


# From Divergence to Alignment: Diagrammatic Thinking Across Industrial Design, Engineering, and Marketing

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## Makale Bilgisi

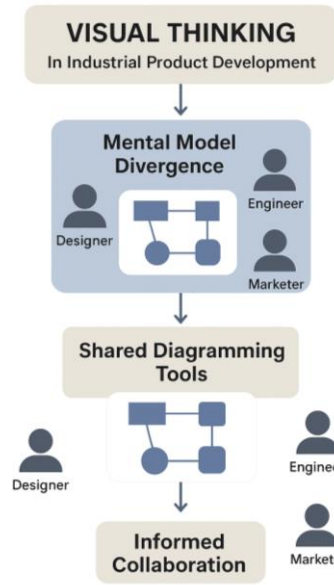
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## Anahtar Kelimeler

Endüstriyel ürün geliştirme,  
Görsel düşünme,  
Zihinsel modeller,  
Disiplinlerarası iş birliği,  
Diyagramlarla temsil,  
Sınır nesnelere,  
Yoruma dayalı sürtüşme

## Graphical/Tabular Abstract (Grafik Özet)

This study uses an autoethnographic simulation to explore how designers, engineers, and marketers think visually in industrial product development. Through diagram creation and analysis, it measures divergence and alignment in visual reasoning, showing how shared diagrammatic tools can bridge disciplinary gaps and enhance multidisciplinary collaboration. / Bu çalışma, endüstriyel ürün geliştirmede tasarımcıların, mühendislerin ve pazarlamacıların görsel düşünme biçimlerini incelemek için otoetnografik bir simülasyon yöntemi kullanmaktadır. Diyagram oluşturma ve analiz yoluyla görsel düşünmedeki farklılık ve uyumu ölçerek, ortak diyagram araçlarının disiplinler arası iletişimi güçlendirebileceğini göstermektedir.



## Highlights (Önemli noktalar)

- The study examines cognitive divergences between design, engineering, and marketing disciplines in industrial product development through an autoethnographic simulation. / Çalışma, endüstriyel ürün geliştirmede tasarım, mühendislik ve pazarlama disiplinleri arasındaki bilişsel farklılıkları otoetnografik bir simülasyon aracılığıyla inceler.
- It analyzes how visual thinking and diagrammatic representations mediate — and sometimes strain — interdisciplinary communication. / Görsel düşünme ve diyagramatik temsillerin disiplinler arası iletişimi nasıl aracıladığı ve zaman zaman nasıl gerilim yarattığını analiz eder.
- The findings reveal the critical role of diagrams as “boundary objects” in fostering conceptual alignment and collaboration. / Bulgular, diyagramların “sınır nesnesi” olarak kavramsal uyumu ve iş birliğini güçlendirmedeki kritik rolünü ortaya koyar.

Figure A: The summary of the process / Şekil A: Sürecin özeti

**Aim (Amaç):** The study aims to explore how visual and diagrammatic thinking mediates cognitive divergence among industrial designers, engineers, and marketers in product development processes. / Bu çalışma, endüstriyel ürün geliştirme süreçlerinde tasarımcılar, mühendisler ve pazarlamacılar arasındaki bilişsel farklılıkların görsel ve diyagramatik düşünme aracılığıyla nasıl aracılanabileceğini araştırmayı amaçlamaktadır.

**Originality (Özgünlük):** The study is original in employing an autoethnographic simulation that combines disciplinary role-playing with diagrammatic analysis. / Bu çalışma, disiplinler rol canlandırmasını diyagramatik analizle birleştiren otoetnografik simülasyon yaklaşımıyla özgünlük taşımaktadır.

**Results (Bulgular):** The results show that diagrams act as boundary objects that can either facilitate or hinder Interdisciplinary collaboration depending on how they are constructed and interpreted. / Bulgular, diyagramların nasıl oluşturulup yorumlandıklarına bağlı olarak disiplinler arası işbirliğini kolaylaştıran veya zorlaştıran sınır nesnelere olarak işlev görebildiğini ortaya koymaktadır.

**Conclusion (Sonuç):** The study concludes that shared visual frameworks can enhance communication, reduce interpretive friction, and support alignment across disciplines in product development. / Çalışma, ortak görsel çerçevelerin iletişimi güçlendirebileceği, yorum farklılıklarını azaltabileceği ve ürün geliştirmede disiplinler arası uyumu destekleyebileceği sonucuna varmaktadır.



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### Abstract

In industrial product development, effective collaboration among designers, engineers, and marketers is crucial, yet is frequently challenged by fundamentally divergent mental models of how a product should function, appear, and succeed in the market. Each discipline interprets and communicates design intent through distinct visual and cognitive frameworks, including conceptual sketches, technical schematics, customer journey maps, and market flows. This article investigates how these disciplinary perspectives manifest in visual thinking practices and how shared diagramming tools function as mediators or points of friction within multidisciplinary teams. The study maps the interplay between mental models and representational practices by drawing on literature from design cognition, visual semiotics, systems thinking, and empirical observations from collaborative design settings. It further explores how misalignments impact decision-making, innovation, and project coherence. The findings contribute to a deeper understanding of visual mediation as a critical factor in collaborative product development and propose strategies for aligning cognitive and visual frameworks to improve interdisciplinary communication and design outcomes.

