WHEN TECHNOLOGY CHALLENGES FINDING THE RIGHT TEAM: AN ENTREPRENEURIAL APPROACH FOR PRODUCT DESIGNERS

C. Dastoli, M.E. Sosa Martì, S.D. Ferraris

Politecnico di Milano (ITALY)

Abstract

How can designers find the adequate know-how to design new products in times of fast technological advancements? Technological evolution is challenging the definition of who is required within the collaborative team for product design and development since technology's characteristics evolve as a continuum. Traditionally, designers play a crucial role in simplifying and humanizing these complexities, ensuring users can understand and interact with technology effectively. Designers help bridge the gap between advanced technology and user comprehension, making technology more accessible and usable for everyone through product design. However, if technology continues to evolve and designers' knowledge about technological features is in a state of constant adaptation, how do designers make an impact? In this work, the authors adopt an entrepreneurial approach to identify which capabilities typical of product design can support the identification of diverse stakeholders. By relying on the literature of entrepreneurial complex systems (i.e. entrepreneurial ecosystems), the authors provide a classification of design capabilities that could be relevant for engagement and identification of heterogeneous know-how. In continuously advancing technological contexts, product designers could refer to this classification to initiate engagement activities in complex systems of stakeholders.

Keywords: Technology evolution, product design, design capabilities, entrepreneurial ecosystems, capabilities taxonomy, stakeholder engagement.

1 INTRODUCTION

The development of new design products encompasses many phases where diverse actors interact, as design products depend on integrating heterogeneous competencies. Bucciarelli [1] says that design is not developed by an individual at a workstation but has a collective nature, with all participants contributing to the product's final form. Therefore, a monodisciplinary effort is not enough for the design and development of new products: it is the combination of diverse stakeholders' know-how that enables the process.

Among the others, Kleinsmann et al. [2] argue that today's complex design problems imply the work of multiple actors, as no single actor possesses all the necessary expertise to complete a design task. Although the interaction between multidisciplinary know-how for new product development is a widely discussed topic in several fields of Design research, we find that the Design discipline is in a pivotal moment for expanding research about the type of intervention of designers within complex systems of interacting stakeholders. Technology and its evolution introduce increasingly complex systems and products, and designers play a crucial role in simplifying and humanizing these complexities, ensuring users can understand and interact with technology effectively. Designers help bridge the gap between advanced technology and user comprehension, making technology more accessible and usable for everyone. However, how can designers find the adequate know-how in times of fast technological advancements that enable these impactful interventions?

Traditionally, Design research describes multi-actor participation in product design within the participatory design field, where collaborative initiatives support the combination of diverse expertise for new design outputs [3]. While participatory design is a widely acknowledged support for product designers when understanding users' needs and behaviors, technological evolution is challenging the design process in terms of defining who is required within the collaborative team for product design and development. Indeed, design teams often lack adequate know-how about technological possibilities, and, as a consequence, they often require widening the arena of collaborating stakeholders [4]. Designers ask, "Which are the properties of new computational technologies that could support the process of new product design and development?". To design and develop significant products for society, designers often need to combine and integrate knowledge from increasingly numerous stakeholders dealing with the current computational dimension of technology. Therefore, professionals such as Computer Scientists, Software Engineers, Hardware Engineers, Data Scientists, System

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Architects, Network Engineers, Artificial Intelligence (AI) Researchers, and Human-Computer Interaction (HCI) Specialists collaborate, and interdisciplinary teams address the computational properties of technology and develop innovative solutions that meet the needs and requirements of users, organizations, and society.

In this context, we believe that product design can assume an entrepreneurial approach in the way designers are called to find a support knowledge system for designing impactful products for users in continuously advancing technological contexts.

1.1 An entrepreneurial approach when technology evolves fast

Technology drives the dynamics of product design and development as its characteristics enable human actions. However, continuous technological advancements lead to users embracing significant changes faster than the reaction of the production system [5]. Consequently, standards for product design are continuously disrupted as consumers demand is fast-changing [6].

