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Using Digital Technology to Innovate Product Meaning: Case studies in Electric Vehicles

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Completed Research Paper

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Abstract

Human Computer Interaction scholars have predominantly adopted a "user-centered" approach to study changes in product functions and aesthetics. Relatively few, however, have explored how designers radically innovate by proposing new product meaning with digital technology. Product meaning refers to an impression, conveyed collectively by a defining set of functional and/or aesthetic qualities of a product, that cause it to be perceived as a particular kind of product. We draw on design and innovation theories and use comparative case studies of electric vehicle to articulate three mechanisms by which designers propose "what would be desirable" for users: designers use digital technology (1) as a part of the product, in the process of delivering product, and in new contexts to propose innovative meaning (2) to collect user feedback, and (3) to selectively take user feedback to re-propose innovative meaning. The paper extends previous user-centered IS literature with a designer-centered approach.

Keywords: Product innovation, meaning, qualitative methods, case study, innovate with digital technology, electric vehicles

Introduction

Digital technology plays an important role in product innovation. Human Computer Interaction research has mainly studied product innovation in terms of designers following users needs in functions or aesthetics. Function refers to a product's utility, characterized by "the structural and technological features that collectively provide the utility of a product" (i.e., utilitarian benefits) (Townsend et al. 2013). Aesthetics refers to a product's beauty, style, or other subjectively perceived impressions, e.g., to what extent a website interface is visually appealing (Wells et al. 2011). Innovating or improving either function or aesthetics may lead to more positive consumer responses (e.g., Talke et al., 2009; Mugge and Dahl, 2013; Rubera and Droge, 2013).

However, designers also change product meaning by proposing "what would be desirable" (Verganti 2011) in addition to changing functions and aesthetics to meet user requirements. Product meaning refers to an impression, conveyed collectively by a defining set of functional and/or aesthetic qualities of a product, that cause it to be perceived as a particular kind of product. Such an impression is not conveyed by the random addition of functional and aesthetic qualities, yet requires mindful and selective choices of the specific set of functional and aesthetic qualities, just as the way different notes make up the music. A shift in product meaning implies a change in how users think about or categorize a product, in its role in their own experiences. Designers who innovate meaning change people's understanding of what a product is, what the product can do, and in what contexts the product might be used (Verganti 2011). When innovate meaning, designers aim to give users new reasons for buying a product, rather than fulfilling existing needs. For example, Apple designers propose "what would be desirable" for users—they did not aim for providing a better or prettier DVD player, but removed DVD players from MACs to build a product that they perceived as elegant. Their product was not perceived as inferior by users but as a trend for the future. Another example is that Swatch innovated the meaning of the watch by differentially relying on quartz technology. At the time that watches were either a piece of jewelry (e.g., Rolex with diamond and gold) or a functional timekeeping instrument (e.g., Seiko's digital watches), Swatch opened a new category by introducing Swatch as a flexible fashion accessory with outlandish designs that a user changes to match her or his emotions and outfit (Raffaelli 2019). Swatch represents a radical innovation in the meaning of watch, from luxury jewelry to a fashion accessory, keeping time-keeping functions the same. Swatch example shows that designers can lead users by innovating product meaning beyond functions and aesthetics.

Innovating meaning with digital technology is an important but understudied aspect of product innovation for these reasons. First, much of the IS literature is oriented toward responding to user requirements, but innovation is also driven by designers who integrate advanced digital technology and appealing aesthetics into products (Norman and Verganti 2014). This paper extends previous user-centered literature with a designer-centered approach. It seems that designers usually receive product specifications to implement, and they design a product within a variety of constraints, in which case designers may not have the option of making what they truly think is meaningful. However, designers have the flexibility of actively proposing new meanings to users, beyond passively reacting to user requirements. Although designers and users are both important actors in the innovation process, we have a much sparse understanding of how designers propose "what would be desirable" for users, as compared to existing theories on designers following user needs in terms of functions and aesthetics. Without studying how designers lead users and innovate product meaning with digital technology, our understanding of the role of digital technology in product innovation is incomplete. Second, IS scholars rarely consider digital technology as a way to create innovative product meaning, although they explore how digital technology enables new or better functions or aesthetics (e.g., Hoehle et al., 2019; Nadkarni and Gupta, 2007). There are only a few exceptions in which IS scholars have considered digital technology as a way to create innovative product meaning. For example, designers may design an app that may carry a meaning of dignity, and control for managing chronic diseases (Dadgar and Joshi 2018) and a game may bring a novel cultural meaning to players (Nandhakumar et al. 2013). Designers carefully choose product components to reach an ideal product meaning (Wang et al. 2022). However, even among these exceptions that discussed product meaning, it remains unclear how digital technology plays a role in the emergence of meaning. In all, this paper studies *how designers innovate product meaning with digital technology*.

This paper focuses on products within which digital technology plays an integral role in delivering functionality, outcomes, or experiences that are sold for direct use, e.g., electric vehicles (EV). In this study, digital technology in the context of EV refers to systems and devices that generate, store, and process information, including digital technology in the hardware part (e.g., Bluetooth unlocking doors) and in the software part (e.g., car intelligence supported by interactive technologies). Designers are employees or contracted partners who are involved in the product design and innovation process, often as part of teams, with or within organizations, e.g., product managers, user experience designers, and consultants. Designers lead the creation of the intended overall consumer interpretations of products; thus, they are different from developers who are given detailed technical specifications to complete.