## Farklılıktan Uyuma: Endüstriyel Tasarım, Mühendislik ve Pazarlama Disiplinlerinde Diyagramlarla Düşünme

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### Öz

Endüstriyel ürün geliştirme sürecinde, tasarımcılar, mühendisler ve pazarlamacılar arasındaki etkili iş birliği büyük önem taşır; ancak bir ürünün nasıl çalışması, nasıl görünmesi ve pazarda nasıl başarılı olması gerektiğine dair kökten farklı zihinsel modeller nedeniyle bu iş birliği sıklıkla zorluklarla karşılaşır. Her disiplin, tasarım niyetini kavramsal eskizler, teknik şemalar, müşteri yolculuğu haritaları ve pazar akışları gibi kendine özgü görsel ve bilişsel çerçeveler aracılığıyla yorumlar ve aktarır. Bu makale, disiplinler arası bakış açılarını görsel düşünme pratiklerinde nasıl tezahür ettirdiğini ve paylaşılan diyagram araçlarının çok disiplinli ekipler içinde birer arabulucu mu yoksa sürtüşme noktası mı olduğunu araştırmaktadır. Çalışma, zihinsel modeller ile temsil pratikleri arasındaki etkileşimi tasarım bilişi, görsel göstergebilim, sistem düşüncesi ve iş birliğine dayalı tasarım ortamlarından elde edilen ampirik gözlemler ışığında haritalandırmaktadır. Ayrıca, bu uyumsuzlukların karar alma süreçleri, yenilikçilik ve proje bütünlüğü üzerindeki etkilerini incelemektedir. Bulgular, görsel aracılığın ortak ürün geliştirme süreçlerinde kritik bir faktör olarak daha derinlemesine anlaşılmasına katkı sağlamakta ve bilişsel ve görsel çerçevelerin hizalanmasına yönelik stratejiler önererek disiplinler arası iletişimi ve tasarım çıktılarının niteliğini artırmayı amaçlamaktadır.

## 1. INTRODUCTION

In contemporary industrial product development, multidisciplinary collaboration has become common and essential [1]. Designers, engineers, and marketers must collaborate to create products that are both technically feasible and visually appealing, as well as commercially viable [2]. However, this convergence of disciplines often

leads to miscommunication and conceptual misalignment due to the distinct ways each profession models and interprets product logic [3]. These divergences are not merely semantic or procedural [4]; they are rooted in fundamentally different mental models, internal representations of systems, processes, and priorities that each participant brings to the design table [5].

Visual thinking is a key mechanism in multidisciplinary collaboration, providing a shared medium for articulating ideas, resolving ambiguity, and coordinating efforts [6]. Visual representations serve as the lingua franca of product development processes [7], encompassing sketches and wireframes [8], system diagrams [9], and marketing funnels [10]. However, the very diagrams that facilitate collaboration can also obscure disciplinary intent or oversimplify complex logic, leading to clashes in interpretation or direction [11]. While much research has explored collaboration in design teams [1], there has been less focus on how visual tools specifically shape, support, or conflict with the underlying mental models of different disciplinary actors.

This article investigates the role of visual thinking in shaping and exposing mental model divergence in industrial product development. Using a reflective, autoethnographic methodology [12], the author analyzes personal design experience and constructs simulated scenarios that embody the perspectives of designers, engineers, and marketers. Through this lens, the study identifies how each discipline's preferred representations reflect unique priorities, levels of abstraction, and assumptions about users, systems, and markets. Furthermore, it evaluates how shared visual tools—such as diagrams, sketches, and flowcharts—mediate understanding or contribute to misalignment.

By mapping these cognitive and representational differences, this article seeks to deepen our understanding of cross-disciplinary communication [13], ultimately enhancing collaboration and coherence in product development. The findings highlight the importance of visual literacy [14], meta-representational awareness [15], and diagrammatic flexibility [16] as strategies for aligning multidisciplinary teams. By doing so, this research offers valuable insights for practitioners and educators seeking to enhance collaboration in complex design environments.

## **2. BACKGROUND RESEARCH ON LITERATURE**

This section explores the theoretical foundations and earlier research related to mental models, visual thinking, and interdisciplinary collaboration in product development. It provides a concise overview of the key concepts underpinning the study's investigation into how various disciplines visually represent product logic, and how these representations align or conflict within collaborative design processes.

