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Open Challenges and Research Roadmap: Visual Representations aiding Organizational Leadership in Decision Making for New Product Development at the Early Innovation Stage

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Abstract—Innovation is a cornerstone for an organization’s survival and success in the global competitive landscape in the VUCA world. The New Product Development (NPD) process is a crucial part of the portfolio and Innovation Management (IM) process. The leadership of an organization has a disproportionate impact on the outcome of innovation activities. Their involvement in IM and NPD is critical for success, considering they make strategic decisions to allocate resources for business growth. The leadership team demands a holistic picture of ideas before making decisions at early stages. The leadership challenge in decision making is that they have a limited time to make decisions by understanding many related aspects and insights quickly. The visual approaches have been vital in management practices to understand the situation and aid in decision-making by supporting cognitive processes. The fundamental problem in using visual representation is hidden expectations of leadership teams to represent needed elements to aid in strategic decision-making by leadership at the early stage of innovation. Also, the configuration of elements and interplay is another issue. The core challenge lies in understanding the effectiveness of currently used visual representations and then improving them by identifying needed elements and their configuration and placement in the visual representation. The paper takes literature review, expert interviews, and brainstorming approaches to distill the challenges to the concrete research questions and objectives. Providing solutions to the open research questions and challenges can significantly enhance the quality and speed of innovation-related decision-making.

Index Terms—canvas, strategic decision-making, visual tools, innovation management, New Product Development

I. INTRODUCTION

Innovation is a cornerstone for an organization’s survival and success in the global competitive landscape in the VUCA world. Innovation enables organizations to develop new products and offering to delight customers and win in the marketplace. The New Product Development (NPD) process is a crucial part of the portfolio and Innovation Management (IM) process [1]. Worldwide organizations have adopted Stage-Gate or variations of it to run IM and NPD processes [2]–[4].

In recent times, Agile-Stage gate and related hybrid models have taken center stage to combine the benefits of agile and stage-gate [4]–[8]. The philosophy of stage-gate mechanisms is that each stage constitutes four parts: hypothesis, activities, analysis, and decisions [2]. The activities and analysis are performed to in/validate the hypothesis. At the end of the stage-gate, the decision is made to either continue or stop [2]. The early stages of IM and NPD are a challenge as it involves strategic decision-making, mainly by leadership, with the broad and limited information that lacks specificity.

The leadership of an organization has a disproportionate impact on the outcome of innovation activities [9]. Their involvement in IM and NPD is critical for success, considering they make strategic decisions to allocate resources needed by teams to carry out activities as part of each stage gate [8], [10], [11]. At the early stage, decision-making is critical as it involves providing resources and sponsoring them, and protecting ideas and teams [9]. The leadership team demands a holistic picture related to ideas before making decisions at early stages. The leadership challenge in decision making is that they have a limited time to make decisions by understanding many related aspects and insights quickly [10]. The decision-making speed with good enough but holistic information is vital for IM processes and, by extension, success for organizations.

With the increase of information overload, leaders must understand information and how they relate to each other quickly. The visual approaches have been vital in management practices to understand the situation and aid in decision-making by supporting cognitive processes [12], [13]. The success of the Business Model Canvas [14], [15] was partly because of its visual approach where critical elements are laid out in graphic elements and organized in a way to get a clear understanding. There are more than 95 visualizations related to business model innovation available as of now today, and practitioners are using them [16]. Visual tools offer a mechanism

Fig. 1. Graphical Overview of Challenges and Key Research Questions

to structure the information, improve understanding of the relationship among the information structure, and offload the cognitive processes to visual perception [12], [17]. Therefore, visual tools are widely accepted in decision making where speed is sought after.

In summary, for innovation activities to succeed, the speed of decision-making by leadership at the early stages of innovation is essential. Visual representations and tools can help leaders to make quick and quality decisions by making sense of disparate and broad information in a short time. However, visual representations are not studied widely in the given context.