Conceptual foundations

Design is a language that a product communicates three interrelated elements—function, aesthetics, and meaning—to users. New product design, for example, includes functional, aesthetic, and symbolic dimensions (Homburg et al. 2015). *Function* refers to a product's utility such as technical attributes and features (Creusen and Schoormans, 2005; Moon et al., 2015). "Both science and technology are socially constructed cultures" (Bijker et al., 1989: 21). Thus, people may perceive the same product differently (Pinch and Bijker 1984). *Aesthetics* refers to a product's beauty, style, or other subjectively perceived impressions such as shape, form, color, and sounds (Bornemann et al. 2015). "Aesthetics deal with a philosophical inquiry regarding the beautiful in nature and art" (Litzinger and Schaefer, 1966: 340). Scholars have operationalized aesthetics such as beauty (Abrahamson 2011; Adler 2015) and color (Beyes 2017). Aesthetics is a relational concept that results from users requirements, material properties, and designers' performance (Austin and Devin, 2009). Aesthetics might not have practical utilities while it results from psychological and social processes on standards of beauty (Becker 1978). Designers craft both functions and aesthetics as well as propose meaning. *Meaning* in product innovation refers to emotional, psychological, and sociocultural reasons for buying a product (Verganti 2011). Meaning is different from function, as the latter focuses on what a product can do, whereas meaning focuses on what people associate with a product (Gray et al. 1985), e.g., meaning signals tacit associations that an artifact elicits (Rafaeli and Vilnai-Yavetz 2004) beyond the product's material components. Designers can change product meaning with or without changing product function and aesthetics (Dell'Era et al. 2018). Functions, aesthetics, and meaning are all related to "what design is"—they, and their combination, are important constituent qualities from which meaning may emerge.

There have been debates on whether product design should be informed primarily by users' or designers' ideas. Product designers often distinguish between user-driven innovation (see, for example, von Hippel, 1986) and design driven innovation (Verganti 2011). The essence of the distinction is whether the innovator is innovating for her or his own benefit (user-driven) or to sell to others (producer/designer-driven). In "lead user research" (von Hippel 1986), lead users may introduce innovations and foresee the needs of the majority, whereas in more design-driven settings (e.g., Apple under Steve Jobs) the designer may propose design elements that users would not have easily envisioned. It remains an important design decision whether designers adhere to their own judgments or listen to users' ideas. Most designers do some of each, but the balance can tend toward either end of the spectrum. In product innovation, designers both propose meaning and listen to user feedback. Designers might perceive a product as novel while users might disagree (Goode et al. 2013). Designers usually carefully balance product technical newness and design newness (Talke et al. 2009) so that users can better understand designer' ideas. Meanwhile, designers may receive a large amount of user feedback and talk with users to proactively seek feedback from interviews or questionnaires. It is not feasible for designers to listen to every piece of feedback. Designers may have to disregard some feedback.

Literature Review

We systematically reviewed papers related to product design in the basket of eight Information Systems (IS) journals (MISQ, ISR, JAIS, JIT, JMIS, ISJ, EJIS, and JSIS). We first searched for IS papers that contain any of the keywords "design*", "aesthet*", "meaning", or "beaut*" in the abstract. Then we kept only papers that are related to product design and innovation. We read these relevant papers and use backward referencing to create a literature pool.

Functions, Aesthetics, and Meaning in IS

Designers innovate product's functions with digital technology. For example, researchers study the impact of incorporating RFID reader features (Hoehle et al. 2019), and researchers compare features across devices, e.g., between mobile devices and personal computers, to uncover the impact of feature differences (Piccoli 2016). Moreover, researchers study the impact of different features such as high download speed (Nadkarni and Gupta 2007), short delay time (Galletta et al., 2006; Palmer, 2002), and high security (Wells et al. 2011) on the perceived product quality. Yet more sophisticated functions do not guarantee better user satisfaction as perceived website complexity might negatively influence user satisfaction depending on task goals (Nadkarni and Gupta 2007).

Aesthetics in IS consists of common attributes such as navigability, visual appeal, and visual complexity. First, digital technology helps designers make their products more navigable (Luo et al., 2012; Palmer, 2002). Navigability refers to the ease of moving around the website to find information, which is related to website design and therefore aesthetics. Second, digital technology helps designers make their products more visually appealing. High visual appeal of certain website aesthetics like human images may even increase users' trust towards a website (Cyr et al. 2009). Some researchers show similar results that these aesthetic attributes increase purchase intention (Wells et al., 2011; Parboteeah et al., 2009) and perceived website reputation (Kwak et al. 2019). Third, digital technology helps designers change products visual complexity, which is related to the number of visual elements' types (e.g., text and images) (Deng and Poole 2010), the amount of information (Hong et al. 2013), and organizing of information (e.g., hierarchical levels) (Galletta et al. 2006). Although aesthetics attributes may improve users' evaluation of a product, these IS papers did not explore the relationship between aesthetics attributes and product meaning.

Aesthetics are studied at both product level and feature level on how designers use digital technology to innovate aesthetics. At the product level, researchers studied the role of digital technology in innovating aesthetics of different products such as websites and databases. For example, scholars have studied the effect of different products' interfaces in terms of the display of information (Webster and Ahuja, 2006; Jahng et al., 2002) and the display of categorical content (Wells et al. 2005). At the feature level, researchers study the impact of whether to include certain digital technology design elements such as virtual three-dimensional (3D) priming objects (Bhagwatwar et al. 2018), pop-ups (Tan et al. 2015), flash animation (Hong et al. 2004), and horizontal scales with a slider (Xu et al. 2014). Researchers also study the styles of certain digital technology features such as a website's text filler (Lee et al. 2012) and recommendation agents' text and voice (Kretzer and Maedche 2018), exploring the impact of a specific aesthetics, e.g., a well-designed website can even mitigate the negative impact of website delay (Galletta et al. 2006).