### **2.1. Mental Models in Design Collaboration**

Mental models refer to the internal representations of knowledge, beliefs, and expectations that individuals use to understand and interpret the world around them [17]. In the context of product development, these mental models govern how individuals approach the problem-solving process, prioritize different factors, and communicate their ideas to others [18]. Mental models are shaped by professional training, experience, and cognitive biases [19], which can lead designers, engineers, and marketers to have fundamentally different views of the same product. For designers, the product is often envisioned as a holistic user experience of aesthetics, functionality, and intuitive interaction [20]. Engineers, in contrast, focus on technical specifications, manufacturability, and design feasibility [21]. Marketers, meanwhile, approach the product through the lens of market demand, usability, and the communication of brand values [22]. As such, each discipline's mental model reflects its unique role within the development process and the corresponding knowledge domain [23].

In multidisciplinary teams, different mental models can cause friction, as each professional uses his/her criteria to assess the same design problem [24]. This divergence can complicate communication and collaboration, especially if participants are unaware of or do not actively negotiate the differences [25].

### **2.2. Visual Thinking and Diagrammatic Representation**

Visual thinking, or the ability to represent ideas through images and diagrams, is a fundamental aspect of problem-solving in design [26]. Sketches [8], diagrams [27], and flowcharts [28] allow designers to externalize their cognitive processes, make abstract concepts tangible, and communicate complex ideas to others [29]. Visual representations also support rapid iteration and modification [30], which are key aspects of the design process [31].

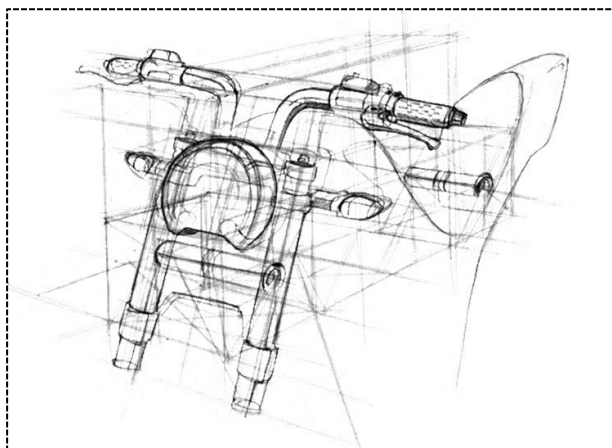


Figure 1. Designer's sketch of a motorcycle [8]

Designers often use sketching, similar to the one in Figure 1, for ideation, capturing quick concepts, and refining their thoughts through continuous drawing and modification [32]. In contrast, engineers frequently employ formalized technical drawings or system diagrams to articulate how a product works or will be manufactured [33]. These drawings and diagrams, such as circuit schematics, blueprints, or CAD models, similar to the one in Figure 2, reflect a structured and logical representation of the product [34].

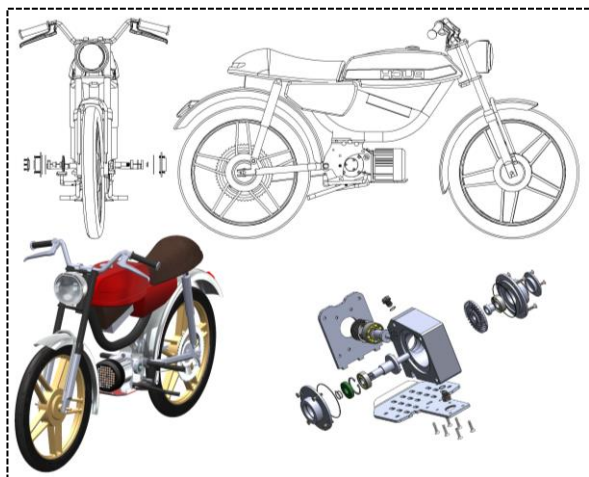


Figure 2. Engineer's CAD model, technical drawing, and assembly scheme of an electric moped (Author's work)

On the other hand, marketers tend to rely on flowcharts, customer journey maps, and personas to understand the user's relationship with the product [35]. These visualizations, such as the one seen in Figure 3, often focus on the emotional and experiential aspects of the product and the consumer's needs and desires [36].

While each visual representation has its place, the varying degrees of abstraction and focus between disciplines can create opportunities for convergence and sources of conflict, too [37].

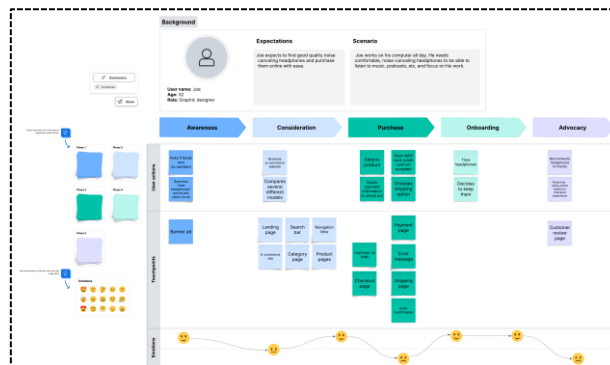


Figure 3. Customer journey map [38]

### 2.3. Multidisciplinary Team Dynamics in Product Development

Research into multidisciplinary collaboration in product development highlights the challenges of aligning diverse perspectives [1]. In a review of studies on product development teams, it has been noted that integrating various disciplines, such as design, engineering, and marketing, often leads to communication breakdowns, with each discipline prioritizing different aspects of the product [39]. Designers may emphasize user experience and aesthetics [40], while engineers focus on functionality and manufacturability [21], [41]; marketers, meanwhile, may prioritize marketability and user appeal [42].