The rest of the paper is arranged into five main sections. In section II, the paper discusses the overview of challenges with the help of figure 1 and provides an overview of the methodology employed. In section III, the evolution of key ideas related to innovation, leadership, stage-gate, decision making, and visual representations are discussed along with their intersections. Also, the gaps and challenges are identified. In section IV, the paper discusses expert opinions and provides triangulation with literature review. Based on previous sections, in section V paper crystallizes open challenges into the research questions, subquestions, objectives. Paper provides limitation of proposed research and related roadmap in section V-A and then discusses the impact of providing a solution to open challenges and related research question in section V-B. The paper ends with conclusion in section VI.

II. OVERVIEW OF CHALLENGES

Figure 1 provides a graphical overview of challenges by placing them in the context. The focus area is at an early stage of Agile Stage-Gate. At the early stage of NPD, the leadership

team has to decide on resources allocation using visual representations. The discussed problem is at the intersection of innovation processes from innovation management, decision making from a leadership perspective, and visualization tools from cognitive sciences.

The fundamental problem in using visual representations is hidden expectations of leadership teams to represent needed elements to aid in strategic decision-making at the early stage of innovation. The leadership team needs to understand key drivers related to innovation from disparate information for making a decision. The key drivers are not standardized and keep changing on a case-by-case basis. The leadership team has a latent expectation about key drivers present in visual representation. Additionally, the configuration of elements and interplay among elements is another issue. The disparate key drivers need to be presented to make logical connections and derive insights, leading to strategic decision-making by the leadership team.

The core challenge lies in understanding the effectiveness of currently used visual representations and then improving them by identifying needed elements; and their configuration and placement in the visual representation. The literature survey indicated the availability of limited research to understand the structure and structural relationship within visual representations for decision-making in the early innovation phase. The challenge is distilled into top-level two research questions, based on methodology discussed in II-A.

- 1) What is the purpose of using visual representation by organization and leadership in IM?
- 2) How can the visual representations be made more effective?

A. Methodology

The open challenges related to visual representation at the early stage of Agile Stage-Gate for decision making by leadership is ascertained with the help of literature review in section III and experts interviews in section IV-A. Authors have used brainstorming techniques to derive an actionable roadmap to address the open challenges and to derive research questions, subquestions, and objectives. Figure 3 provides graphical overview of methodology with steps taken to derive and ascertain the research questions.

Fig. 2. Overview of methodology used to derive proposed research questions

During brainstorming, authors converted the open challenges into hypothesis and then converted it into research questions and objectives¹. Then, the authors performed relationship mapping between open challenges, research questions, and objectives for ensuring completeness. The result of relationship mapping is available in figure ???. The details of research questions, sub-questions, and objectives are discussed in section V.

III. LITERATURE REVIEW

The subject area is at the intersection of innovation, decision making, and visualization. Therefore, the literature review demands to deal with multiple topics and subtopics from various areas as shown in figure 1. The integrative literature review shows that researchers carried out previous studies and research in a specific field or at the intersection of 2 areas. Therefore, the integrative literature review within the paper aims to provide an overview of work carried out mainly at the intersection of areas to establish relationships and identify key challenges.

A. Innovation and Leadership

Innovation is the critical success factor for organizations [19]. Tushman and Nadler [20] indicated that innovation management is the vital task of the organization's executive leadership in today's dynamic and uncertain environment. Many organizations have implemented the innovation management

¹The first author is creating a detailed research proposal as part of doctoral research work to address the raised research questions. The first author is developing a research proposal as a working paper [18].

system accordingly to Diamantini et al. [21], mainly to manage the early stage of the new product development process [1], [8]. According to Ernst [22] and van der Panne et al. [23]; the success factor for innovation depends on top management support. The top management team needs to balance the short-term focus on existing business (exploit) and the long-term direction for building new business (explore) [9]. Strategic decision-making in allocating resources for exploitation and exploration remains the topmost tradeoff for leadership [9], [11]. Effective decision making for framing the innovation problem, allocating resources, coordinating among managers for innovative new product development remains key open challenges for leadership according to Kuratko and Neubert [24]. Among open challenges, effective decision-making for innovation is the critical challenge for a leadership team for business growth. The key challenge is summarised and represented in the box below².