IS scholars have studied meaning in different ways, although they do not always explicitly use the term "meaning". First, a product might have different meanings across user groups despite the same functions and aesthetics. Personal communication technologies such as short message and email have "different meanings about their natures and purposes" for users in different cultures (Tan et al., 2014: 308). Similarly, with various embodiment patterns, users can view the same product as a device to fulfill current needs, an accessory to show one's tastes, or an opportunity to discover new needs (Hedman et al. 2019). Second, scholars have discussed the importance of innovating meaning in the context of product innovation. One recent study explicitly calls for studying the emerging literature on product meaning in IS, emphasizing that product meaning is an important but undertheorized aspect of product innovation (Wang et al. 2022). By examining changes in product components in the context of digital theater, Wang et al. (2022) identified two meaning-making loops: a reinforcing loop that clarifies the fundamental product meanings and a differentiating loop that captures developing product meanings. Further, researchers have investigated the process of designers envisioning a new product and proposing a novel cultural meaning in the context of game design (Nandhakumar et al. 2013). Similarly, to design an app for patients with chronic diseases, designers need to view the app not only as a tool for self-management but as a way for patients to gain back confidence, dignity, and control (Dadgar and Joshi 2018). Third, IS researchers have conceptualized spirit, which is related to meaning for two reasons. One, spirit and meaning are both holistic constructs that are more abstract than functions and aesthetics. Spirit is comprised of "immaterial values that are subjectively revealed within a user group in the social context in which the IT artifact is embedded" (p. 7) between IT and users in a social group (Cheikh-Ammar 2018). Spirit "helps users understand and interpret the meaning of the technology"(p.126) (Desanctis and Poole 1994). The other reason that spirit and meaning are similar is that they are both relational constructs with similar evolving patterns. Spirit and meaning are concepts "in flux" that emerge and evolve as humans interact with technological artifacts recursively. Spirit helps to understand innovation in meaning. For example, Markus and Silver (2008) argue that not only objective existence (e.g., functions and aesthetics) but also subjective interpretations (e.g., spirit) are involved in the diffusion of innovation. Cheikh-Ammar (2018) argues spirits helps to understand enactment and entanglements between human and IT, especially for innovative and experiential technologies.

Despite its importance, we lack an understanding of how designers use digital technology to innovate meaning. Although the literature shows evidence in using digital technology to innovate functions and aesthetics, it is not the case that the more functions, the better. We need to stretch our theorization beyond innovation in functions. Similarly, product aesthetics literature is mainly skewed toward the influences of aesthetics design on user behaviors. It is worth exploring how aesthetics interact with meaning. Compared

to the other two design elements (functions and aesthetics), we find a dearth of knowledge on how designers use digital technology to propose innovative meaning. Though designers provide more values beyond functions and aesthetics to users (e.g., Dadgar & Joshi, 2018), fewer papers uncover the role of digital technology in changing product meaning. Though some researchers describe the emerging process of envisioning product meaning (Nandhakumar et al. 2013), they focus on designers' collaborative process and boundary spanning. Though IS scholars have started a conversation on meaning and recognized the importance of meaning (Wang et al. 2022), it is not clear how digital technology helps to innovate meaning via different mechanisms. Similarly, IS spirit is related to meaning but it remains unclear how designers shape technology spirit recursively with user feedback.

Designers Propose Ideas and Listen to User Feedback

IS literature mainly studies users' preferences, e.g. on technology functions, which influence subsequent product choice (Valacich et al. 2018). User participation and user engagement are important in the design process in Information Systems (Kohler et al. 2011). Designers compare and evaluate aesthetic design based on users' reactions (Wells et al., 2011; Webster and Ahuja, 2006). Even for new meaning, designers interview users to understand what values users are looking for from the product (Dadgar and Joshi 2018). Moreover, designers aim to use digital technology to match a product's design with users' existing schema. Previous papers have focused on the importance of alignment between design and user schemas. For example, the design of labels to forward bad news with "like" goes against users' schema (Heimbach and Hinz 2018) so that designers need to make changes in product design. Likewise, designers aim to maintain a fit between users' familiarity and the virtual world design (Saunders et al. 2011).

Although most papers focus on designers listening to user feedback in a user-centered approach, some other papers show that designers use digital technology to propose "what would be desirable" beyond users' existing needs. Product design is not only for pre-existing needs, but also allows users to discover new needs (Hedman et al. 2019). Furthermore, designers can envision the future of a product (Nandhakumar et al. 2013) and reimagine practices (Riemer and Johnston 2014). As for a product's aesthetics, designers can use symbols such as text or images on a website to convey meanings. For example, adding human images to an e-commerce website conveys meaning to users that the website is personal and warm (Cyr et al. 2009). Meanwhile, user feedback is a valuable source for updating a product. Designers continually modify products and incorporate user feedback in developing new versions of a (Griffith 1999). Nevertheless, users may give conflicting feedback and user feedback are not always consistent with designers' opinions (Gu and Rahrovani 2019). Thus, designers need to listen to user feedback selectively.

However, IS literature largely focuses on how designers follow users' needs to change product functions and aesthetics, rather than how designers propose "what would be desirable" and selectively take user feedback. The IS literature lacks an explanation of when and why designers mainly propose new ideas to users and selectively listen to user feedback. Given reciprocal interactions between designers' and users' ideas on product design (Orlikowski 2000), it is vital to study how designers envision an innovative meaning that prevails over users' ideas in product design. In this paper, we look at designers taking or rejecting user feedback to complement existing user-centric views.

