ESTUDOS EM DESIGN
DESIGN ARTICLES

Images as qualitative visual references: recommended image boards for product development process activities

Imagens como referência visual qualitativa: painéis imagéticos recomendados para as atividades do processo de desenvolvimento de produtos

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Abstract
Image Boards (IB) are visual reference tools and their application in the Product Development Process (PDP) is currently concentrated in the early project stages, especially in marketing and industrial design. On the other hand, the current facilities for creating, capturing, selecting, assembling, and sharing images using electronic devices increase the possibility of applying IB in other PDP activities. The aims of this study were to identify the PDP activities in which the IB contributed with information that promote alignment, comparison, or visual inspiration. For this was employed a double quantitative and associative analysis between the PDP activities, images and the IB. The results indicated that the use of images could be beneficial for different PDP activities. Moreover, different PDP activities can be associated with different types of IB. In this sense, the use of IB can offer advantages for multidisciplinary areas of PDP, going beyond design and marketing.

Keywords: Image boards, Qualitative tools, Product development process, Engineering activities.

Resumo
Os Painéis Imagéticos (PI) são ferramentas de referência visual e sua aplicação no Processo de Desenvolvimento de Produtos (PDP) encontra-se concentrada nas fases iniciais do projeto, sobretudo nas áreas de marketing e design. Por outro lado, as atuais facilidades para criar, capturar, selecionar, montar e compartilhar imagens por meio de aparelhos eletrônicos, potencializam a possibilidade de aplicação dos PI em outras atividades do PDP. Neste sentido, o objetivo desse estudo foi identificar as atividades do PDP nas quais os PI contribuem com informações que promovem alinhamento, comparação ou inspiração visual. Para isso, foi empregada uma dupla análise quantitativa e associativa entre as atividades do PDP e os PI. Os resultados indicaram que o uso de imagens pode ser benéfico em diferentes atividades do PDP, que também podem estar associadas a diferentes tipos de PI. Neste sentido, o uso do PI pode oferecer vantagens para áreas multidisciplinares do PDP, indo além do marketing e design.

Palavras-chave: *Painéis imagéticos, Ferramentas qualitativas, Processo de desenvolvimento de produtos, Atividades de engenharia.*

Introduction

The use of different tools in the execution of project activities is a widespread situation. This condition occurs because the human body's capacity and abilities are limited to the identified demands regarding any process of creation or transformation. In this sense, humankind has adapted and devised tools that maximise its natural actions, with which it has gradually achieved control of its environment (LÖBACH, 2001). This dynamic also applies to the Product Development Process (PDP) and contributes to the project's final goal with less cost, effort, and time (PMI, 2017). Thus, the regular use of tools with appropriate methods for executing activities is an important part of acceptable design practices. Given this, expressive tools currently available can be applied in different PDP activities. Each one presents particularities related to the input information, ways of use, and output results (ROZENFELD et al., 2006). Therefore, the management associated with the tool's choice is directly linked to the project's demand, the device's availability, the results that it offers, and the familiarity that the executing team has with each of them (BACK et al., 2008).

Among the tools applied in design activities, there are Image Boards (IB). IB are visual tools of semantic reference and visual comparison, which can be considered multisensory media (texture, movement, and sound) (MCDONAGH; DENTON, 2005). Furthermore, this tool is considered a means to establish and define agreement on an initial environment for a product during the design process (ENDRISSAT; ISLAM; NOPPENEY, 2016).

In this sense, the benefits of IB are well defined in different areas. Marketing uses this tool to help understand the profile of consumers and competitors of the product proposal. Simultaneously, the industrial design area obtains references and visual comparisons, creative inspiration sources, and semantic alignments for the product's aesthetic conception process (MCDONAGH; STORER, 2004). Thus, in general, it is already evidenced in the literature that the coordination and alignment of concepts also occur through IBs, which can maintain plurality while presenting a steering and alignment effect (CASSIDY, 2008; ENDRISSAT; ISLAM; NOPPENEY, 2016).

