THE IMPACT OF USER PARTICIPATION IN THE DESIGN PROCESS ON NEW PRODUCT DEVELOPMENT: IMPLICATION TO DESIGN EDUCATION

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ABSTRACT
Participatory Design (PD) emphasises the potential importance of user participation in enhancing the effectiveness of New Product Development (NPD). The article focuses on two main aspects within participatory product design: "the Conceptual Positioning with User Participation" and "the Relationship between User and Designer." The results indicate that, in the design process of NPD, "Information Exchange," "Knowledge Co-creation," "Identification-Activation of Creative Users," and "Responsible Behaviour of Users" all positively influence the effectiveness of NPD. However, the intensity of these effects and the moderating effect of "Enterprise Absorptive Capacity" depend on the actual implementation of user participation. This study provides new perspectives and data support for the theoretical research and practical application of participatory design and also offers recommendations for PD education in universities in China.

Keywords: Participatory design, users, degree education, empirical study, NPD

1 INTRODUCTION
Scholars in the field of design advocate that for enterprises to foster breakthrough innovation they should utilise external stakeholders such as users to inform its NPD processes. Thus, it is suggested to extend the internal design expertise to those outside of the companies including the "future users" [1]. This study specifically selected the "Users" among external stakeholders, and to emphasise the importance of "Participation", as advocated by the proponents of the "Participatory Design" (PD) method. Nigel Cross pointed out, the goal of design is to find an appropriate solution, rather than finding a "correct" answer [2]. In this case, user perception is crucial because they are the ones with the authority to judge whether the design is appropriate for "them".
The important purpose of design education is to cultivate designers' design literacy, which is understood as the ability to "read" (understand design products) and engage in design activities [3]. Educational researchers are showing a growing interest in Participatory Design and other collaborative co-design approaches [4]. In PD, participants typically need to assume two roles simultaneously: that of end-users of the product and proposers of solutions. Designers, on the other hand, should act as both executors of design solutions and guides of the design process [5]. The significance of PD in design education lies in its emphasis not only on enhancing students' own design literacy but also on cultivating their ability to elevate the design literacy of PD participants through participatory design processes, thereby leveraging their tacit knowledge to guide product design innovation. In the current context of design disciplines, "design" has shifted from a reactive, artefact-based practice to a more proactive, with emphases on the social practices [6]. Design education seeks to break through the boundaries of schools to address this trend, allowing design literacy education to permeate non-designer groups (citizens) [7]. This impact is expected to be expansive and enduring.
A review of the literature reveals that there is a significant amount of case studies and empirical research internationally. For example, Niels Hendriks et al. explored how designers establish relationships with users and how these relationships influence their design decisions through a case study involving dementia patients participating in the design process [8]. Ozkil conducted empirical research on the

collective design platform (Thingiverse), confirming that such platforms can help designers identify primary users in their respective fields and discover potential needs from different sub-communities or geographical regions [9]. Aytekin and Rızvanoğlu proposed the application of participatory design methods to design education using a qualitative multi-method approach, suggesting that it can help build "Learning Bridges" and assist in the transfer of implicit knowledge and experience [10]. However, such design research is relatively scarce in China, leading to a lack of clarity among Chinese enterprises regarding the specific impact of user participation in the design process on the output of NPD projects. This study limits its investigation to designers in China who have product design experience with user participation, aiming to conduct empirical research. The study conducted a survey of the curriculum design in 10 Chinese universities. The study holds significant practical implications for Chinese enterprises and also it provides valuable insights for Chinese Higher Education.

2 RESEARCH HYPOTHESES AND RESEARCH MODEL

Through a literature review, two key issues in PD discussions can be identified. Firstly, a substantial body of research has demonstrated the significant role of PD in the conceptual positioning stage of product development, particularly concerning the aspects of Information Exchange and Knowledge Co-creation [18]. Secondly, the discussion about the relationship between users and designers [19] has consistently been at the core of PD-related studies, further classified into perspectives from both designers and users. This study focuses on these two critical issues and incorporates them, along with the output effectiveness of new product projects, as three measurement dimensions, thereby extracting six variables (one of which is a moderating variable) requiring measurement. Variables and their codes can be found in Table 1.