Methods

Research Design: Case Study Approach

We used comparative case studies (Eisenhardt 1989; Yin 1994) because this approach is especially appropriate for open-ended inquiry about a phenomenon with nascent understanding (Edmondson and Mcmanus, 2007). We used mechanisms building to theorize and explain rather than to predict (Davis and Marquis 2005). Although meaning cannot be designed deterministically, we act as observers of designers' behaviors (Eisenman, 2013). We selected case sites that not only design and sell EVs but seem likely (due to past tendencies or intentions) to innovate meaning with digital technology. Companies A and B fulfill prerequisites for being a case site. We chose the electric vehicle (EV) context since it includes significant digital components that can and do support innovative meanings. People might interpret EV in different ways, e.g., EV as a toy, a transportation tool, or an extension of their environmental activism.

We theoretically sampled interviewees (Yin 2014). In the beginning, we got to know and interviewed a key informant at the executive level at each case site. Then the key informant suggested a list of people whom we might contact. During subsequent interviews as well, we asked interviewees to recommend people whom they think we should talk to. Interviewees in each case were involved in designing and selling the same EV with different job roles such as product managers, engineers, and marketing managers. In addition, we used the expert panel together with interviews because the conceptual difficulty of "meaning" requires a theoretical leap from data to theory to build abstract conceptualizations. We leveraged the expert panel to go beyond the mechanical coding of the data and to interpret the data with "disciplined imagination" in creative form (Van de Ven 2007; Weick 1989). The expert panel acted as a methodological aid to interpret the data, because many designers do not usually talk in these terms like meaning or innovation with digital technology. Rather, designers might say they plan to try new things that seem cool, play with different amendments, and see how it works out. To reach more robust conceptual frames, we discussed with experts on the emerging themes we saw in the process. We theorized by analogizing or adopting metaphors and ask experts to comment on our conceptual interpretations (Cornelissen 2006), which allowed us to see what designers say about their daily work as knowledge on more abstract descriptions of their innovation activities in meaning. Experts are executives and product directors who can help us to develop the data into a more abstract level of theorizing based on metaphor and analogy. We theoretically sampled experts from personal networks and those of colleagues. After identifying a contact and building connections with the person, we asked experts already chosen to recommend colleagues who might have knowledge of product innovation in meaning in the EV context, and then we selected from among the people identified in this way to get a range of experiences and backgrounds.

We chose such a theoretical sampling strategy because it gave us the greatest chance of spanning the theoretical space of shifting functionality, aesthetics, and meaning. So, through theoretical sampling, we were trying to sample across instances of changes to function, aesthetics, and meaning. That is why, speaking of external validity (Maxwell 1992), the theory developed here in the context of EVs should be useful in making sense of similar situations. During interviews, we looked for signs of the emergence of meaning, regardless of whether designers intentionally engage in innovating meaning with digital technology, including innovative ideas that might happen by accident (Austin et al. 2012) during a deliberate process of improving functions and aesthetics. Interviews were recorded and transcribed unless interviewees refused so. Furthermore, we visited factories, took photos, and chatted with designers informally while they guided us around the factory. Our presence in case sites might have altered the phenomena we were observing, because the people we observed may tend to be more alert and more engaged in their work. Having said that, participant observation was not a major concern, because we were not involved in the innovation process. It was very natural that the designers showed us around their factories before we talked about their work in innovating EVs. Our field visits helped us to build rapport with designers (Guest et al. 2013). Please refer to Table 1 for more case details.

	Case A	Case B	Expert panel
Number of Interviews	9	8	9
Interviewee Number and Roles	1. Vice President - new customer experience 2. Regional President 3. Sales Manager 4. Client manager 5. New media marketing manager 6. PR manager 7. Previous Chief Innovation Officer 8. Project manager	10. Production manager (interviewed twice) 11. Product director 12. Marketing manager 13. Engineer 14. Senior engineer 15. Production manager 16. Vice president - EV	17. Product manager on smart transportation regional demonstration zone 18. Previous Chief technology officer of a Fortune-500 automobile company 19. Product director for a driving assistance software 20. Product director for EV production diagnostics 21. Product manager on EV camera and voice recognition 22. EV consultant who once consulted for company A

	9. Vice President - Sales		23. Vice President Marketing of a large EV camera supplier 24. Marketing director of the same EV camera supplier 25. Previous Chief Architect of a Fortune 500 automobile company
Number of Site Visits	3 (2 factories, 1 office)	2 (1 office, 1 EV experience center)	Not Applicable

Table 1. Case Details

Data Analysis Procedures

As for within-case analysis, we used NVivo 12, a qualitative data analysis software, to organize and analyze data. We used a three-stage process of open, axial, and selective coding (Corbin and Strauss 2014; Wiesche et al. 2017). First, we started with open coding. The goal of open coding was to get familiar with the data and think about what the data is telling us and how the data answer (parts of) our research question. We assembled primary and secondary data into folders in NVivo. We wrote memos that consisted of descriptions and preliminary thoughts of case sites. Each case has a folder, by reading which helped us to get familiar with a case. Additionally, we kept comparing research questions and data with an open mind for new insights. First-order concepts are data-driven facts that emerge from the data. Second, at the axial coding stage, we connected and categorized first-order concepts so that abstract second-order concepts emerged. In this process, we iterated emerging concepts between literature review and data analysis, because first-order and second-order themes may emerge from an extensive iterative process between the evidence and emerging theory (Corbin and Strauss 1990). Later we naturally shifted the focus from looking at factors that might contribute to the innovative meaning, to exploring the mechanisms of how designers innovate meaning with digital technology. For example, the theme function started from the degree of technological superiority to detailed battery technology, and driving safety, and later consists of technology within the EV (e.g., previous codes on in-car technology) and technology beyond the EV itself (e.g., emerging codes such as the latest technology and driving experience sometimes are in conflict). Third, we used selective coding to explore theoretical relationships among concepts and arranged the data to support a more nuanced conceptualization. Following research design guidelines (Maxwell 2012), we categorized and connected codes to identify meaningful relationships in light of case contexts. We initially bundled codes on technology within the car (e.g., gesture control with Apple car play and the electric panoramic sunroof). Then we contrasted technology within the car and technology outside the car (e.g., the option to experience the car with virtual reality technology in experience centers). Moreover, we looked for deeper connections by linking codes. We triangulated interview scripts with archival documents to reduce biases.