However, even though IB are a well-known tool employed for marketing and industrial design related activities (BAXTER, 2011; BÜRDEK, 2015; MERINO, 2016), they have not been associated with design activities in different PDP models (MAGRAB et al., 2010; PAHL et al., 2007; ULRICH; EPPINGER; YANG, 2020). On the other hand, some tools present in the mentioned models use visual elements, with suggested applications for specific tasks (brainstorming 635, conceptual matrix, sketch, and storyboard). These tools have their functionality based on creating drawings or illustrations that point to solution principles for some need presented. None of these, however, indicate a more intense use of images during the project.

The application of tools in design activities is under frequent renovation. New methods, new technologies, and new applications expand and improve the characteristics of use, promoting better results during the design process. Considering the facilities that technology has made available to daily life, working with images is no longer complicated and time-consuming. They can be captured, edited, and made available in a matter of minutes to an entire project team, sharing information, reactions, and results in real-time.

As the product production processes become more limitless, dispersed, and less hierarchical, visual organisation relevance tends to gain impulse (ENDRISSAT; ISLAM; NOPPENEY, 2016). Thus, IB can be a tool employed and widespread in different areas and activities of PDP and may convey core values, emotional experience, and authenticity to other design areas by increasing the number of information sources available for these demands (ENDRISSAT; ISLAM; NOPPENEY, 2016).

In this sense, understanding the associations that can be conducted between the IB and the PDP activities is not yet adequately evidenced. Thus, this study's objective was to identify PDP activities in which the IB contributed with information that promotes alignment, comparison, or visual inspiration.

This study's contribution indicates the possible associations between the IB and the activities employed in PDP models, increasing the number of qualitative information sources available for the required demands. The research was limited to a single PDP model's activity, widely recognised by project development areas. The following section discusses the PDP, highlighting the visual design devices, and the IB, presenting the tool and its variations.

PDP and the project-related tools

Developing products requires planning and performing activities to obtain a satisfactory result within specific conditions of cost, time, and scope (PMI, 2017). In this sense, PDP is characterised as a sequence of phases or activities that a company employs to conceive, design, and commercialise a product (ULRICH; EPPINGER; YANG, 2020). The act of planning a project requires identifying activities to be developed, the sequence or simultaneity of these activities, the times and resources needed, the responsibility for the actions, and the beginning and conclusion of the project (BACK et al., 2008). Because of the growing demand for well-structured projects, PDP models have been organised to facilitate the planning and management of project activities. The models present a generic project structure to encourage the study, sequencing, and adaptation of a set of actions to a given project (PAHL et al., 2007).

In general, PDP models are divided into phases, including in their scope a set of activities, tools, techniques, methods, and observe the best practices applied during the project's development. Phases are composed of activities to be developed to obtain the desired result and move on to the next phase or project completion. Project activities have a similar process structure, where each one produces one or more outputs from one or more inputs, using appropriate techniques and tools (PMI, 2017). Tools and techniques are means that exist to support the realisation of PDP activities (ROZENFELD et al., 2006) being, the project team responsible for choosing and applying each of them.

Tools on PDP

Tools are objects adapted to extend human capabilities for transformation. They often take the form of a physical object (a handheld device or machine) to perform a specific action that requires superior properties - i.e., strength, skills, talent, endurance. Other times, they refer to

systems, protocols, programs - even individual people. Tools are thus defined by the context of their use (ERLHOFF; MARSHALL, 2008).

