

DESIGN PROCESS FOR INTEGRATIVE REASONING: A MODEL FOR IDENTIFYING AND ENHANCING COMPETENCIES

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ABSTRACT

This research addresses persistent challenges in design and engineering education and practice, particularly the fragmentation of knowledge in contrast with the complexity of real-world product development problems. Assuming that different modes of thinking can strengthen learning and decision-making processes, the study presents the Integrative Reasoning Model, a circular framework developed to identify and articulate competencies required to address complex problems in product design contexts. The model structures three complementary modes of thought: Design Reasoning, Scientific Reasoning, and Common-Sense, demonstrating how the integration of these perspectives can support more comprehensive approaches to project analysis and development. The research adopts a qualitative and exploratory approach structured through applied workshops conducted in a corporate environment. The activities were carried out within product design departments of a large company in southern Brazil, involving professionals engaged in product development processes. During the workshops, a visual canvas-based tool derived from the proposed model was used to support the identification and discussion of the different modes of thinking present in project decision-making. Results indicate that the model helped make explicit the different cognitive perspectives mobilised during product development processes, enabling participants to identify how design-based, scientific, and everyday experience-based approaches influence project decisions in complex situations. The applications also revealed competencies related to the integration of perspectives, critical reflection, and adaptation in the face of uncertainty. Participant feedback contributed to the refinement of the model and confirmed the usefulness of the canvas as a reflective support tool in professional product design contexts. The study contributes to the field of design by proposing an integrative approach capable of supporting reflection and decision-making processes in product development environments characterised by complexity, interdisciplinarity, and multiple forms of knowledge.

Keywords: Reasoning, design education, modes of thinking, competencies, design process

1 INTRODUCTION

Contemporary organisations face increasingly complex challenges characterised by multiple variables, uncertainty, and interdependencies between technical, social, and economic factors. In this context, approaches based on disciplinary fragmentation are often insufficient to address problems that require the integration of different types of knowledge.

In the field of design and product development, this complexity becomes particularly evident. Product development processes involve the articulation of engineering, technology, user experience, market dynamics, and organisational strategies. As a result, professionals must mobilise different forms of reasoning and competencies to understand problems and develop innovative solutions.

Several authors highlight the role of design as a field capable of integrating multiple perspectives in complex problem-solving processes. Buchanan [1] argues that design connects different areas of knowledge when addressing wicked problems, characterised by ambiguity and the absence of definitive solutions. Similarly, Cross [2] describes design thinking as a specific way of reasoning oriented toward exploring complex problems through iterative cycles of analysis, synthesis, and experimentation.

This research investigates the concept of Integrative Reasoning as an approach aimed at identifying and developing competencies needed to address such complexity. Previous studies introduced the

conceptual framework of Integrative Reasoning, proposing the articulation of scientific reasoning, design reasoning, and common-sense reasoning as complementary modes of thinking [6].

In a later stage of the research, this framework was translated into a visual canvas applied in educational contexts to support project-based learning activities [10]. Results from these applications suggested that making different modes of reasoning explicit can stimulate reflective processes and broaden the understanding of how problems are approached.

However, the need emerged to explore the application of this model in professional environments, particularly in product development contexts where multidisciplinary teams must integrate technical, creative, and experiential knowledge.

Therefore, this article presents the development and application of a circular Integrative Reasoning Model Canvas (IRMC) used in workshops conducted within a product development organisation. The aim of the study is to investigate how this tool can support the identification and articulation of competencies involved in design and innovation processes.

2 THEORETICAL BACKGROUNDS

2.1 Complexity and problem solving

Problems faced by contemporary organisations often exhibit characteristics of complexity and ambiguity. Rittel and Webber [8] introduced the concept of wicked problems to describe situations in which problems cannot be clearly defined and solutions cannot be definitively validated.

Such problems require approaches capable of integrating knowledge from multiple domains. Simon [9] argues that design processes involve transforming existing situations into preferred ones through iterative cycles of analysis and solution generation.

Reports on the future of work indicate that competencies related to complex problem solving, critical thinking, and creativity are increasingly important across professional fields [11]. This reinforces the need for educational and methodological approaches capable of fostering these capabilities.

2.2 Cognitive processes in design

Several scholars have examined the cognitive processes involved in design practice. Cross [2] argues that designers develop particular forms of reasoning oriented toward constructing solutions in open-ended situations.