We continued with cross case analysis to probe the reasons for similar or different patterns. We analyzed and compared different theoretical dimensions between case A and B to reconcile evidence to generate new insights, following methodological guidelines (Miles et al. 2020). The first comparison was between EV features such as functions and aesthetics in the two companies. Second, we compared different codes and categories to look at the process of innovating meaning with digital technology. Third, we compared data from companies A and B by different phases of innovating meaning with digital technology. We compared designers' different ways of initially designing a car and later dealing with user feedback to update the car.

Results

Within Case Analysis

The two case companies are both traditional automakers that design and innovate EVs. Company A has a high reputation for manufacturing reliable and high-quality cars with multiple brands across the world. Company A started researching about EV in the early 2010s. Company A was faced with fierce challenges in the local EV market. But company A has the ambition to invest in EV technologies and win more than half of the local EV market in terms of sales. Company A's strategic goals include being a leader in selling EV and in providing EV software such as autonomous driving. To achieve this goal, company A invests in

EV innovation and uses revenues from ICE (Internal Combustion Engine) cars to support the transformation. Company A released a new EV model in 2021, in which company A bricolages its traditional advantages and advanced innovations. Company A continues its tradition of producing reliable and comfortable vehicles. Meanwhile, company A pursues technology innovations in its EV.

Company B is a Chinese automaker that was founded in the early 1990s. The company sells EVs mostly in China but some in Europe. Company B started designing EV in 2015 and launched its new EV model in 2021. This new EV model in company B targets users with families who need an affordable car. The model has technological advantages. Advanced technologies in the EV help to build a meaning of young and modern vehicles. For example, the focal model takes less than 0.8s to accelerate from 0 to 100 km/h. In addition, company B is proud of its new ways of presenting and delivering the EV. Company B argues that customers look for new buying experience rather than the current dominant ways of buying cars from dealers. In the experience center that looks like Apple Store, salespeople use iPad to introduce EVs with transparent prices, which further supports choosing additional service bundles with several clicks and gives users a strong sense of technology (interviewee #16).

Mechanisms of using digital technology to innovate product meaning

The cross-case analysis showed a variety of mechanisms by which EV designers use digital technology to innovate product meaning, collect user feedback, and repropose meaning (Table 2).

First-Order Concepts	Second-Order Themes	Aggregated Dimensions
• Using new digital technology to add to product functions • Using new digital technology in product aesthetics (e.g., look, feel, and touch)	Using digital technology as a part of the product	Stage 1 Using digital technology to propose innovative meaning
• Presenting products with digital technology in new ways • Selling products with digital technology in new ways	Using digital technology in the process of delivering product	
• Repurposing digital technology, e.g., with new application scenarios and new the business models • Relating product to other products in its ecosystem in new ways	Using digital technology in new contexts	
• Providing customized service immediately • Redesigning the vehicle in the future	Collecting user information	Stage 2 Collecting user feedback via digital technology
• Monitoring product data, e.g., battery health	Collecting vehicle information	
• Narrowing target customer group after receiving feedback • Influencing user interpretations • Discarding user feedback without further actions	Rejecting user feedback	Stage 3 Re-proposing meaning with digital technology
• Bricolaging meaning elements of the past and future with user feedback • Changing product design to adjust to unexpected user feedback	Listening to user feedback to re-propose meaning	

Table 2 Mechanisms of using digital technology to innovate product meaning

Stage 1 Using digital technology to propose innovative meaning

Using digital technology as a part of the product Digital technology acts as a part of the product to add to product functions and aesthetics, both of which affect product meaning. First, designers *use digital technology to add to product functions* in the product. Designers need to decide which digital technology to be integrated into the product as functions in what new ways. For example, facing the trend of wireless

charging for mobile phones, designers considered whether to put USB ports in an EV to be released in five years (interviewee #11, company B). Such a wireless charging function might signal a meaning of modern EVs. Similarly, designers needed to decide whether to use digital technology as functions such as back-up cameras, radar, or 360° monitoring cameras in EVs. In the process of using digital technology to add to product functions, designers make these detailed but important decisions that might affect the meaning of EVs. Further, EV is a unique context with a long design project lead time. It takes at least 36 to 40 months to design an EV from development to production in both companies A and B. Thus, designers need to envision what digital technologies are going to be trendy and decide whether to use digital technology to add to product functions. Further, new functions do not necessarily lead to higher usefulness. Sometimes new functions are peripheral rather than core, but such a function helps to propose an innovative meaning. For example, some EVs allow users to play multiplayer online games with the center screen. But designers may think gaming is not a core function in EV but rather a function to show off technology. Users do not necessarily think such a function makes the vehicle better (interviewee #4). But this function helps to propose a meaning of young, fashionable, and high-tech EV.

Second, designers *use digital technology in product aesthetics (e.g., look, feel, and touch)*. Aesthetics are not only about the beauty of the shape itself but reflect certain meanings. For example, designers in company A argued that making door handles simpler or hiding door handles is not only about changing the way that the EV looks, but also about making the EV feel wilder (interviewee #2). In addition to door handle design, the design of interior screen size, color, and so on, are all related to innovating a car's meaning. Designers in company B commented similarly. They used special lighting to create "a feeling of arriving home" when customers enter the EV (interviewee #11). Although these greetings and welcome messages are not technically difficult to realize, competitors have not thought of using digital technologies in these ways to change how EV feels.

