CONCEPT EXPLORATION IN NEW PRODUCT DEVELOPMENT — AN EMPIRICAL STUDY

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New Product Development (NPD) Projects aim to create avenues of revenue generation for organizations. Successful launch of a new product depends on the ability to clearly map the requirements right from the conceptual phase. This empirical study attempts to establish the need for making 'Concept Exploration' an integral part of NPD projects. Concept Exploration has been studied using internal information and external information. Concept Development Method, Network Usage and Organization Commitment are considered for supporting elements for Concept Exploration. The results of the pilot study have been presented.

Keywords: Concept Exploration, Empirical Study, New Product Development, Fuzzy Front End.

1. INTRODUCTION

Development of new products augment sustainable competitive advantage of many an organization in the target markets. Further, market diffusion, product performance and customer satisfaction are some of the major contributing factors for the organizational success. Factors such as business requirements, customer needs, and technological feasibility have a bearing new product development.

New Product Development (NPD) project consists of two major phases, Concept Development and Product Development [1]. While product development received considerable attention in the research literature, there is an upsurge of interest in exploring concept development too. Concept Development is considered within the initial process in NPD which is also known as the Fuzzy Front End (FFE). It is a phase sandwiched between the first consideration of an opportunity and its transformation into a product concept through a structured development process [2, 3]. This Concept Development phase includes the Concept Generation, Screening, Scoring, and Testing processes.

Researchers have recommended several methodologies that could help the organization and designers to overcome the fuzziness [4], uncertainties [5] during the concept development phase. Best practices [6] and critical success factors [7] were identified for FFE. These studies comprise conceptual models [8], qualitative methods [9] and quantitative methods [10]. However, studies based on qualitative methods outnumber those based on quantitative methods. Most of these studies concur that early involvement of all the concerned departments could pave the path for the successful launch of new products by minimizing the business risks.

The Concept Development phase plays a major role in the final product outcome, since all the available product development options are fully 'explored' and duly evaluated. Many organizations enter a fire fighting mode [1] in the Product Development phase mainly because they do not adequately and systematically 'explore' product conception. Often, organizations tend to realize the importance of exploration much later in the NPD, which may result in missing time, quality, cost and market share targets. This study attempts to establish the concept development phase as an inalienable part of NPD.

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Case study approach has been adopted for comprehending the experiences of product design firms which are in the process of developing physical products for the consumer market. The conceptual model was developed by combining the extensive literature review with the findings of the case study. Survey questionnaire was developed to verify the success factors that are incorporated in the conceptual phase itself. This study will also bring out the impact of Concept Exploration on new product success.

2. BACKGROUND

In the NPD literature, Concept Development is discussed under two major research streams. The first stream of research addresses the internal factors of a product development firm. Internal factors include Product Development Team, its Capability, Process, Strategy, Method, Network, and Organization. Kratzer *et al.* [11] studied the effectiveness of social networking among product development teams and found that teams with wider network were able to produce feasible output. The study also revealed that network efficiency negatively impacted teams' creativity. His study [12] recommended that team leaders should limit their involvement in communication and act as a gatekeeper for the external sources of information. Barton [13] mapped the dimensions of core capabilities such as skills and knowledge base, technical system, managerial systems and values and norms through which organization can expand the new products and services. Through empirical study Dvir *et al.* [14] established the impact of project planning on project outcome. Wagner and Hayashi [15] demonstrated, with the help of a structured methodology, that the generation of ideas could be strengthened and measured through quality, relevance and implementability. There is also a need for a holistic approach for augmenting the front-end process and factoring in product strategy, market and organizational contexts [16].

The second stream of research explains that Concept Development could be altered by the external factors such as market (customer and competitor), technology and supply chain. Researchers identified that understanding the customer requirement was essential for product success [3, 17, 18]. Competitor studies are combined with the customer requirements in a way that the new product could be differentiated effectively [19, 20]. Herstatt *et al.* [10, 21] identified that in the FFE phase reduction in technology uncertainty has positive influence on the product success. However, in contrast, reducing market and technical uncertainty during FFE has a negative influence on communication and increase deviation during project execution [22]. Gima [23] highlighted that the highest level of involvement of buyers was in the developmental stage followed by the design stage. Early integration of supply chain requirements results in smoother execution of product development.

A few studies have been conducted by combining these internal and external factors using quantitative methods. When an idea is transformed into a concept both the factors are considered for screening and the same has been found by the current study. This study focuses on the transformation process of an idea into a concept, which is termed as "Concept Exploration (CE)". CE is defined as process of gathering information from varied sources so as to define the scope of a new product. This will be followed by Concept Generation process,. Impact of CE on product outcome, process outcome, and concept outcome and knowledge creation is explored through an empirical pilot study.