OC1 *Effective decision making by leadership team for resource allocation for innovation*

B. Stage-Gate in Innovation Management

The leadership's innovation-related decision-making challenges are further accentuated by the realities of the VUCA world today, where external context related to technology, consumer behavior, competitor, geopolitics, and the market is changing and evolving at an unprecedented rate according to [10], [24]. The organizational dynamics, capabilities of the organization, and people's competencies add another layer of complexity to the challenges [9]. In response to the challenges, Cooper [25] introduced a stage-gate model as a blueprint for NPD providing a conceptual and operational framework to mature ideas systematically. The stage-gate divides the process into stages, and each stage includes decision-making about furthering to the next step or not. Therefore stage-gate demands incremental decision making from leadership based on evidence and activities carried out. The progressive, evidence-based decision-making nature at each stage of stage-gate was appealing enough that most of the organizations have adopted it [1], [6], [8]. However, the stage-gate system had its limitations [4], [8], which was handled well by adopting hybrid approaches combining agile, design thinking, lean startup methodology at various stages [6]. The agile stage-gate is one of the newer forms of stage-gate, which is widely used across organizations as it combines the strength of agile philosophies and stage-gate methods [8]. Despite introducing the agile approach in stage-gate, the challenges are not fully solved. For example, later stages are driven by matured and detailed evidence. However, early stages are not entirely dependent on evidence and include a judgment call by practitioners and leaders [26]. The literature does not addresses the challenge adequately for agile specific stage-gate approach [16], [27]–[31], as it is mainly in the practitioners' domain without

²OC_x - Open Challenge *x*

common consensus. Therefore, understanding and developing mechanisms or frameworks for an early stage of agile stage-gate from the leadership team's perspective remains an open challenge.

OC2 Agile Stage-Gate early stage decision making mechanism and framework for NPD in IM

C. Decision making and Visual Tools

Decision-making is a cognitive process involving processing information, synthesizing insights, generating alternatives, selecting evaluating criteria, and selecting the best option based on insights and criteria [32]. The critical task of business leaders is to make frequent decisions for various business areas with incomplete and disparate information under multiple scenarios. Cognitive science researchers have extensively studied the decision-making phenomena and discovered that leaders could make effective decisions when information is presented visually [13], [33]. According to Tversky [17], the elements in visual representation, their placement, relationship, size, and shape form the visual language and make it easier to process information, make sense of information, and reduce cognitive load. Visual tools are widely used in business decision-making, and there is a new leadership style emerging out of it called *Visual Leaders* [34]. The visual tools' central promise is the ability to use visual perception to make meaning out of information, the relationship among information, and contextualize the information for a given task, in this case, decision making. In the early stage of innovation, the leaders have to understand aspects at the macro-level and micro-level from external and internal perspectives before making decisions [9], [35]. Also, the information lacks specificity and completeness at an early stage of innovation. Therefore visual tools are widely used in innovation management processes for decision making by practitioners, as suggested by Sibbet [34]. The principal challenge for practitioners also is to choose the proper visual representation for the leadership for the decision-making, considering the maturity of innovation and available information. The academic research is limited toward addressing the challenge of choosing the appropriate visual representation in decision-making in the early stage of innovation management. Therefore, understanding the visual representation suitable for innovation decision-making remains a crucial challenge.

OC3 Early stage innovation-related decision making with visual representations

D. Visual Representation

One of the emerging trends observed at the intersection of visual representation and innovation is the emergence of canvases. Canvases utilize elements view where each element is visually represented on a single page, and information related to the element is captured in the box. The ability

of canvases to represent distilled and diverse information in simplified visual representation makes it appealing for practitioners to use [16]. For example, the business model canvas [14], [15] and lean canvas [36] are at the forefront of the trend. Täuscher and Abdelkafi [16] indicated that practitioners use both the canvases extensively in the context of business model innovation and new product developments as they have developed additional artifacts to support practitioners. Bianchi et al. [5] and Hannola et al. [37]; indicated that organizations also use business model canvas and lean canvas as part of the decision-making process in the agile stage-gate method. The practitioner-academic divide [38] discussed across other fields of business and decision making is also evident here as there are more practitioner canvases available and less academic research on canvases. Täuscher and Abdelkafi [16] argues that the same visual artifacts of the business model innovation canvases are ill-suited for initiation, ideation, and integration phases. Therefore, developing a suitable visual representation along with required artifacts to support practitioners at the early stage of the innovation process remains a challenge.