Using digital technology in the process of delivering the product Designers not only use digital technology as a part of the product, but also in the process of delivering the product. Specifically, designers change the ways of presenting and selling products. First, designers *present products with digital technology in new ways*, i.e., opening interactive customer experience centers. Digital technology enables new customer experience. In company A, their EV experience centers were similar to Apple Stores (interviewee #1, 9). Those EV experience centers have large glass doors, decorated in cyberpunk style, and are in shopping malls. Customers no longer need to go to the suburban area to buy cars. Further, salespeople in those EV experience centers wear jeans rather than suits. Interviewee #1 compared EV experience centers with Apple Store as in both places users can touch, feel, and play with the product. Supported by interactive technologies, users can talk to driving assistance software, test drive the car, and play those games installed in EVs with friends in the EV experience centers. Further, a designer in company A commented on a competitor's customer experience center that it is "not only about the sales of the vehicle, but also as a new customer meeting point" (interviewee #8). In that competitor's customer experience centers, customers can buy coffee and other branded products such as clothes, school bags, and car models. Customers may interact with each other, and their children may have fun in the indoor play space.

Second, designers *sell products with digital technology in new ways*. One way is to sell EVs with transparent prices published online. Digital technology enables buying EVs online from an automaker's website. This is a fundamentally different delivery experience for customers as they no longer need to negotiate prices with dealers. Traditionally, dealers buy vehicles from automakers and customers buy from dealers. Both companies A and B abandoned the traditional ways of distributing cars with dealers. Now customers buy EVs directly from automakers with a fixed price and transactions can be completed online. In company A, designers hope to direct user attention away from prices to focus on reliability and comfortability (interviewee #9). Similarly, designers in company B told us that they do not ask about customers' budgets and do not put as much pressure on customers to buy EVs in their experience center. Because salespeople earn a fixed commission rather than a fixed percentage of the gross profit made on the sale of the vehicle. In other words, with the new pricing system supported by online purchasing of EVs, users do not need to worry if they are charged higher prices or if they need to negotiate prices better (interviewee #16). Such a new way of buying with digital technology aims to make users comfortable and relaxed.

Using digital technology in new contexts Using digital technology in new contexts refers to the process in which designers might repurpose digital technology and relate a product to other products in its

ecosystem in new ways. First, EV designers may revisit what to innovate by *repurposing digital technology*, e.g., with new application scenarios and new business models. Designers gauge the meaning of EV and some of them realize that the meaning of EV is deeply embedded with digital technologies and high-tech experience. Designer #22 argues that "EV is not about using electricity but high-tech experience and the feeling of using a smart vehicle". "Customers choose EV is not because of cheap or good quality, but because of the sense of technology; it is not a rational and economic choice, but they want to try new technologies" (interviewee #22). Similarly, another designer argues that consumers buy EVs for experience, not for transportation (interviewee #7).

Second, designers *relate product to other products in its ecosystem in new ways*. For example, in case B, designers used a Bluetooth unlocking function that is also available to competitors. Instead of innovating Bluetooth unlocking technology, e.g., for more accuracy and longer distance to unlock an EV with Bluetooth, designers in case B imagined a user scenario where users were freed from worrying about car repairing. To reach that goal, designers related the Bluetooth unlocking technology to the 24-hour maintenance service. "Bluetooth keys are not particularly new, but we use it in a relatively new way" (interviewee #16). Whenever a user needs the EV to be maintained or repaired, the user can authorize Company B staff to unlock the vehicle, e.g., for 4 hours at night using Bluetooth. During this period, Company B staff take care of the vehicle and bring the repaired vehicle back. This example shows that innovation sometimes goes beyond using the latest and most advanced digital technologies for functions and aesthetics. Designers may leverage existing digital technology in new contexts to propose innovative meaning as well.

Stage 2 Collecting User Feedback via Digital Technology

As for collecting user feedback via digital technology, designers might collect user and vehicle information in new ways. First, designers collect user information to *provide customized service immediately*, e.g., knowing bioinformation helps to adjust seat height after recognizing drivers' faces. Designers collect bioinformation to provide customized services. For example, the face recognition function in EV helps to tell who the driver is. If family members share an EV, through face recognition, the EV knows which person is driving and later adjusts the steering wheel and seat height to provide customized services" (interviewee #11). In addition to seat height, EV provides further customization services such as music, navigation, and car temperature. This customized service is not only for convenience but means a car that "understands you [consumers]" (interviewee #16). Second, designers collect user information to *redesign the vehicle in the future*, e.g., knowing driving habits to improve the driving assistance system. Designers can track driving habits such as the time of the day a user drives, how fast a user drives, and where a user drives. Further, designers can monitor the EV itself, e.g., using the battery management system to track battery health. Such user feedback was either not available previously or requires additional efforts. Further, EV allows connecting to the Internet of Things such as sending information to traffic lights and other vehicles on the road. In the future, EV might connect to other personal data, which helps to make life more convenient. Designers envision a meaning of "smart cabin" for EVs (interviewee #12).

As for collecting vehicle information, designers collect vehicle information to *monitor product data, e.g., battery health*, in three ways. First, designers track the real range of each charge and compare it with the estimated range. Second, designers get information about performances of different charging practices, which might later help them to give suggestions to users. Third, designers better understand the impact of driving behaviors, e.g., accelerations, on battery life. In all, digital technology components in EV enable two new ways of collecting user feedback that were not feasible in the context of ICE cars. Designers can now collect user and vehicle information more easily.