Table 1. Factors Coding

Dimensions	Factors	Code
the Conceptual Positioning with User Participation	Information Exchange	A
	Knowledge Co-creation	B
the Relationship between User and Designer	Identification-Activation of Creative Users	C
	Responsible Behaviour of Users	D
Moderating Variable	Enterprise Absorptive Capacity	E
Output Effectiveness	New Product Development Effectiveness	F

a) The conceptual positioning with user participation

The significant characteristic of PD lies in the thorough consideration of user perception as a decisive evaluative factor for new products, serving as the starting point for the process of product conceptual positioning. "Information Exchange" primarily emphasises the quality (effectiveness) of communication. Participatory Design researchers commonly emphasise the potential value of individuals and elements outside the design team, with particular emphasis on the value of users. Participatory innovation can be understood as the result of "cross-intention negotiation," where the process of this cross-intention negotiation is also referred to as information exchange [11]. Although the association between the design team and participants during this process may involve destructiveness, it also brings about new possibilities for innovation [12]. Knowledge co-creation refers to the process in which users and design teams collaboratively create new knowledge and solutions to achieve product innovation. The design product serves as an intermediary between user logic and design logic [13], and the process of knowledge co-creation involves the integration and refinement of information from multiple sources, emphasising the utilisation of users' unique experiences and insights.

Hence, this study proposes the following research hypotheses:

H1a. There is a positive correlation between information exchange and NPD effectiveness.

H1b. There is a positive correlation between knowledge co-creation and NPD effectiveness.

b) The relationship between user and designer

In PD, the relationship between users and designers is innovative, and this relationship requires to be sustainable and systematic to ensure the generation of design concepts and solutions required for innovation [14]. This close connection enables timely feedback on NPD projects upon market entry, providing a foundation for further product improvement. From the perspective of designers, the key to fostering this relationship lies in identifying and activating creative users. From the perspective of users, their actions in the design process are essentially a form of "responsible behaviour." When participants in the design process realise they are part of a NPD project, a sense of responsibility emerges. Some

scholars regard the responsible behaviour of users in participatory design as a prerequisite for achieving value co-creation [15].

Therefore, we propose:

H2a. There is a positive correlation between the identification-activation of creative users and NPD effectiveness.

H2b. There is a positive correlation between responsible behaviour of users and NPD effectiveness.

c) The moderating role of enterprise absorptive capacity

A significant portion of participatory product design research overly focuses on the participation process within PD projects, while neglecting the evaluation of actual project outcomes, leading to a misalignment between theoretical research and practical application [16][17]. In addition to the two aspects mentioned above that may directly impact the development effectiveness of new products, it is also necessary to consider whether there is a moderating effect of third-party factors between these two influence paths. In the design process of NPD, the initial distribution of various resources is relatively discrete or even implicit. From the perspective of the enterprise, the unique resources provided by participants are considered external resources. The ability to integrate, transform, and successfully apply multidimensional external resources to product design is referred to as enterprise absorptive capacity. This study posits that there are differences in absorptive capacity among different enterprises, and this difference will affect the strength of the two aforementioned influence relationships. The research model is illustrated in Figure 1. This study then proposes the following hypotheses:

H3a. Enterprise absorptive capacity positively moderates the relationship between information exchange and NPD effectiveness.

H3b. Enterprise absorptive capacity positively moderates the relationship between knowledge co-creation and NPD effectiveness.