These differing priorities can cause tension in the collaborative process, as each discipline's mental model may not align with the others [43]. Moreover, the professionals involved may be unaware of their cognitive biases, leading to misunderstandings or assumptions about how others approach the task [19]. Successful collaboration depends on the team's ability to recognize and negotiate these divergent perspectives [44]. Shared visual representations can help mediate these differences, but they must be flexible enough to capture the diverse aspects of the product as seen by each discipline [37], [45].

### 2.4. Visual Tools as Mediators of Cross-Disciplinary Understanding

Shared representations are "boundary objects" that allow participants from different knowledge domains to communicate and coordinate their work [46]. These objects facilitate communication by providing a common point of reference while allowing for different interpretations and contributions from each discipline [11]. Visual tools, used in collaborative design platforms, are critical in bridging disciplinary divides [47], and they enable team members to align their thinking, ensuring all perspectives are considered [48]. These tools might range from simple sketches to

immersive virtual reality tools[49]. However, the success of these tools depends on their ability to accommodate the different levels of abstraction, priorities, and cognitive styles of the disciplines involved [50]. For example, a sketch that works well for a designer may be too vague or imprecise for an engineer [51], while a technical schematic may be overly complex for a marketer [52].

Research on visual thinking in design highlights the need for meta-representational competence, which is the ability to understand and adapt to various visual conventions with their implications for communication [53]. When team members can understand others' visual languages and cognitive assumptions, they are better equipped to use shared tools effectively [54]. However, a mismatch between the tools' representations and the participants' mental models increases the potential for misunderstanding, leading to delays, conflicts, or ineffective collaboration [37].

### 3. METHODOLOGY

This study adopts a first-person autoethnographic methodology to investigate how visual thinking manifests differently across disciplinary roles—specifically those of the designer, engineer, and marketer—in industrial product development. The method allows the author to engage deeply with the construction and comparison of mental models using visual tools, thereby generating firsthand data through controlled and immersive simulation.

#### 3.1. Autoethnographic Approach

In the first-person autoethnographic framework [55], the author assumes three distinct professional personas: industrial designer, mechanical engineer, and marketing strategist. Drawing on academic background, field experience, and an understanding of industry workflows, the author emulates each role's cognitive approach and visual representations. This reflexive practice enables a consistent internal comparison of how each discipline frames product logic through visual media. Care is given to minimize the influence of one role's cognitive biases [56] while embodying another. Transitions between roles are facilitated through targeted preparatory readings, examination of authentic project briefs, and focused mental immersion into the distinct goals and frameworks of three disciplines. This internal triangulation provided methodological rigor and ensured that the diagrams produced were not arbitrary, but purpose-driven and contextually valid within each role.

#### 3.2. Scenario Construction

Three original project scenarios were written to simulate realistic conditions from the viewpoint of the designer, engineer, and marketer. The scenarios centered around a moderately complex consumer product (an electric-powered personal vehicle) to ensure a shared conceptual base while allowing for divergent disciplinary interpretations. The scenarios included brief constraints such as target users, core functions, how to use them, expected manufacturing limitations, and market position. These provided enough detail to anchor ideation without over-determining the visual form of responses. Each scenario was then graphically interpreted by creating a visual diagram that most accurately conveyed the logic seen through the lens of that role. This aims to ensure comparability while preserving disciplinary integrity.

#### 3.3. Diagram Development

The case study was conducted in a dedicated personal workspace, intentionally designed to foster focused, uninterrupted deep work and facilitate systematic visual inquiry. Each session was preceded by a brief immersion phase (reviewing relevant literature, sketches, or workflows) followed by reflective journaling [57]. The process yielded diagrammatic artifacts and reflective notes, which added depth to the qualitative analysis by capturing cognitive shifts and interpretive nuances across roles. Timeboxing each persona's session helped preserve ecological validity while enabling equitable comparison across disciplines. All diagrams in the study were created using Lucidchart [58], a flexible web-based diagramming tool suitable for technical schematics, user experience (UX) workflows [59], and narrative maps [60]. Lucidchart was selected for its versatility in accommodating the diverse visual languages of all three disciplines while maintaining a uniform digital workspace. Each diagram was developed independently over a 90-minute session to reflect a realistic working time constraint. They are drawn from scratch, without templates, to ensure originality and reflect authentic mental model construction.