Stage 3 Re-proposing meaning with digital technology

Rejecting user Feedback After collecting user feedback, designers may re-propose meaning with digital technology by selectively listening to user feedback. Our data shows that there are many reasons designers might insist on their own opinions and judgments. When designers reject user feedback, they have several mechanisms to repropose meaning. First, designers *narrow the target customer group after receiving feedback*. Designers need to restrain the tendency to satisfy the needs of too many people. "Satisfying the needs of too many people at the same time makes it difficult [for company A] to do a better job at every point" (interviewee #2). If designers in company A mindlessly listen to user feedback on EVs, they may end up creating an EV that fits user's schema of ICE cars, even if they hope to distinguish EVs and ICE cars. To

propose an innovative meaning of EV with digital technology, it takes courage to insist on designers' own opinions and restrain the tendency to satisfy the needs of too many people. "Within the old structure, we need to find a new way" (interviewee #2).

Second, designers *influence user interpretations*. Designers direct user attention by hiding or highlighting design elements (e.g., functions or aesthetics) to *change what users think and do*. The EV model in company A faced with challenges of being old-school because the EV still has many controls (e.g., switches and levers) nearby the steering wheel. On the contrary, some competing EV models look more intelligent with far few physical controls but voice controls. For example, some users are fascinated by a function in a competing brand that the EV supports opening the window by voice control. If a user sits in the driver's seat and says, "open the window", only the window at his/her side was opened. Interviewee #4 from company A, however, was concerned about this function despite its convenience. Because some human motions (e.g., pushing a button) are still faster than EV systems. It is almost instant if customers open car windows by pushing a button, but it takes time for the in-car technology to recognize a voice. The difference is only several seconds. But these short gaps can be very large in emergencies. In this case, designers reject user feedback to remain faithful to some non-negotiable element of the product. Users might suggest a function that seems cool with advanced digital technology. But designers try to influence user interpretations by highlighting how physical controls enhance driving safety.

Third, designers *discard some user feedback without further actions*. Users might think a function or aesthetics design is cool but not consider all costs or influence. For example, user preferences on aesthetics often evoke conflicts with manufacturing costs. But users do not know exactly how much a change in design influences costs. But designers understand that the cost of stamping material depends on the material utilization rate. The higher the utilization rate, the lower the cost (interviewee #10, company B). When an EV is designed to have a body of parting or fractal surface, it brings challenges (e.g., more material consumption, low utilization rate, more processes, and higher cost) to stamp this "strange" or "odd-shaped" design with curvature and extension. In company A, designers have similar comments that users usually do not have an accurate estimate of the price of adding a function. If a user asks for adding a function, designers for sure can add it as required, but the price will go up. Then users are likely to change his or her requests for the function after knowing the final price (interviewee #1).

Listening to user feedback Besides rejecting user feedback, designers sometimes listen to user feedback in the process of re-proposing innovative meaning with digital technology. Typically, designers may bricolage meaning elements of the past and future with user feedback. Alternatively, designers may change product design to adjust to unexpected user feedback. First, designers *bricolage meaning elements of the past and future with user feedback*. They may tweak previous meaning with meaning suggested by users. Designers in company A decided to tweak the previous meaning as they were surprised at two things. One is that the proposed meaning of company A's EV as affordable high-tech vehicles was not as valued by users. Instead, users have a very flexible budget for EV, as compared to buying their first car (usually ICEs), according to interviewee #22. It turned out that buying an EV is not only a decision of car quality and price. Buying an EV might not even be a rational choice and it is different from buying ICEs. The other surprising thing is that users seem not to care about EV quality. Because users suggested alternative meanings of EV, e.g., "s*ome users might treat EV as a toy*", said interviewee #22. These users seek to experience the latest digital technology in the EV. They care about the overall driving experience and the extent to which the EV is smart. It is no wonder that these users have a high tolerance for quality problems. As a result, although designers in company A proposed a meaning that their EV has exceptional manufacturing quality, some users do not accept this meaning. Because those users are not buying an affordable and reliable tool for transportation. Instead, these users may see EV as a cool toy, expecting cool technologies in EVs and hoping to drive a car that makes them look different. Facing these challenges and pushbacks for the proposed meaning, designers in company A tweaked previous meaning with meaning suggested by users. They decided to improve the high-tech aspect of their EV for this group of customers. "We make good cars, but if customers simply do not come to see or do not consider us when they choose EVs, what is the point of good workmanship?" (Interviewee #22). Designers in company A reflected on user suggested meaning and recognized users' preferences for cool digital technologies in EV. Additional to tweaking meaning, designers reserve part of the previous meaning that users liked. Designers in company A believe that users still look for quality and reliability in their EVs. Once users test drive company A's EV, they will find how and why their EVs are better than others (interviewee #6).

Second, designers *change product design to adjust to unexpected user feedback*. Innovative meanings proposed by designers do not always land with users as designers intended. To deal with unexpected user feedback, sometimes designers adjust product design. It was surprising that designers continued to enhance the technical part of EVs to an extent that EVs were "far more intelligent than anything anyone would need" (interviewee #2 from company A). At the same time, designers commented that "nobody cares about 800 kilometers range. You don't need 800 kilometers range here" because people use EV for daily commutes (interviewee #1). Such a choice of enhancing the technical part did not result from the obsessions with pushing the limit of those digital technologies. Instead, designers aim to signal that their EVs are intelligent, young, and different.

