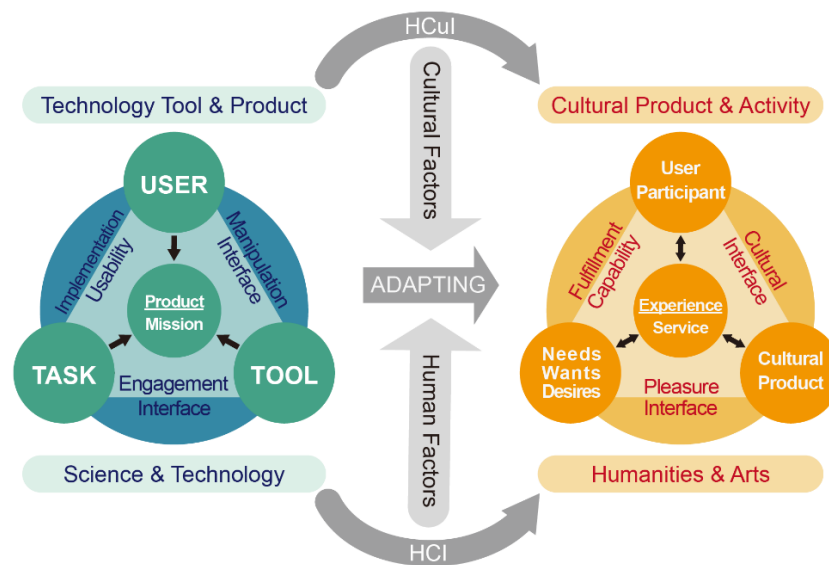

Figure 9. Adaptive development of the archetypal design paradigm (adapted from [55]. Redrawn for this study).

In 2009, Lin et al. [49] (p. 49) stated that "over the past several decades, we have made many efforts to understand human-computer interaction (HCI). But beyond HCI, we need a better understanding of human-culture interaction not just for taking part in the cultural context, but also for developing the interactive experience of users." In contrast with the fulfillment of user experience, the new perspective looks beyond the implementation of product usability. This study transfers the three objects of user–tool–task to user/participant–cultural product–needs/wants/desires, transforms the manipulation interface to the cultural interface, and transforms the engagement interface to the pleasure interface. In order to achieve the adaptation of the development of the design paradigm from HCI human-computer interaction (HCI) to human-culture interaction (HCuI), this study also inspects the necessary changing and shifting from sciences and technology to humanities and arts, and from technology tool and product to cultural product and activity.

4.3. Design Evolution and Contextual Stages

Another intention of this study is to summarize the contextual stages and mega trends of design evolution over the past decades from the active interaction and motivational feedback between design theory and design practice as discussed earlier. In summary, the evolutions consist of three orientations as shown in Figure 10: (1) from function to feeling, (2) from use to user, (3) from hi-tech to hi-touch.
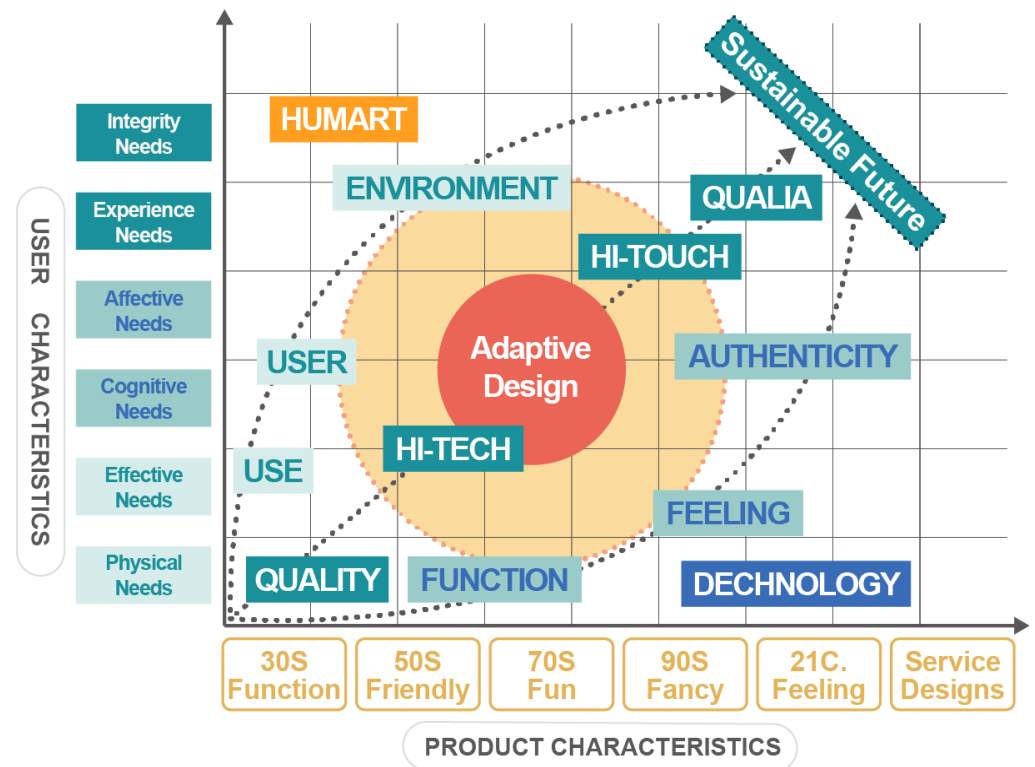

Figure 10. Design evolution with contextual stages (adapted from [56]. Redrawn for this study).