*The designer's diagram* is presented in Figure 4, which is a conceptual UX diagram emphasizing the experiential product logic: how a user interacts with an electric-powered personal vehicle through its key interfaces and touchpoints. It focuses on user interaction, emotional tone, and affordances, utilizing flowcharts, interface states, and design annotations. There are 12 nodes and 17 links. It

primarily has a horizontal flow with mild branching for emotional and interface feedback. Curved arrows represent decision points, while straight arrows indicate sequential flow.

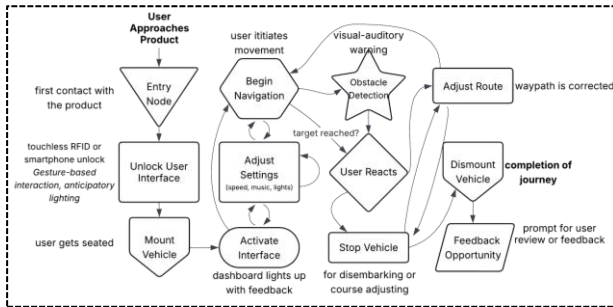


Figure 4. Designer's diagram

The engineer's diagram in Figure 5 is a system architecture schematic, focusing on the functional and technical structure of the electric-powered personal vehicle. It is in a layered block diagram form with hierarchical flow, top-down from energy input to user interface nodes. It represents component relationships, signal flows, power distribution, and subsystem interdependencies, emphasizing technical components, system logic interdependencies, control flow, and feedback mechanisms through functional block diagrams and signal paths. There are 15 total nodes and 22 links.

Color variations are used for power (red), control logic (blue), mechanical systems (grey), feedback (green), sensors (orange), and audio signal (yellow). Images are also used for various components such as battery, motor, brake lever, control card, etc., which can be supplemented by technical drawings later.

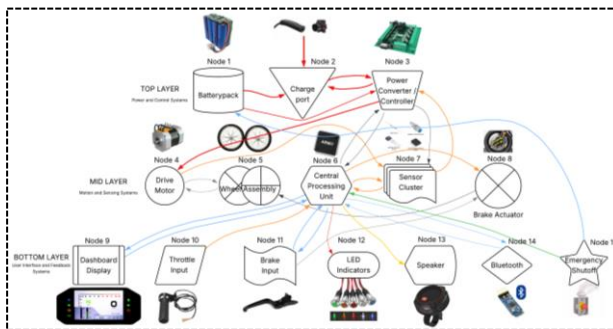


Figure 5. Engineer's diagram

The marketer's diagram in Figure 6 used narrative arcs and persona-based mapping to highlight the user journey, pain points, brand touchpoints, and value propositions. It is a strategic customer journey and messaging flowchart, visually mapping the conceptual logic behind an advertising campaign for the electric-powered personal vehicle. The focus is on targeting, communication flow, media selection, and campaign evaluation. The diagram prioritizes clarity, sequence, and segmentation,

showing a lower structural complexity compared to the previous schematics. There are 7 nodes and 8 links in total. Arrows connect nodes in a linear downward flow with no feedback loops. Consistent shapes (rounded rectangles) and semantic icons are used for clarity (e.g., a graph icon for "Performance", a bullseye for "Target Audience").

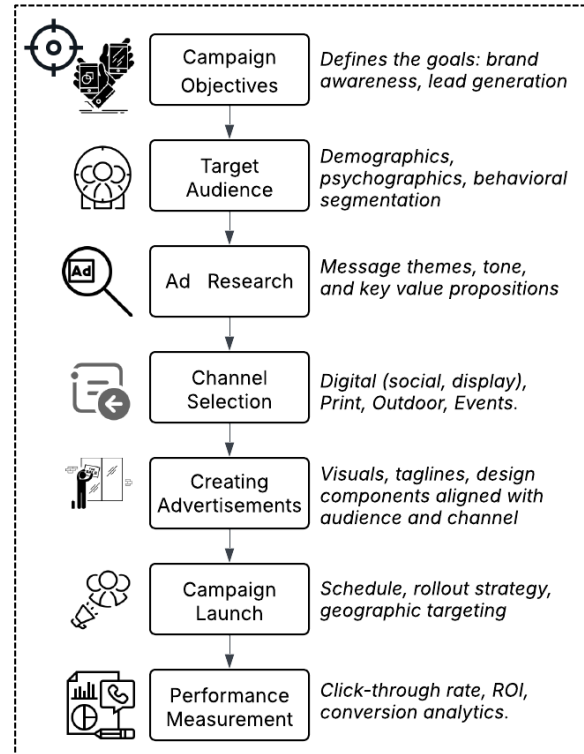


Figure 6. Marketer's diagram

Shared Diagram: After developing individual diagrams, a shared diagram was constructed by reconciling disciplinary priorities and symbols. This diagram, shown in Figure 7, functions as a mediating framework that balances technical clarity, user experience logic, and market relevance. It integrates elements from all three disciplines in a unified, hierarchical structure, consisting of three horizontal layers, one for each disciplinary perspective. It shows how elements in each layer relate vertically (across disciplines) and horizontally (within each discipline). There are 15 Total Nodes, 5 per discipline (UX/User Flow, Engineering Modules, Marketing Phases) linked by 22 total connections, consisting of 10 vertical (mapping relationships between related nodes across disciplines) and 12 horizontal links (logical flow within each disciplinary track).