In this context, entrepreneurial ecosystems as a post-industrial entrepreneurial approach to economic growth consider technology under an evolutionary perspective [7]. Kelly [8] defines technology as "wanting" and "driving" users' actions to modify systems' organizational configurations for new product development. Accordingly, Neff et al. [9] describe technology as provided with "affordances," namely actionable properties that reflect its characteristics. Benkler [10] refers to technology affordances as creating new feasibility spaces for social practice. Hence, entrepreneurial ecosystems focus on creating new organizational configurations of social action for new product development as informed by a driving technology's actionable properties.
By considering technology from an evolutionary perspective that enables collective action for new product development [11], the affordances of technology provide the possibility to organize arrangements of stakeholders' knowledge to identify new opportunities, mobilize resources, and reconfiguring them toward a new product [12]. Specifically, the complexity of technologies can inform actors about new configuration possibilities. Hence, products result from multiple system-level knowledge that collectively exploits available technologies' characteristics.

1.2 Engaging with stakeholders by the open innovation theory

Lopez-Vega et al. [13] describe how boundary-spanning practices occur when companies search for external stakeholders' knowledge. The authors provide a helpful classification of the ways entrepreneurs search heuristics, or external data and information that expand their knowledge base. In their study, *cognitive* and *experiential* search represent the two dimensions that inform search practices in open innovation contexts [13]. Gavetti and Levinthal [14] describe cognitive and experiential dimensions as two distinctive ways of searching for information. Cognitive search refers to the modalities through which the knowledge system around the entrepreneur is conceptualized. Cognition allows entrepreneurs to simplify the complexity of knowledge relationships and the interactions among actors through representations of their problem space . Conversely, experiential search is defined by the mechanisms that shape what an entrepreneur does [14]. In these terms, experiential search is defined by actions derived from feedback on current activities. Therefore, cognitive and experiential search represent the modalities through which entrepreneurs engage with stakeholders for new product development in open innovation systems.

1.3 How product designers traditionally design impactful products

It is widely acknowledged that Design raised its popularity by applying its capabilities in problem-solving activities for new product design and development. Indeed, creative problem-solving moves the problem into a solution by expanding the problem boundaries and providing novel solution trajectories [15], [16], [17]. Therefore, the literature review widely reports product design capabilities for creative problem solving, as synthesized in Tab. 1.

The table reports a selection of relevant product design capabilities as they are commonly defined, or by their finality.

Table 1. Product Design capabilities retrieved from the Design literature

Product Design capabilities	***Definition***	***Finality***	***Authors***
Knowledge brokering	The ability to access the implicit understanding of products' function and meaning that are shared inside the user's cultural community	Envisioning potential/emerging cultural changes	Bertola and Teixeira
Visualization	The ability to make ideas and insights visual and tangible	Bringing a common view to concepts	Carlgren, Dell'Era, Micheli, Owen
Visual communication	The ability to reveal and explain patterns and simplify complex phenomena to their fundamental essence	Enabling the initial intent realization	Frascara, Turner and Topalian
Framing	The ability to order systems and synthesize patterns	Assessing the value of arrangements in current contexts	Beckam, Conley, Jones, Paton and Dorst
Reframing	The ability to reposition a concepts, solution, or option in different contexts	Widening the solution space; identifying new interaction paths	Buchanan, Johns, Schon
Envisioning	The ability to imagine and represent alternative future possibilities	Expanding the implementation of an initial vision	Joziasse, Miller and Moultrie, Topalian
Criticism	The ability to interpret the network partners' perspective	Envisioning new directions	Verganti
Negotiation	The ability to create a shared understanding of the problem and foster a joint commitment to possible resolution actions	Deepening the problem definition	Camillus, Ito and Howe, Jones
Experimentation	The ability to learn through iterative forms, prototyping and trials that test a range of possible solutions with end-users	Acquiring updated products information over iterative trials	Beverland, Brown, Carlgren, Micheli

2 METHODOLOGY

2.1 Objectives of this work

This contribution has been guided by the research question: How can designers find the adequate know-how to design new products in times of fast technological advancements?

The work aimed at introducing an entrepreneurial approach to the product designers' work by integrating into the process a preliminary phase focused on stakeholders' engagement for know-how identification and consequent collaboration.

For this intent, the work aimed at making tangible the actions that product designers could perform within a systemic context of diverse stakeholders through the development of a dedicated taxonomy of capabilities.