3. LITERATURE REVIEW

3.1. New Product Development

Earlier researchers in the areas of NPD, Concept Development, Modular Design, Core Capabilities, Competitor Analysis, Organizational Success and Strategic Product Planning identified the role of Concept Exploration process in NPD. Cooper and Kleinschmidt [24] investigated NPD projects and identified all the practices from a large sample of firms. Krishnan and Ulrich [25] through their review of literature provided key insights about research contributions in the areas of Concept Development and Product Development. Dooley, Subra and Anderson [6] conducted an empirical study and discussed the best NPD practices and their repeated usage in an industry. Herstatt *et al.* [10], Verworn [22], Milson and Wilemon [26] identified that market uncertainty plays key important role for the new product performance. However, Cooper [19]; Verworn [22] established relationship between technical

uncertainty and new product performance. Product strategy [16], life cycle [23], team [27], management support [11] are the other factors that are researched out and which can also alter the new product performance. However, the concerned researchers agree that irrespective of these relations, Concept Generation plays a vital role in NPD projects. From the available literature it can be observed that very few authors have commented upon the implications of the Concept Exploration process for Concept Generation.

3.2. Concept Development

The review of research literature has shown that the Concept Development phase comprises several processes including Concept Generation, Screening, Testing and Selection. It is clear that Concept Development is a divergent-convergent process since its Concept Generation process requires divergent thinking for exploration and generation of worthy alternatives and Concept Selection requires convergent approaches to result in 'work-worthy' alternatives. Peplinski, Allen and Mistree [28] defined Concept Exploration in terms of the 'robust regions' identified in design space through the Robust Concept Exploration Method (RCEM). Khurana and Rosenthal [16] examined the FFE and confirmed the effectiveness of Concept Exploration in enabling a holistic perspective. RCEM was used by Simpson, Chen, Allen and Mistree [29] for Concept Development of a family of products. For RCEM, with the given overall design requirements, one needs to identify design parameters through which robust regions can be mapped. There is no further discussion about Concept Exploration. In a later study, Simpson, Maier and Mistree [30] developed the Product Platform Concept Exploration Method (PPCEM) for scalable family platform products. Concept Development for product families was researched upon further by Dahmus, Zugasti and Otto [31]. They used the Portfolio Architecting process for Concept Development in the case of inter-changeable modules. Conceptual design and development forms a step in Portfolio Architecting, but no mention is made of Concept Generation. The Concept Development methods they suggested for product families require product references. The methodology involves complex mathematical analyses. Ulrich and Eppinger [32] have suggested several useful methods for the Concept Development phase. There is a literature gap of how the concept is generated by transforming the idea and impact of the same into product and process outcomes.

4. RESEARCH MODEL

Figure 1 illustrates the relation between the key variables related to Concept Exploration. CE is studied by categorizing the key variables into External Information and Internal Information. Method and Network Usage are considered for moderating effect and Organizational Involvement is considered for mediating effect. By gathering the internal and external information before Concept Generation, the study identified the outcomes comprising the four dependant variables, such as Product Performance, Process Performance, Concept Outcome and Knowledge Creation.

4.1. Study Intent

Based on the literature review, this study identified the factors that affect NPD project outcome in Concept Development context. The impact of CE process is established by mapping the internal and external components. Four dependant variables will be measured including New Product Performance, NPD Process Performance. Further, knowledge creation due to the NPD project is also studied as an outcome.

4.2. Concept Exploration — Hypothesis

Cooper [19] proposed the term "Exploration" to leverage idea resources for product success as a result of effective concept generation. He stressed the importance of considering this information in the earlier stage would result in product success. Nonaka [34] used Exploration to gain new knowledge by capturing the tacit knowledge for a dough making machine. Khurana and Rosenthal [16] exercised