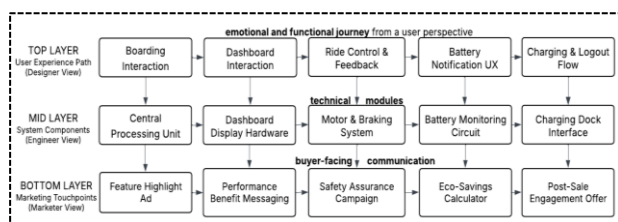


Figure 7. Shared diagram

It is essential to note that these diagrams are not intended to encapsulate the mindsets of the three disciplines fully; rather, they represent provisional constructs that inevitably remain incomplete and subject to ongoing revision throughout the development process. They are created for demonstration purposes, with comparable levels of detail to ensure internal consistency. While simplified, they are intended to approximate the structure of real-world diagrams, which would typically be more expansive and complex.

### 3.4. Visual Content Analysis

Following the creation of the diagram, each visual artifact was disassembled into its constitutive elements (nodes, connections, annotations, icons, layers) and analyzed using a custom coding scheme. Attributes such as element density, semantic focus, temporal sequencing, and narrative structure were quantified and compared. The coding process generated raw data that fed into comparative metrics. This stage also included a visual inspection for layout logic, spatial orientation, and the use of symbols to uncover tacit assumptions embedded in each discipline’s graphical style.

### 3.5. Quantification Metrics

Five key metrics were developed to compare the diagrams:

- *Diagram Complexity Score:* Counts of distinct elements and nested structures.
- *Mental Model Divergence Index:* Ratio of non-overlapping symbolic features across diagrams.
- *Representation Purpose Score:* Proportion of elements intended for conceptual, technical, or communicative purposes belonging to the three disciplines, respectively.
- *Cross-Interpretation Effort Score:* The perceived ease with which a diagram could be understood and interpreted by individuals from the other two disciplines.

These metrics provide a numerical and interpretive framework for assessing the representational logic, communicative clarity, and the preparation effort required for each diagram.

## 4. FINDINGS AND ANALYSIS

The outcomes of three simulated product development scenarios, each approached from the perspective of a designer, an engineer, and a marketer, are presented in this section. The aim was to explore how each discipline conceptualizes and visually represents product logic and to identify divergences in their mental models, forming the basis for a multi-disciplinary common diagram that will be created as a more effective means of cooperation among all three types of professionals. Quantitative metrics were developed to complement the qualitative observations, providing analytical rigor and multidimensional insights into visual thinking differences.

The grades given for each of the five metrics—Diagram Complexity Score, Mental Model Divergence Index, Representation Purpose Score, Interpretability Score, and Cross-Interpretation Effort—were calculated using a mix of structured visual analysis and reflective evaluation based on clear criteria and then translated into scores out of ten for comparability, as follows.

### 4.1. Diagram Complexity Score

This metric captures abstraction and information density in each discipline's diagram by counting the number of distinct visual elements, such as labeled nodes, directional arrows, color-coded clusters, annotation layers, and layout variations, as shown in Table 1.

Table 1. Distinct visual elements for all three diagrams.

Discipline	Diagram Type	Total Elements
Designer	UX flow sketch	27
Engineer	Functional schematic	52
Marketer	Customer journey map	18

The engineer's diagram demonstrated the highest complexity, with extensive labeling, layered logic flows, and precise spatial relationships reflecting a system-level mental model. The designer’s diagram exhibited lower visual density, prioritized sequencing, interface zones, and experiential logic. The marketer’s diagram centered around narrative arcs, personas, and value touchpoints, revealing a storytelling-oriented mental model.

The Diagram Complexity Score (out of 10) was derived by comparing the raw counts in Table 1 to a predefined scale representing increasing levels of complexity. The goal was not to reward complexity for its own sake, but to assess structural richness relevant to each discipline.

**4.2. Mental Model Divergence Index**

This score measured how much each diagram differed from the others in terms of content and visual structure. First, we identified unique elements in each diagram, those not shared by the others. The higher the number of exclusive features (like discipline-specific symbols or organizational logics), the higher the divergence score. To quantify disciplinary differences, a Divergence Index was computed by counting the number of distinct visual elements unique to each diagram, emphasizing the degree of non-overlapping representational logic across roles.

Unique elements across diagrams:	65	Divergence Score
Total elements across diagrams:	97	$(DS) = \frac{65}{97} = 0.67$

For calculating Mental Model Divergence Index (out of 10), these counts were normalized and graded on a scale of 1–10, with 10 representing the maximum divergence and lower values indicating more conceptual overlap with other disciplines.