2.2 Method and approach

A new taxonomy of product design capabilities has been developed by categorizing design capabilities under an ontological criterion (Blaikie & Priest, 2019; Corbetta, 2015) rather than their finality of application. Therefore, design capabilities have been classified by considering their intrinsic form in relation to the categorization dimensions of cognitive and experiential search in open innovation theories. By deriving from the literature review what constitutes design capabilities that simplify complexity (i.e. cognitive search) and drive actions (i.e. experiential search), it has been possible to classify product design capabilities for under a different lens. Rather than supporting creative problem-solving, the taxonomy shows the design capabilities that support stakeholder engagement in open innovation contexts due to their ontological characteristics.

3 RESULTS

This work results in the taxonomy shown in Tab.2. The taxonomy is driven by the two main dimensions of stakeholder engagement reported within the open innovation literature (i.e. cognitive and experiential search), under the explicative names of *simplifying complexity* and *driving actions*. Then product design capabilities have been reported coherently within the two dimensions depending on their ontological definition. The column "observable items" makes capabilities tangible as it reports activities and artifacts that reflect the application of each capability.

Table 2. Product Design capabilities for stakeholder engagement and identification

Stakeholder engagement dimensions in Open Innovation	***Product Design capabilities***	***Ontology***	***Observable items***
SIMPLIFYING COMPLEXITY (cognitive search)	Visualization	Simplification of framing and of the communication of complex systems	Sketches, drawings, mock-ups, prototypes, and in general physical artifacts
	Visual communication	Creation and consolidation of the requirements to develop new products, such as understanding tasks, the condition for synthesis, and choices	Text, slides, posters, reports, models in hardware, photos, videos, CAD drawings, diagrams, demonstrations
	Framing	Generation and acknowledgement of the legitimacy of alternative viewpoints	Affinity diagrams, mindmaps, customer journey maps
	Reframing	Negotiation of meaning, shared mental models and common understanding of a situation	Future workshops, counter-briefs
	Negotiation	Establishment and transformation of personal and professional relationships around a shared vision	Brainstorming sessions, focus groups
	Envisioning	Holding new frames together	Scenario representations, storyboards
DRIVING ACTIONS (experiential search)	Experimentation	Elicitation of the product requirements	Product prototypes, A/B tests
	Criticism	Absorption of the deep life experiences of systemic users	Providing "things to use", providing broader perspectives
	Knowledge brokering	Translation of signals about social and cultural changes	Participatory observations, focus groups

3.1 Product design capabilities for simplifying complexity

Simplifying complexity is the first taxonomy category and represents the cognitive dimension enabling engagement in complex entrepreneurial contexts of new product development. When cognitive search support engagement through practices that simplify complexity, design capabilities that ontologically belong to those practices have been reported. As Simon [18] described, cognition refers to the simplification of complex problems space through the representation of concepts. Gavetti and Levinthal [14] relate cognition to those mechanisms that support the conceptualization of the company in relation to its environment. Lopez-

Vega et al. [13] define cognitive heuristics as the knowledge achieved through mechanisms of knowledge codification. Hence, simplifying complexity can be defined as the dimension that categorizes design capabilities that synthesize and make knowledge tangible through cognitive learning.

3.1.1 Visualization

Weil and Mayfield [19] refer to visualization as the capability that simplifies framing and communicating complex systems. Therefore, product designers can make intangible insights and concepts workable by recurring to physical artifacts like sketches, mock-ups, storyboards, and prototypes that embody and communicate abstraction. Remarkably, the design practice emphasizes the role of prototypes in concretizing and externalizing conceptual ideas [20]. Under this perspective, prototypes are “filters that traverse a design space” or “embodiments of critical elements of the intended design” [21]. Although prototypes for new product development are often intended as a means for formal evaluation, their characteristic of simplifying complexity is widely acknowledged in design practice.

3.1.2 Visual communication

Communication among distributed perspectives is enabled by visual artifacts that embed the knowledge complexity of new product development [22]. Visual communication creates and consolidates the requirements to develop new products, such as understanding tasks, the conditions for synthesis, and choices. By creating a shared understanding of product requirements through tangible means, visual communication simplifies sharing norms and values and codifies tacit knowledge.