(1) From function to feeling: "Form follows function" had been the major principle of product design in the early 20th century. Today, "design" delivers a new form as "service" in a new platform because of the progress of technologies. The product characteristics have increased from the designing of function for the user's need to the servicing of feeling for the user's pleasure [56–58]. As a result, the design foci have been moving "from product design to service innovation" for pursing the essential authenticity in sincere experience and genuine esthesia.

(2) From use to user: In satisfying the development of user characteristics on human's needs (physical, effective, cognitive, affective, experience, and integrity), the design subjects have been changing "from use to user" for reaching the balance and harmony between human and environment [56]. Thus, the concept of emotional design that stresses "design for feeling" has become the key factor for innovative products.

(3) From hi-tech to hi-touch: Giddens (1984) [59] proposed the concept of "the form of life" to discuss the influence of globalization. Today, in reviewing the evolution "from Dechnology to Humart" of design features, the authors also perceive the transformation "from Quality to Qualia" of lifestyle [56]. It is suggested that careful consideration of the human, social, and cultural factors in the design will enhance its effectiveness [60]. Furthermore, people may apply the hybrid energy of science and arts as well as the extension of "from hi-tech to hi-touch" when pushing adaptive design toward a sustainable future.

5. Conclusions

This study clarified the interrelations and shifting between design theory and design practice by discussing the three foci of human factors, human actors, and cultural aspects. It explored the transformation of an archetypal mode by means of an illustrative paradigm and identified design evolution with contextual stages in the past few decades. Finally, the authors propose three perspectives and suggestions for future planning and further research for the design communities of industry and education.

5.1. The Merging of Man and Machine

We are encountering the rapid evolution of information and communications technology in which adaptive design transformation will create new values for society and industry. Turning attention to our society and environment, there are many challenges which will need to be resolved as we move into the future. For example, as society ages, people will rely more on machines. Thus, there is an urgent necessity for the cooperation and merging of man and machine in the new era of the 21st century. The successful integration of cultural ergonomics and industrial design will result in pleasurable and functional products which provide a superior experience. Based on the concept of "new human-centered design", we may consider how to create and use the new interactive interfaces between man, new machine, and new society.

5.2. The Trade-Off between Technology and Humanity

Actually, we are just at the turning point of "the fourth industrial era" of scientific breakthroughs. There are many technological areas of fascination for us and there is an urge to turn emerging technologies into reality that will change the way of our current life. Amazingly and excitedly, the new era of "The Society 5.0", a super-smart society, will follow soon. Hybrid fusion of technology and humanity will supply the strong stimulation and innovation in the design progress. Nonetheless, reaching the balance and harmony between technology and humanity will be another important issue. What should design and design education be in the new era of change? This study believes that the design of the new era should truly return to the thinking of "human nature" and the reflection on the process of creation and production. Design education in the new era may return to the combination of Dechnology and Humart, which is a meaningful way to keep improving. Design education in the new era may be retriggered by the cultivation of adaptive design thinking and the capability of mindset construction.

5.3. The Adaptability of Design Education

The new era aims at creating a society where people can resolve complex challenges by employing the innovations of the fourth industrial revolution into future life and industry. As a result, designers are facing increasingly complex and weighty challenges in this coming new era of "The Society 5.0". They will be expected to make all people's lives more comfortable and sustainable. Thus, we should immediately re-examine the education system to teach students and support these young designers so they are ready for these crucial issues and future challenges. Learning multi-disciplines and cross-disciplines remain the strategy for design education in order to respond to social evolution and its impact on the new era. Moreover, design education should be more aware of the importance of how to learn and transform the timeless features of the archetypal paradigm from theory to practice in order to cultivate adaptable designers contributing adaptive designs toward a sustainable future life.

Based on the three case studies of the REACH toothbrushes, IEF wearable computer, and Linnak twin-cup, the research findings witnessed the advancement and transformation from hi-tech to hi-touch. Furthermore, this study illustrates the adaptive application of the archetypal model of user–tool–task from the 1970s to the 21st century. These three case studies across the boundaries of location, time, and category demonstrate the applicability of an adaptive paradigm from the daily necessity of the toothbrush, a wearable computer

of commercial electronic product, to the aboriginal cultural product of the creative industry, which demonstrate the potential applicability to a general context.

In conclusion, the authors indicate the challenges and new directions in three aspects: the merging of man and machine, the trade-off between technology and humanity, and the adaptability of design education for future challenges and further research. Significantly, based on the adaptive concept of "new human-centered design," the following study may consider creating and applying the new interactive interfaces between the new generation, new machine, and the new society.

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