Lawson [5] describes design as a continuous movement between problem analysis and solution generation, where designers explore possibilities while simultaneously developing an understanding of the problem.

Schön [7] highlights the reflective nature of design practice, emphasising the concept of reflection-in-action, in which professionals develop knowledge through experimentation and iterative learning.

Dorst [3] further emphasises the role of abductive reasoning in design, which enables the exploration of new possibilities by proposing creative hypotheses connecting problems and solutions.

Together, these perspectives suggest that design involves the combination of analytical, creative, and contextual forms of reasoning.

2.3 Integrative Reasoning

Building on these discussions, this research proposes Integrative Reasoning as an approach that articulates different modes of thinking in complex problem-solving processes.

The model considers three primary forms of reasoning:

- **Common-sense reasoning:** grounded in everyday experience, intuition, and contextual understanding.
- **Scientific reasoning:** associated with systematic analysis, hypothesis formulation, and evidence-based validation.
- **Design reasoning:** related to creative exploration, experimentation, and iterative solution development.

The articulation of these forms of reasoning can broaden problem understanding and support innovation processes. Kolko [4] highlights the potential of design to integrate different forms of knowledge and generate new perspectives.

The Integrative Reasoning framework was initially introduced in previous studies examining the complementarity of these reasoning modes in learning and professional contexts [6]. It was later translated into a visual canvas applied in higher education environments [10].

3 METHODOLOGIES

This research adopts a qualitative exploratory approach structured through iterative cycles of model development and application.

The methodological process involved three main stages:

- Conceptual development of the Integrative Reasoning model through literature review.
- Development of visual tools to operationalise the model.
- Application and qualitative analysis in educational and professional contexts.

This article focuses on the application of the model in professional environments related to product development. The workshops were conducted in a company located in southern Brazil and involved professionals working in product development teams, including designers, engineers, and innovation managers. Participants used a circular canvas to map different modes of reasoning involved in challenges related to product development. Data collection included observation of the workshops, photographic documentation of the artifacts produced, and qualitative feedback provided by participants.

4 DEVELOPMENT OF THE CIRCULAR MODEL

The evolution of the research led to the development of a circular representation of Integrative Reasoning. The circular structure was adopted to represent the dynamic and iterative nature of design processes. Unlike linear models, the circular format emphasises continuous interactions between different modes of reasoning (Figure 1).