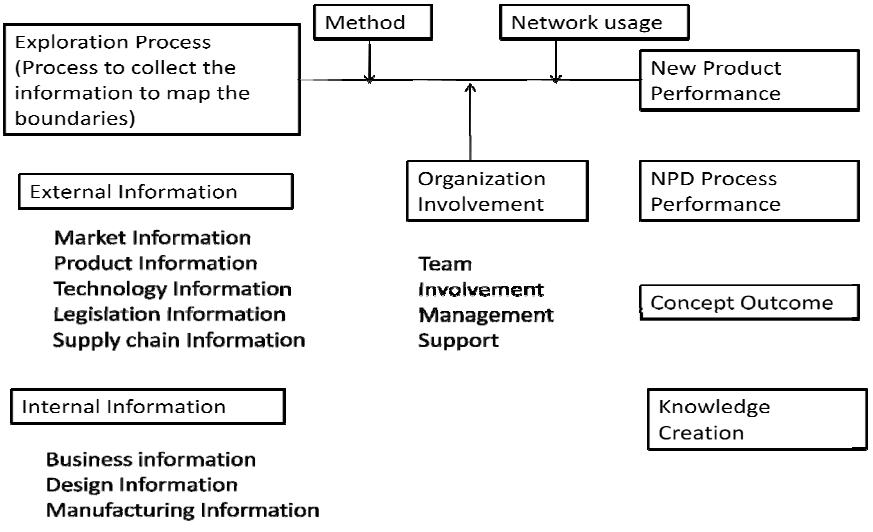

Figure 1. Research Model.

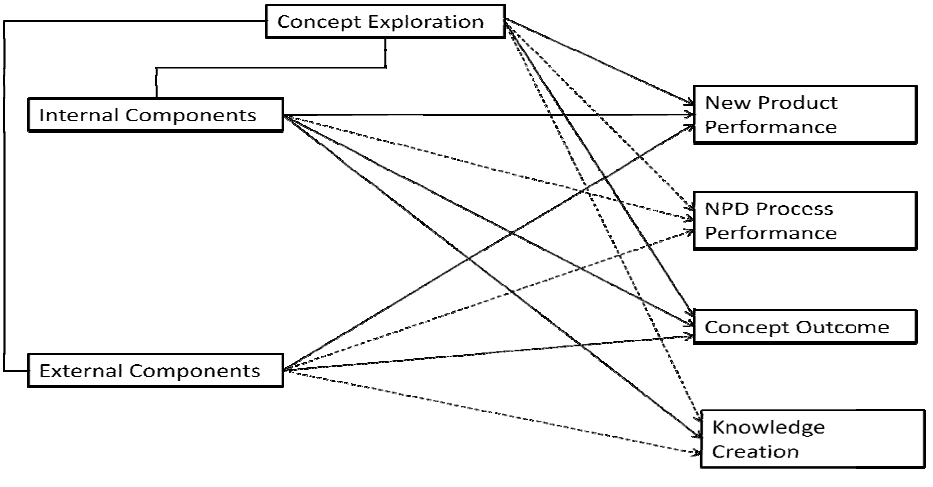

Figure 2. Proposed Hypothesis (Dotted lines indicate not significance).

Exploration to form the clear product definitions and boundaries for product development. Exploration also used to generate new concepts [28], and to understand the holistic requirements of shareholders [16]. Most of these studies are performed in the context of New Product Development as whole rather than Concept Generation in FFE. In this study Concept Exploration is considered as a process before Concept Generation. The impact of CE is explained by outcomes of product, process, and concept and knowledge creation. It is hypothesized as represented by Fig. 2 in the direction of arrows.

External Information is considered in five categories which is Market Information [7] (customer and competitor), Product Information [14, 16, 24], Technology Information [20], Legislation and Supply Chain Information. Apart from Legislation the other variables are considered largely in the context of NPD and FFE. Internal information is further sub divided into Business Information, Design Information and Manufacturing Information. Our case study reveals that designers consider one or more of this information for concept generation. Effect of the CE process is analyzed against product

Table 1. Sample Items for Marketing Information.
Indicate your perception, whether the following activities are carried out prior to Concept Generation for a proposed new product.

Item
Opportunity analysis (business plan) is performed
Potential market size in terms of volume is assessed
Customer requirements (such as features, functionality, usability etc.,) are identified
Customer requirements are prioritized
Buyers/users cultural components are identified
Customer complaints are studied
Proposed product requirements (such as features, functionality, usability etc.,) are verified (visual/descriptive) with customers.
Competitors similar products are studied
Product bench marking is performed

performance in the market, process performance (execution process), concept outcome (novelty and originality of the concept) and knowledge creation. Table 3.1. illustrates sample items used for this study.