**4.3. Representation Purpose Score**

This score reflects how effectively each diagram communicates its respective disciplinary priorities. For example, a designer’s diagram was assessed for how well it captured user experience flow and emotional tone; an engineer’s for clarity in system mechanics and functional accuracy; a marketer’s for audience targeting and messaging. Each visual element was coded based on its intended function: conceptual exploration, technical specification, or communicative clarity, as shown in Table 2.

**Table 2.** Representation purpose counts

Discipline	Conceptual	Technical	Communicative
Designer	8	2	2
Engineer	1	10	1
Marketer	1	1	8

The Representation Purpose Score (out of 10) was then determined by assessing each diagram against a checklist of five core communicative goals, then converting this evaluation into a score that reflects how thoroughly and effectively those goals were addressed.

**4.4. Cross-Interpretation Effort Score**

This score indicates how challenging it is for someone outside the discipline to comprehend a diagram. To assess interdisciplinary readability, the other two personas evaluate diagrams using a reverse Likert scale, where 1 = "very easy to understand without prior knowledge" and 5 = "very difficult without explanation," with counts displayed in Table 3.

**Table 3.** Cross-interpretation effort assessment

From / To	Designer	Engineer	Marketer
Designer	—	5	2
Engineer	4	—	3
Marketer	3	4	—

These scores were then inverted and scaled to 10 to obtain the Cross-Interpretation Effort Score (out of 10), so a high number reflects greater ease of cross-disciplinary interpretation. Diagrams full of jargon or implicit logic had lower scores; those that used shared symbols or explanatory labels scored higher. An average cross-interpretation score of 4.3 (excluding native evaluations) reveals high interpretive friction. The engineer’s detailed technical diagram was particularly opaque to others, while the marketer’s narrative structure was somewhat more accessible, though still lacking in functional precision.

**4.5. Shared Diagram Overlaps.**

The improvement in overlap between producing the shared diagram was measured by counting mutually intelligible elements shown in Table 4, before and after the integration.

**Table 4.** Alignment through shared visuals scores.

Stage	Overlapping Elements
Before integration	5
After integration	16
Improvement	+220%

**4.6. Overall Results in Table Form**

The results calculated on a /10 scale are presented below in Tables 5-8. These metrics help to clarify the hidden structure of cross-disciplinary communication, showing what diagrams convey and how and to whom they communicate.

**Table 5.** Designer’s diagram metrics

Metric	Value	Description
<b>Diagram Complexity Score</b>	7/10	Moderate complexity with feedback loops and sub-flows
<b>Mental Model Divergence Index</b>	High	Emphasizes experience/emotion, not physical mechanisms
<b>Representation Purpose Score</b>	9/10	Strong focus on sequencing and UX logic
<b>Cross-Interpretation Effort</b>	6/10	May need translation for engineers/marketers

**Table 6.** Engineer’s diagram metrics

Metric	Value	Description
<b>Diagram Complexity Score</b>	9/10	High component and signal density
<b>Mental Model Divergence Index</b>	High	Focused on structure/function, not experience
<b>Representation Purpose Score</b>	8/10	Prioritizes technical coherence and dependencies
<b>Cross-Interpretation Effort</b>	7/10	Requires translation for designers/marketers

**Table 7.** Marketer’s diagram metrics

Metric	Value	Description
<b>Diagram Complexity Score</b>	4.2/10	Low component and signal density
<b>Mental Model Divergence Index</b>	High	Shares only 2 abstract concepts with other diagrams
<b>Representation Purpose Score</b>	9.1/10	Goal-oriented messaging clarity
<b>Cross-Interpretation Effort</b>	7.8/10	Semantic-heavy, requires translation for technical roles

**Table 8.** Shared diagram metrics

Metric	Value	Description
<b>Diagram Complexity Score</b>	3.8/10	-
<b>Mental Model Divergence Index</b>	1.2/10	Very low
<b>Representation Purpose Score</b>	4.7/10	Medium Success

<b>Cross-Interpretation Effort</b>	1.1/10	Very low
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**5. DISCUSSION**

This section interprets the findings through the lens of mental model theory and collaborative design practice. The combination of visual content analysis and metric-based evaluation provides a clearer picture of how divergent mental models affect interdisciplinary communication and collaboration.

The findings from the study strongly support the central hypothesis: designers, engineers, and marketers create and convey product logic using distinctly different visual languages. This separation is evident in the Divergence Index score of 0.67, which indicates substantial variation among the diagrams produced. These differences are not arbitrary; they reflect discipline-specific cognitive orientations. Engineers prioritize procedural precision and system accuracy; designers focus on flow, interaction, and experiential logic; while marketers emphasize value propositions, narrative clarity, and consumer-facing messages. Importantly, this divergence is not a liability but a potential strength. It introduces cognitive diversity, which, if harnessed, can stimulate innovation. The primary challenges identified include low baseline intelligibility between disciplines and the absence of standardized visual conventions for interdisciplinary diagrams. Yet, these challenges present valuable opportunities.