3.1.3 Framing and Reframing

Beckman [23] positions framing and reframing capabilities in the cognitive dimension of learning as they involve inquiry to uncover assumptions and acknowledge the limitation in perspectives for seeing alternative frames. While framing supports the legitimacy of alternative perspectives, reframing sustains the common understanding of a situation. Consequently, framing and reframing represent the ability to connect different and collective narratives thus simplifying the complex problem space through the communication of the guidelines for decision making.

3.1.4 Negotiation

Making decisions for new product development implies that different perspectives negotiate a shared vision. Jones [24] defines negotiation as the design capability to generate agreement between different perspectives. However, in heterogeneous context of participation designers “move towards practices where differences and controversies are allowed to exist, and dilemmas are raised and possibilities explored” [25]. The participatory design literature acknowledges conflicts as an opportunity to explore possibilities that might eventually lead to alignment (e.g., see [26]). Hence, negotiation simplifies the complexities involved in providing a shared vision within a landscape of multiple actors and relations, in terms of establishing and transforming personal and professional relationships around a shared vision.

3.1.5 Envisioning

While negotiation allows for exploring new possibilities given different perspectives and expertise, envisioning as the ability to imagine and represent alternative futures supports new products development by helping design teams holding new frames together [23]. When scenario representations embed connections among different frames, the understanding of the complex construction of concepts is simplified. Liedtka and Buchanan [27] highlights that making connections tangible support the seizing of opportunities when preventing error presents a barrier to new product development and innovation. Consequently, the simplification of new concepts through representations supports decision-making.

3.2 Product design capabilities for driving action

Driving action is the second category of the taxonomy and represents the experiential dimension enabling engagement in entrepreneurial ecosystems. When experiential search support engagement through practices that drive action, design capabilities that ontologically belong to those practices have been reported. Gavetti and Levinthal [14] describe experiential mechanisms of knowledge search relying on direct feedback on current activities. Experience allows trying actions and experiencing outcomes for improvements. Hence, driving action can be defined as the dimension categorizing design capabilities that involves the partial implementation of alternatives for informing new actions through experiential learning.

3.2.1 Experimentation

The design literature reports experimentation for new product development as the ability to learn through iterative forms for acquiring updated products information (e.g., see [28]). Experimentation is related to obtaining early feedback about the new product with minimum investments in the up-front phase of new product development [28], [29]. Iteration, trial and error and prototyping make experimentation a low-risk opportunity to fail and learning through failures [30]. Hence, by eliciting the product requirements through prototypes, experimentation capability drives the new actions to be performed for new product development.

3.2.2 Criticisms

Traditionally, consumers provide the input to improving actions. However, Verganti [31] argues that providing an exclusive reliance on customers inputs leads to limiting the innovation possibilities. Therefore, the author introduces criticism as the ability to learn from the collection and interpretation of information gained by network partners in new product development [32]. In these terms, criticism drives new actions by submitting early products to a broader set of inputs.

3.2.3 Knowledge brokering

Hargadon [33] finds a community of users as the broader context from which translating signals toward resources mobilization. Through participatory observations of the product usage within the community of users, knowledge brokering expands the possibilities for collecting feedback and insights about new product development. Bertola and Teixeria [34] highlight that knowledge brokering provides entrepreneurs the helpful information for adapting business processes to emerging social and cultural change, thus driving new actions for new product development.

4 CONCLUSIONS

This work aims at supporting product designers in identifying the right technological competencies for product design. Although this work does not deepen stakeholders' know-how in qualitative, technological terms, it supports designers in engaging with them, since technology-related stakeholders reflect a complex system of dispersed know-how.

For this reason, this contribution offers a new taxonomy of capabilities for product design, that reframes the type of intervention of traditional capabilities under a stakeholder engagement lens in complex systems of intervention. By embracing the theory of open innovation, the proposed taxonomy can support product designers in technological stakeholder finding for designing products with an impact. Indeed, although product design raised its positive influence through creative problem-solving, today it might require a preliminary, entrepreneurial approach that enables product design potential within a context of continuous technological advancement.

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