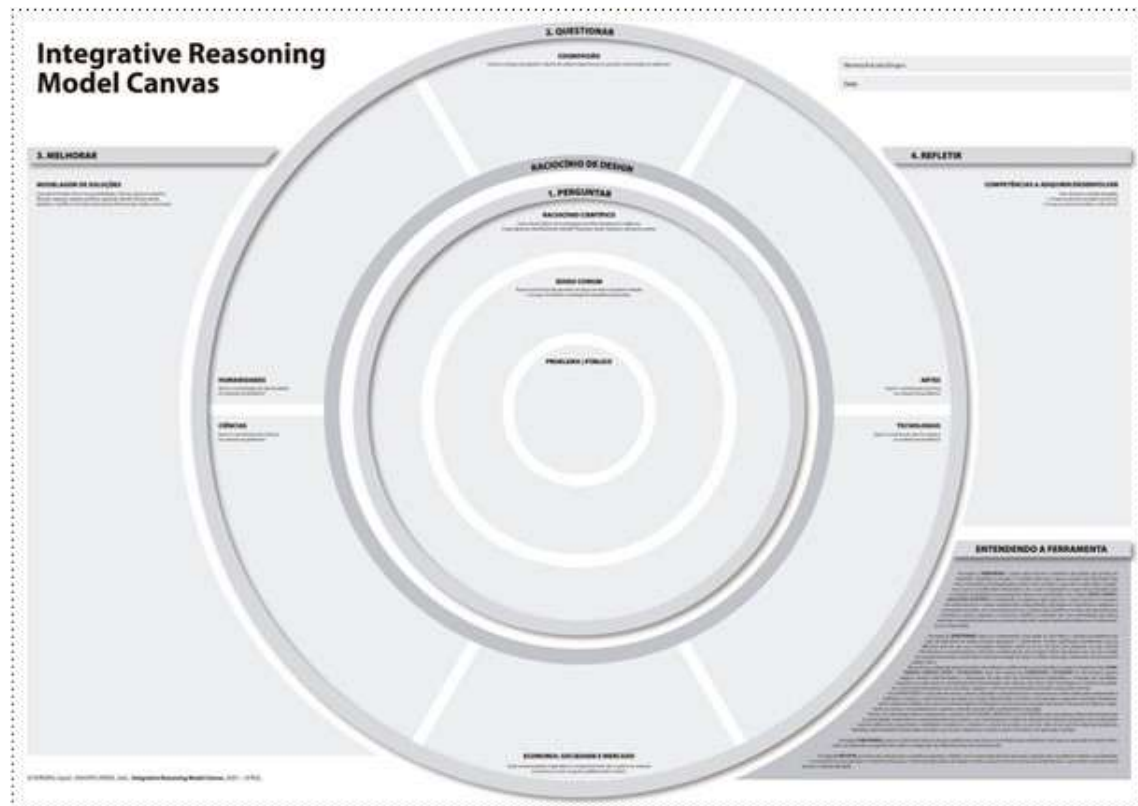


Figure 1. IRMC - Integrative Reasoning Model Canvas

In the model, scientific reasoning, design reasoning, and common-sense reasoning are positioned as interdependent dimensions that can be mobilised at different moments during the design process. This approach aligns with perspectives that describe design as an exploratory and reflective activity in which problems and solutions co-evolve [5][7].

The canvas also includes spaces dedicated to identifying competencies associated with each mode of reasoning, encouraging participants to reflect on the skills mobilised in product development processes.

5 WORKSHOP APPLICATIONS

Two workshops were conducted in product development units of a large company in southern Brazil: an industrial development team and a private-label product team. A total of 20 professionals participated, aged between 21 and 44, working as analysts, specialists, and coordinators.

Based on Dorst's levels of design expertise [3], participants in the first workshop were mostly positioned at the competent level, while the second group included both competent and proficient professionals, suggesting higher design maturity.

Regarding organisational roles in design practice, participants mainly identified with profiles associated with human-centred perspectives, technological facilitation, and network-building roles within organisations.

The competencies most frequently mentioned by participants were teamwork, resilience, curiosity, organisation, and proactivity, followed by critical thinking, adaptability, and problem-solving. Conversely, competencies such as leadership, assertive decision-making, originality, and entrepreneurial vision were less frequently cited and later identified as areas for development.

After introducing the Integrative Reasoning concept and the IRMC structure, participants were invited to discuss challenges related to product development in their teams.

In the first workshop, discussions focused on issues related to product development processes, cross-department collaboration, and decision-making throughout the design cycle (Figure 2).



Figure 2. Working with the IRMC – Product Development Department (Industry)

In the second workshop, discussions centred on the market positioning of private-label products, including challenges related to value communication, competition with international brands, and marketing investment constraints (Figure 3).



Figure 3. Working with the IRMC – Private Label Product Development Department

The IRMC guided discussions through four stages: Ask, Question, Improve, and Reflect, encouraging participants to analyse problems from multiple perspectives and identify competencies required to implement solutions.

6 DISCUSSIONS

The workshop results indicate that the IRMC can support integrative reasoning processes in product development contexts.

The tool helped broaden discussions by encouraging participants to consider technical, social, cultural, and economic factors simultaneously. This aligns with contemporary perspectives that describe design as an interdisciplinary practice addressing complex problems [1][2].

By structuring problem analysis across multiple knowledge dimensions, the IRMC makes relationships explicit that often remain implicit in design processes, fostering a more systemic understanding of problems and enabling collaborative solution development.

Another relevant aspect concerns professional competency development. The reflection stage of the canvas encourages participants to consider the skills necessary to implement proposed solutions, connecting design practice with broader discussions on professional capability development.

Additionally, the workshops revealed common tensions in product development environments, particularly the need to balance innovation, economic constraints, and market strategies.

7 CONCLUSIONS

This article presented the development and application of the Integrative Reasoning Model Canvas (IRMC), a tool designed to support integrative reasoning in design processes.

Workshops conducted with two product development teams demonstrated the potential of the model to structure discussions around complex challenges and encourage the integration of multiple perspectives. The results suggest that the IRMC can help make explicit the various factors influencing product development processes while promoting reflection on competencies required for implementing solutions.

The study is limited by the number of applications and the fact that workshops were conducted within a single organisation. Future research may explore the use of the IRMC in different industrial and educational contexts, as well as investigate digital versions of the tool to support collaborative design processes.

7.1 AI-assisted writing disclosure

ChatGPT (OpenAI) was used exclusively for language editing and improvement of textual clarity. The authors fully reviewed and validated the final content.

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