Discussion

This paper contributes to the user-centric IS research that focuses on better functions or aesthetics in two ways. First, this paper extends previous user-centered literature with a designer-centered approach in innovation. IS literature mainly studies users' preferences but designers can envision an innovative meaning. Researchers have criticized the user-centric position in technology innovation (Kallinikos 2004), which calls for taking a design perspective to investigate the role of technology. Back when graphical interfaces began to be widely used, IS field began to discuss the importance of designing a product suitable for users for better productivity (Ives 1982). IS research has shown different interface design influence user trusting beliefs and buying behaviors (Hess et al. 2009; Parboteeah et al. 2009) and influence task performance, e.g., a text-based query interface better suits tasks with low complexity than a visual query interface does (Speier and Morris 2003). This stream of IS research focuses on users' preferences on functions and aesthetics (e.g., Wells et al., 2011; Webster and Ahuja, 2006; Valacich et al. 2018; Heimbach and Hinz 2018). Designers aim to meet user expectations by changing product design and collaborate with users to better understand users' preferences on product specifications (Conboy 2009). That is to say, previous research has explored ways to make a product nicer or more functional for users, e.g., incorporating RFID reader features (Hoehle et al. 2019) or website's text filler (Lee et al. 2012).

But designers may actively use digital technology to innovate meaning and propose "what would be desirable", rather than following users' preferences. Designers can innovate with technology to support new goals (Rahrovani and Pinsonneault 2020), in addition to innovating in technology for existing goals (i.e., enhancing product function or aesthetics). In the context of EVs, for example, to deal with drivers' anxiety about EV's range, designers can offer drivers a quick replacement of a dead battery with a fully charged battery in EV charging stations. In this way, designers innovate with digital technology and redefine relevant functions and aesthetics (Rogers 2003). Alternatively, designers may increase battery charging speed or battery capacity. In this way, designers innovate in digital technology by enhancing the battery in previous standards such as charging speed or capacity. When it comes to innovating meaning with digital technology, designers are not passive implementers of user feedback and expectations. Rather, designers are similar to movie directors who pursue realizing their vision, least focused on viewer's feedback. Designers use digital technology to create a new product meaning and re-propose their intended meaning mindfully. Such an innovation is driven by designers rather than coming from users. Although meaning is influenced by functions and aesthetics, innovating product meaning with digital technology is distinct in that it leads users to perceive a connection to some idea of conception that is not necessarily or directly implied by the product's function or aesthetics. Without studying this type of innovation with digital technology in meaning, our understanding of the role of digital technology in innovation is incomplete. In all, designers may propose a new meaning and reach their vision by innovating with digital technology, which is different from improving functions and aesthetics to meet user expectations.

Second, this paper highlights that digital technology helps to innovate not only functions or aesthetics but also product meaning. Few papers discuss the process of innovating meaning with digital technology in product innovation, although designers craft both functions and aesthetics as well as propose meaning. One exception is Wang et al. (2022), who have explored how designers innovated meaning at physical-digital and product-component dimensions. We extend their work by looking at the role of users in the process of innovating meaning, because user feedback (and more, perhaps interaction between designer and users) affect the meaning-making loops. We look at designers taking or rejecting user feedback to complement existing views on product meaning innovation. We further extend research on how designers update systems based on user feedback (Gu and Rahrovani 2019) by showing how and why designers reject and

selectively take user feedback. By capturing the process of designers analyzing user feedback and updating product based on user feedback, we investigate interactions between designers and users with the feedback loop in the process of innovating meaning digital technology.

Innovation in meaning with digital technology may not always follow a straight line or happen as planned, instead, innovation in meaning might not even fit into the initial plan. When a product is initially released, user groups might interpret the meaning differently. For example, users may see EV as a car that saves on fuel, a car to signal status or high-tech lifestyle, a toy to experience the latest technology, a car for convenient and smart mobility, etc. Next, designers may take some user feedback and reject some others. If accept user feedback, then perhaps designers use the information gathered to innovate meaning and change functions and aesthetics to highlight a new meaning of existing digital technology, as product technical characteristics change users' interpretation of the product (Doherty et al. 2006). While designers are working on a meaning, they might reject some user feedback because it is not consistent with the meaning they are working on. Reasons why designers reject user feedback include they restrain the temptation to satisfy the needs of too many people, they may be confident to influence user interpretations, or they may have to discard user feedback that is not realistic. If reject user feedback, then perhaps designers refine product meaning as product design is a work-in-progress. They might ultimately also reject a proposed meaning (abandon it) because they cannot get it to work with users. And if they abandon a meaning, they might go back and accept the feedback they rejected earlier. Multiple wakes of innovation might recursively surface and traverse heterogeneous communities (Boland et al. 2007) while designers selectively take user feedback. To create a new meaning, designers may reimagine existing digital technology in a way that others have not thought of or use digital technology that is not typically used in the field.

Practically, these findings are relevant to designers and managers. Using digital technology to innovate meaning may lead to a longer product life cycle and bring higher profit margins (Verganti 2009). In this paper, we show practical steps and caveats in proposing innovative meaning. When repropose innovative meaning, designers benefit from disregarding some user feedback while selectively taking some other user feedback. Facing changes in EV technology, innovating meaning with digital technology helps designers envision the real needs of customers in the future and reimage a new business model to earn profit. Changes in EV's meaning leads to new requirements on the level of in-time customization of EV product and service as well. Designers benefit from knowing mechanisms in this paper that helps to find possible solutions to accelerate and organize the innovation process.

Like most empirical research, this study has limitations. First, although we theoretically sampled two case companies that used digital technology to innovate meaning, both companies are traditional automakers who aimed to propose an innovative meaning for their EVs. Future research could sample EV startups that are free of associations with their traditional ICE cars. Second, for theorizing purposes, we made an unrealistic but reasonable assumption that designers and users are the two actor groups in the process of innovating meaning with digital technology. Other actors such as key opinion leaders and regulators, however, play important roles as well. Future research could consider how actors other than users influence designers' use of digital technology to innovate meaning. In all, this study sets out to explore and explain the process of innovating meaning with digital technology with a designer perspective.

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