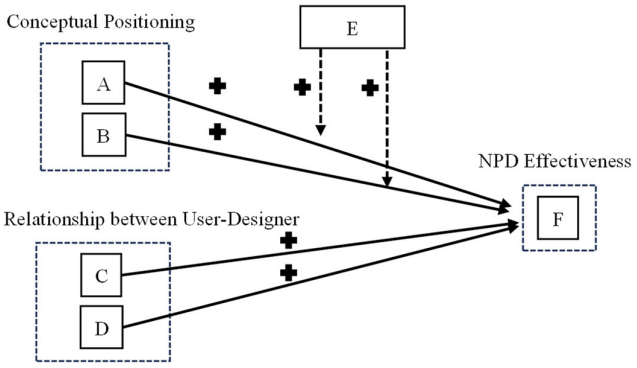

Figure 1. Research Model

The impact of user participation in the design process on NPD is assessed from the perspective of the project, making project designers and enterprise managers the evaluators. It is difficult for insights generated by users to penetrate to this level. Therefore, this study selected designers/ members in design teams who have experience in assisting NPD design practices through user participation as the survey subjects. The questionnaire was divided into two main sections: basic information and variables-measurement (24 questions). The measurement scales used to measure latent variables are mainly adapted from well-established scales used by other scholars (all using five-point Likert scales). Specifically, the Conceptual Positioning with User Participation section is adapted from Drain, Shekar and Grigg [18]; the Relationship between User and Designer section is adapted from [15]; the enterprise absorptive capacity section is adapted from [20]; and the NPD Effectiveness section is adapted from [21].

To ensure the reliability of the survey questionnaire and the validity of the items, this study conducted a pilot survey using an online research method, resulting in a total of 53 valid responses. Reliability analysis conducted using SPSS and SmartPLS revealed the following:

1. Reliability: The Composite Reliability (CR) of each factor exceeded 0.8, and Cronbach's alpha coefficients ranged from 0.772 to 0.853, all exceeding 0.7. Furthermore, after deleting specific items, the alpha values did not significantly increase, indicating that the scale design in the questionnaire is reliable.

2. Validity: The results from SmartPLS showed that the loadings of each item ranged from 0.626 to 0.885, all exceeding the standard value of 0.5. The Average Variance Extracted (AVE) for each latent variable, except for variable B (which was 0.494), exceeded the standard value of 0.5. Based on the literature, when the AVE value is less than 0.5 but the CR exceeds 0.6, the convergent validity of the questionnaire can still be considered good [22].

3 RESULTS

The formal survey stage began in December 2023 and was completed in February 2024, resulting in a total of 252 valid responses collected. Most of the respondents hold a bachelor's degree or higher (87%, n=219). Approximately 82% (n=207) of respondents are primarily engaged in virtual product design and service & experience design, while the remaining respondents are from the field of tangible product design. Table 2 displays the results of the direct effects of each latent variable on the dependent variable F and the moderating effects of the moderator variable E.

Table 2. PLS-SEM test results

Path	β	T	P	2.5%	97.5%	Results
A→F	0.114	2.833	0.004	0.035	0.193	H1a: supported, positive effect
B→F	0.300	6.174	0.000	0.203	0.395	H1b: supported, positive effect
C→F	0.265	6.091	0.000	0.184	0.353	H2a: supported, positive effect
D→F	0.163	3.684	0.000	0.072	0.247	H2b: supported, positive effect
E*A→F	-0.137	3.752	0.000	-0.207	-0.063	H3a: rejected, negative effect
E*B→F	0.045	1.286	0.198	-0.022	0.113	H3b: rejected, not significant