5. RESEARCH DESIGN AND ANALYSIS

The survey instrument was designed to study the impact of CE on NPD outcomes. A seven-point scale was employed to measure the integration between CE and the outcomes. The scale includes two major elements under CE namely External Information and Internal Information. One end of the scale indicates 'strongly agree (1)' and the other end represented by 'strongly disagree (7)'. Based on the literature review and with the help of a case study 85 items are proposed. Product outcome was measured through financial, quality, cost, time to market and product features. Through developmental difficulties, design iterations and execution of planning, Process Outcome is measured. Number of potential concepts generated, novelty and originality of the concepts are used to measure the Concept Outcome. The internal (technical references) and external (patents and publications) documentation measure the Knowledge Creation. All the outcomes of Concept Exploration Process were captured. Content validity was performed with six project members by answering the questionnaire. They participated in the initial validity measurement interview in which the relevance of each question was checked after they answered each question. With the help of these experienced designers, project champions and project managers, some of the questionnaire items are modified and some are eliminated and at the end questionnaire was finalized with 65 structured items. Survey instrument consists of 4 open-ended questions to understand and explain the test results. Four democratic variables are gathered through 12 questions to understand the industry wise pattern.

A pilot study was performed with 35 participants from 17 organizations involved 15 different projects. A prerequisite for the participant is that they should have involved in a product development project (physical product and not virtual product) from its concept development. Through snow ball sampling we could able to perform the pilot test. Cronbach Alpha scores [33] are listed in Table 4.1.. Normality test was performed for each variable and construct level (K-S test Monte Corlo Significance).

Table 2. Reliability and Normality Test Result.

Description	Cronbach alpha	Normality Test
External Information	0.792	0.406
Internal Information	0.864	0.657
Concept Exploration	0.894	0.548

Note: Significance level of $p < 0.01$ for all values.

Table 3. Linear Regression Results.

Variables	New Product Performance	NPD Process Performance	Concept Outcome	Knowledge Creation
External Information	0.036	0.222	0.018	0.117
Internal Information	0.011	0.120	0.018	0.040
Concept Exploration	0.014	0.145	0.012	0.068

Note: Significance level of $p < 0.01$ for all values.

6. RESULTS AND FINDING FROM PILOT STUDY

Based on the data from the pilot study, analysis was performed using a statistical package, SPSS. Simple linear regression was carried out for the listed hypothesis. Significance level of each is listed in the table. Product Outcome and Concept Outcomes are supported by Internal Information, External Information and Concept Exploration. However, Knowledge creation is supported only by Internal Information and not by External Information and Concept Exploration. And Process Outcome is also not supported by all the three. The moderating effect of method and Network Usage is not supported. Mediating effect of Organizational Involvement is also not supported. Hence Method, Network Usage and Organizational Involvement are considered under Internal Information for this pilot study. The entire analysis will be re-computed later with the complete sample size of 300 (proposed sample size) to obtain the final results.

7. EXPECTED CONTRIBUTION FROM THE FINAL STUDY

First contribution of the study pertains to transformation of an idea into a concept by factoring in the stakeholders' expectations. Thus, a conscious decision is made by the NPD team to select/reject product ideas. Reflecting and considering market reality right at the CE stage is expected to increase the product success rate. Early involvement of stakeholders helps to accurately map their requirements. This includes the internal and external teams i.e., the end consumer as well as the service team.

Second contribution of the study relates to establishing the utility of the Concept Exploration process for generating more number of original (new to the world) concepts. Since the end customer expectations are studied, manufacturing process is understood, development difficulties are analyzed and technological capabilities are verified in the initial stage itself, it is possible to generate concepts which might not undergo major modification. Development of products on these lines is expected to undergo fairly less number of design iterations. Development difficulties are minimal in nature and thus product is launched on time while meeting the specifications. This study also brings out the new process of gathering information apart from the key objective of the project.

Apart from gathering the required information, this study also recommends that organizational involvement from the concept generation will produce an environment for creative ideas. Our study also tests management involvement from the conceptual stage leads to better management of business risks. Team involvement from the conceptual stage helps to map the product requirements.

Overall this study introduces a new process of Concept Exploration (preceding concept generation) which helps the design team to understand the product requirements. Feasibility of such requirements can also be verified by considering the supportive elements apart from the key project objectives thus helps to avoid major shocks. Organizations can customize Concept Exploration process, which can be used further for future projects.

The variables considered here are common across industries which can be applicable to any given new product. Impact of these factors can be studied further for any specified industry. Every variable can be studied in detail to access its importance level with various industry types and product levels.

8. DEFINITION

Idea — Most embryonic form of a new product or service. It often consists of a high-level view of the solution envisioned for the problem identified by the opportunity [35].

Concept — A well-defined form, including both a written and visual description, that includes its primary features and customer benefits combined with a broad understanding of the technology needed [35].

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