This interpretation is supported by Representation Purpose Scores, which show how each diagram meets its intended communication goals. The Diagram Complexity Scores indicate that engineering diagrams tend to be more information-dense, design diagrams strike a balance between abstraction and usability, and marketing diagrams are the simplest, optimized for audience understanding but less interpretable by other professionals. The Cross-Interpretation Effort Scores emphasize this further, revealing that diagrams often were not easily understood outside their original discipline.

A shared diagram dramatically improved mutual intelligibility by 220%, demonstrating the value of collaborative visual tools. This improvement suggests that co-created diagrams can function as boundary objects: visual artifacts that are interpretable by multiple groups without sacrificing the integrity of any perspective. Crafting such

diagrams requires restructuring, negotiation, and simplification, highlighting the cognitive and procedural effort necessary for cross-disciplinary alignment. Shared diagrams can bridge conceptual divides, unfamiliar representational forms can cultivate empathy, and layered or modular visual tools may allow each discipline to contribute fully without compromise.

For practitioners, the study recommends three key strategies:

- Invest in co-designing visual tools that emerge through collaboration rather than being imposed.
- Build representational sensitivity within teams to appreciate each discipline's visual logic.
- Adopt hybrid visualization frameworks, such as layered diagrams that preserve disciplinary detail while fostering shared understanding.

While the study's autoethnographic nature provides strong insights, it also points toward compelling directions for future research to provide real-world validation, answering questions such as: How do these patterns play out in live, high-pressure team settings? What role do collaborative platforms like Lucidchart play in diagram convergence? Can visual literacy training actively reduce interpretive friction? Exploring these questions, and more, could refine the metrics used here and deepen our understanding of how visual thinking shapes multidisciplinary design practice.

## 6. CONCLUSIONS

This study examined the role of visual thinking in industrial product development, specifically how mental model divergence among designers, engineers, and marketers shapes collaboration, and how shared diagramming tools can either bridge or widen these gaps. By simulating three disciplinary perspectives and creating corresponding diagrams, the study revealed that each field structures product logic differently, not only in content but also in the purpose and complexity of visual representation. While these differences present inherent challenges, they also offer an opportunity: when addressed intentionally, they can lead to richer, more integrated outcomes.

Rather than viewing divergent mental models as obstacles, the study proposes treating them as a source of creative tension that can be productively harnessed through deliberate, visual co-creation. The developed shared diagram significantly improved mutual understanding across roles, highlighting the potential of visual tools to serve as

dynamic, evolving "boundary objects" that anchor discussion without forcing uniformity. However, this outcome is not automatic. It depends on the willingness and ability of team members to engage with unfamiliar visual languages, adapt their modes of representation, and negotiate shared frameworks. In this light, visual literacy, particularly the ability to recognize and interpret the purpose behind a diagram, is not merely a technical skill but a strategic competence in collaborative product development.

The insights gained here stem from a single researcher's autoethnographic study built on the author's industry and academic experience. While this approach provides a uniquely integrated perspective, it also limits the generalizability of the results. Nonetheless, the processes and metrics developed in this study present a practical and replicable method for further research, testing this method with real-world teams, examining the role of digital collaboration platforms, and exploring how organizational culture shapes the adoption and adaptation of shared visual tools. Additionally, it would be valuable to research how team structures and leadership dynamics influence visual tools, determining whether they foster inclusive, collaborative exchange or reinforce siloed, discipline-specific perspectives.

At its core, this article contributes to a growing methodological conversation about how visual thinking mediates cross-disciplinary collaboration. By foregrounding the representational challenges of working across roles and offering a structured approach to analyzing and addressing them, it points toward a more reflexive, design-aware practice of teamwork, where diagrams are not just containers of information but tools for negotiation, alignment, and innovation.

## DECLARATION OF ETHICAL STANDARDS (ETİK STANDARTLARIN BEYANI)

The author of this article declares that the materials and methods they use in their work do not require ethical committee approval and/or legal-specific permission.

Bu makalenin yazarı çalışmalarında kullandıkları materyal ve yöntemlerin etik kurul izni ve/veya yasal-özel bir izin gerektirmediğini beyan ederler.

**AUTHORS' CONTRIBUTIONS** (YAZARLARIN KATKILARI)

**Özkal Hüseyin ÖZSOY:** He conducted the experiments, analyzed the results, and performed the writing process.

Deneyleri yapmış, sonuçlarını analiz etmiş ve maklenin yazım işlemini gerçekleştirmiştir.

**CONFLICT OF INTEREST** (ÇIKAR ÇATIŞMASI)

There is no conflict of interest in this study.

Bu çalışmada herhangi bir çıkar çatışması yoktur.

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