OC4 Visual Representation with required artifacts to support practitioners at the early stage of innovation process

E. Summary of Literature Review

The integrative literature review indicates plenty of research available in - innovation processes, NPD, and stage-gate methods from innovation management area; strategic management, decision-making from leadership and innovation area; visual tools and canvases from cognitive sciences area. Also, a growing body of literature is available at the intersection of decision making and innovation, innovation and visualization, and visualization and decision making. However, there is an evident absence of literature at the intersection of innovation, decision making, and visualization. That remains a significant challenge considering the prolific use of canvases by practitioner's. Table I provides the list of open challenges derived from the literature review, and it forms a baseline for discussion available in the next section.

TABLE I
OPEN CHALLENGE LIST

Open Challenge	Description
OC1	Effective decision making by leadership team for resource allocation for innovation
OC2	Agile Stage-Gate early stage decision making mechanism and framework for NPD in IM
OC3	Early stage innovation-related decision making with visual representations
OC4	Visual Representation with required artifacts to support practitioners at the early stage of innovation process

IV. DISCUSSION

Innovation is a focused activity in the organizations, and leadership teams closely monitor the same. However, the leadership team is mainly involved in decision-making, considering the limited time availability. They also have to deal with a variety of information for innovation concerning understanding customer problems and need, the desirability of a solution, willingness to pay; feasibility to make it concerning organizational capability, competence, and available resources; and viability of business considering industry/market dynamics, business modeling, and other parameters. The leadership teams are also overwhelmed by decisions they have to make under incomplete information settings, especially for innovation-related activities. The leadership team desires to have tools, mechanisms, and processes at their disposal to make the quality decision at speed.

A. Experts' Viewpoints

The authors conducted five unstructured interviews with industry practitioners and leaders in an informal setting to discuss the open challenges and gain deeper insights. The discussion mainly focused on the performance of innovation management from a leadership viewpoint.

Participants said that their organizations are using hybrid forms of stage-gate for innovation management with agile approaches, affirming results from [1], [6], [8]. They suggested that speed of innovation is an important aspect, confirming the findings from [39]. However, the speed of innovation is mainly hampered by available resources and the organization's focus. Leadership decision-making is the most crucial part of ensuring timely resource allocation to sustain innovation speed and foster them on time (OC1). Participants, representing leaders, also articulated that for decision-making, they need to have essential information presented along with distilled insights and critical tasks presented intuitively at the early stage (OC2). They also described that teams offer the information using various visual representations suitable for teams and not considering expectations of leadership teams (OC3). Due to varied representations, the leadership teams have to learn the representations before they understand the information and make decisions (OC4). The outcome of these discussions is mainly consistent with the findings of the integrative literature survey and listed open challenges³.

Therefore, there is a strong need to address the open challenges by conducting focused research in leadership decision-

³First Author's viewpoint: The first author's professional experience as an innovation manager for over four years is consistent with the experts' viewpoints and integrative literature survey. As an innovation manager seeking the leadership decision, author has utilized the business model canvas [15], opportunity canvas [40], focused innovation canvas [41], enterprise AI canvas [42], machine learning canvas [43], [44], collaborative innovation canvas [45], lean startup canvas [36] and corporate innovation canvas [46]. The canvas choices were mainly based on innovation topic, technology usage, intended outcome, and available information and evidence. In multiple instances, the leadership team asked the author and his team about how to read and interpret the canvas - resulting in frustration for all stakeholders. The lack of suitable visual representation and supporting artifacts was the biggest challenge faced by the author and his team.

making in the innovation process using visual representations from practitioners' points of view.

V. PROPOSED RESEARCH QUESTIONS

The four open challenges are first converged in to two key research questions and labeled with $KRQx$, where x is a numeral. The $KRQx$ then broken down in to six relevant sub questions for improving specificity of research and labeled with $KRQxSy$, where y is a numeral. With improved specificity, total nine corresponding objectives are derived for each $KRQxSy$ and labeled with $KRQxSyOz$, where z is a numeral. The relationship mapping available in figure ?? is used to map $KRQxSyOz$ with open challenges OCx . Following tree structure describes key research question, subquestions, and objectives along with their mapping.