4 DISCUSSIONS

According to the computational results from SmartPLS, we found that “Information Exchange,” “Knowledge Co-creation,” “Identification-Activation of Creative Users,” and “Responsible Behaviour of Users” all exert positive influences on NPD effectiveness. Among them, the effects of B and C are relatively stronger, while the effects of A and D are relatively moderate. In terms of moderating effects, both hypotheses H3a and H3b are rejected. The test results indicate that E*A→F's moderating effect is even negative. This study attributes this result to the fact that all survey respondents are professionals in product design with experience in user participation in the design process. Their judgments on each item are based on the cognition and stance of designers. Designers often equate their own cognition with that of end users, thereby mistakenly believing that the information exchange phase has been completed when, in reality, it has not reached the level required for PD to function effectively. Similarly, when respondents are asked to evaluate their own company's absorptive capacity, the aforementioned cognitive differences may lead to misjudgements. Under the influence of these deviations in judgment, this survey research has yielded conclusions that deviate from the predefined expectations. This also reflects that Chinese companies and product designers still lack a deep understanding of the core of PD. The results of this study can be regarded as a validation of the viewpoints proposed by scholars such as Steen within the design environment in China [23]. It suggests that when participatory/co-design is merely treated as a buzzword, it fails to make the necessary contributions to design projects. Additionally, it supports the viewpoint that “the varying degrees of user participation have different impacts on knowledge co-creation,” [24] indicating that only when users are deeply involved at the emotional interaction level and the knowledge they contribute is heterogeneous compared to the existing knowledge system of the enterprise, can the expected effects of this moderating effect be achieved.

5 IMPLICATIONS TO DESIGN EDUCATION

As prospective talents for enterprise design teams, the education of students majoring in design at universities is particularly important. Drawing on the existing university ranking index in China, this study selected the top 10 universities with majors related to design and conducted an investigation of their course arrangements. It was found that the direct offering of courses named Participatory Design or Co-Design is almost non-existent currently. This indicates that most Chinese universities have not yet established a systematic approach to educating students about the concept and methods of PD. However, some universities have already integrated the concept of user participation into other specialised courses. In China, there have been numerous academic studies exploring “User Participation,”

these studies predominantly focus on participation relationships existing mainly between students and teachers. Despite an increase in student participation levels within the scope of the curriculum, there is a lack of genuine "User-Side" knowledge input during the processes of Information Exchange and Knowledge Co-creation.

As an example, the course "Design Management and Planning" offered by the Design School of Nanjing University of the Arts for master's students is divided into three modules: Design Thinking, Entrepreneurship, and Final Project. Specific subjects include explanations of the product design process, design thinking, NPD processes, financial statements, and practical exercises such as "Improving Web Page Design" and "E-Bicycle NPD Project Plan." The course emphasises the importance of "Users" and mentions that PD methods can stimulate creativity. However, in this course, the term "Users" refers to personas simulated based on preliminary user research. Obviously, this simulation cannot meet the requirements of "User Participation" in PD, and the course still fails to guide students to transition from being designers to facilitators. In this scenario, the concept of "Users" as participants is based on the simulation and assumption of designers, and true "Creative Users" no longer exist in the product design process. However, this teaching model has been considered as a step forward because, compared to traditional teaching methods in universities in China, it enhances the interaction between students and teachers.

Based on the test results and the current development status in China, this study proposes the following recommendations for degree education in design-related disciplines in universities in China:

1. Improve the effectiveness of communication between students (future product designers) and participants. Instructors can appropriately monitor students' PD execution in design practice activities and establish quantitative assessment checkpoints.
2. In the early courses of degree education, it is necessary to strengthen education on PD concepts, methods, and systematic design processes, while design practice should follow these foundational courses.
3. Utilise the resources of industry-education integration and collaboration between universities and enterprises to provide students with practical opportunities in participatory product design processes based on real design projects.
4. Complete PD project is not the only form of educational value; students' independent experimentation and failure have immense potential value. Therefore, educators should encourage them to independently identify and engage users in their design practice.

For a minority of universities at the forefront of PD education, this study holds greater significance. Based on the conclusions of this research, under the condition that students have a comprehensive understanding of the basic concepts and common methods of PD, their application and evaluation abilities regarding the four elements can be improved. Diverse teaching methods can be integrated, such as using cards, role-playing, and scenario-based simulations commonly employed in PD methods [25]. Guided by the principle of PD, design education can cultivate more "facilitator-type" designers. In addition to effectively enhancing the innovation efficiency of enterprise NPD, the more significant contribution lies in infusing creativity vitality into the entire society. As PD design education becomes more refined, it is expected that the impact effects outlined in this study will become stronger, and Enterprise Absorptive Capacity can then play its positive moderating role.

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