Fig. 3. Overview of methodology used to derive proposed research questions

KRQ1 What is the purpose of using visual representation by organizations and leadership in IM?

KRQ1S1 Which visual representations are used by organizations at the early stage of IM within the agile stage-gate method?

KRQ1S1O1 To identify the usage of visual representation in organizations for IM

KRQ1S1O2 To describe the variations of visual representation used in organizations

KRQ1S2 What kind of decisions leadership takes based on visual representation at the early stage?

KRQ1S2O1 To identify leadership objectives for using visual representation in IM

KRQ1S2O2 To establish the linkage between decision making by leadership using visual representations

KRQ1S3 Are current visual representations suitable at the early stage of IM?

KRQ1S3O1 To describe the extent to which the visual representations are suitable in decision making by leadership

KRQ2 *How can the visual representations be made more effective?*

KRQ2S1 *Which elements in visual representation are needed from the leadership team to make decisions?*

KRQ2S1O1 *To determine the suitable elements in visual representation aiding the decision making by leadership*

KRQ2S2 *What is the best suitable configuration of elements?*

KRQ2S2O1 *To establish a suitable element configuration for visual representations*

KRQ2S2O2 *To develop a visual representation that associates the required elements with the suitable visual configuration*

KRQ2S3 *What additional artifacts are needed from practitioners for a visual representation to be useful?*

KRQ2S3O1 *To develop a practitioner ready version of visual representation*

A. Limitations

The proposed research questions and subquestions are evaluative and exploratory. They are aimed to get the real-world understanding and constitute the early phase of research. Therefore, it has limitations related to descriptive power and explanatory power.

In the next phase, once the evaluation is available about visual representations, then based on that, explanatory research can be carried out to understand the workings of it. Similarly, exploratory research for generating new visual representations should be followed by descriptive research and establish a relation among variables impacting the visual representations.

Despite its stated limitation in an early research phase, robust findings from the early phase can contribute significantly by adding knowledge regarding visual representations in innovation decision-making by leadership teams.

B. Impact

Providing solutions to the open challenges and related research questions can significantly enhance the quality and speed of innovation-related decision-making. It aims to bring helpful insights for practitioners and academicians. It is going to result in securing an innovation advantage for an organization ultimately.

The research in the area aims to improve the academic understanding of optimal decision-making by leadership in the early innovation stages using visual representations. The research seeks to inform the ongoing discussion in academia about the use of canvas as a visual representation. The research aims to add to the knowledge base about the Agile Stage-Gate approach with a specific focus on early-stage decision making. The research aims to crystalize the knowledge base related to decision-making by the organization's leadership team for innovation. The phase-wise approach discussed in section

V-A, provides a long-term roadmap for research. Research objectives aim at bridging a knowledge gap between academia and industry.

According to [39], the speed and quality of decisions during the innovation process directly impact the success of innovation. The research has strong managerial implications from the practitioners' viewpoint as discussed in section IV-A. Therefore, The research objectives appear to be desirable by practitioners. Practitioners can transfer the understanding in terms of tools with artifacts to help practitioners and leadership make effective decision-making.

The research roadmap is designed to have far-reaching implications for academia, managers, leaders, and practitioners.

VI. CONCLUSION

Organizations are relying on teams to innovate to secure their future. Leadership decision-making is critical for resource allocation and sponsorship to increase the speed of innovation within an organization. Leadership teams need to make decisions under incomplete and diverse information. Innovation practitioners use visual representation to make it easier for the leadership team to understand and make faster decisions. Most visual representations are chosen based on subjective heuristics, resulting in reduced effectiveness. The integrative literature review reveals a severe lack of previous work at the intersection of innovation, decision making, and visualization. The findings of a literature survey are converted into four open challenges, and the same is validated with the experts' interviews. The open challenges are transformed into two key research questions related to the purpose of using visual representation and improvement of the same. The early phase research and relevant roadmap is derived with an aim to address open challenges and contribute to academic debate and knowledge base. Transferring research findings and recommendations to develop the effective visual representations for the innovation decision-making in the agile stage-gate process reduces the academia-industry gap. The improved visual representations benefit the organization to enhance the speed and efficacy of the decision-making process during the innovation phase - making it a competitive advantage.

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