Of frequent use during the development of a project, tools are an essential part of PDP and contribute to facilitating tasks, such as modelling forms, idea conception, grouping, organisation, and distribution of relevant information. They are physical or conceptual instruments presented in tables, matrices, and resources that control inputs to obtain outputs (PAZMINO, 2015). Furthermore, each design tool should be used according to the task being worked on (BAXTER, 2011). An efficient result of a device is derived from its correct application, with appropriate procedures and practical situations to generate a result appropriate to the project's needs. In this sense, some PDP models indicate tools and methods, recommending where to apply them in the presented process and relating them to some activity (BACK et al., 2008; PAHL et al., 2007; ULRICH; EPPINGER; YANG, 2020). This structure facilitates the choice of appropriate tools for the project, saving research time. There are also publications (MARTIN; HANINGTON, 2012; MARTINELLI; MILOSEVIC, 2016; PAZMINO, 2015) that present lists of tools and methods for application in design activities without direct relation to any PDP model.

Visual tools

Visual tools are systems or sets of non-linguistic elements used to graphically make mental and emotional associations to create and communicate samples of thought (HYERLE, 2009). This tool aims to present information in an accessible way where a textual description is insufficient to give the necessary clarity to the project team at the decision-making moment. Therefore, some PDP tools are characterised by using drawings, schemas, graphic objects, drafts, or images to communicate helpful information to the project.

According to Hyerle (2009), visual tools are classified into three levels: (i) brainstorming networks that foster creativity and open-mindedness; (ii) graphic organisers used to schematise processes or facilitated analytical content; (iii) concept mappings promote cognitive development and critical thinking.

Brainstorming network-level have qualitative tools dedicated to fostering creativity (individual or group) through visual means, using mind maps, brainstorming (regular and 635), and IB. They are made up of sketches, drawings, graphic objects, or images and may be associated with text or words. Graphic organisers, on the other hand, focus on quantitative content, represented by analytical structures and process schemas. Flowcharts and diagrams are part of this level. Conceptual mapping is the level where the last two groups are integrated to generate critical design thinking.

Visual tools are mentioned in PDP models to be applied at different points. However, they are concentrated at the graphic organisers and conceptual mapping level. Ulrich, Eppinger, and Yang (2020) present storyboards and sketches as tools that use visual elements to present and analyse conceptual studies. The storyboard is described as a series of images that communicates a time sequence of actions involving the product. The sketch is a resource to present a still unfinished concept, but they do not suggest using it to compare it with each other or with other references. They also mention photos and renderings as a resource for realistic visualisation of

the sketch. Rozenfeld et al. (2006) cite the 635 brainstorming and morphological matrix methods that use illustrations and images to seek solutions by analysing the options posed. The 635 is a brainstorming application method that uses drawings and doodles rather than textual descriptions of ideas. The morphological matrix keeps some proximity with specific types of IB, but in the form of a matrix of drawings, with possible solution alternatives and value weightings. On the other hand, IB has a bias towards the solution's visual result, being a comparative effect between own and competing solutions.

Image boards as project tools

IB can be used as design tools and applied, as a support element, to decision-making processes using representative images and related to some product (ENDRISSAT; ISLAM; NOPPENEY, 2016; PEREIRA, 2010). Benefits to the project include framing the boundaries of project tasks or solutions, aligning the thinking or vision of different stakeholders, researching and resolving ideas in conflicts or contradictions, discussing at different levels of abstraction, and providing direction to guide future definitions and project development efforts (LUCERO, 2012). They are also applied at times that aim to favour semantic alignment between project team members and clients (CASSIDY, 2011). Marketing and industrial design areas often employ these boards. However, the applications can cover different project phases, covering more areas directly related to the project (GADE, 2016).

IB can be helpful at different project moments when composed of a delimited space filled with selected images (CHANG et al., 2014). At first, within the marketing area's working context, they are an important resource by visually representing the type of target market defined by the company, presenting the customers' way of life through images that show daily activities or using products compatible with this profile (PAZMINO, 2015). In the aesthetic definition process, one of the industrial design area's attributions, the boards present relevant semantic aspects through reference and aesthetic inspiration images (MCDONAGH; STORER, 2004). They are also used to present the different product concepts generated for comparative analysis and select the most attractive alternative. Finally, boards are used to present the finished concept, highlighting the set's look and forms of use or employment.

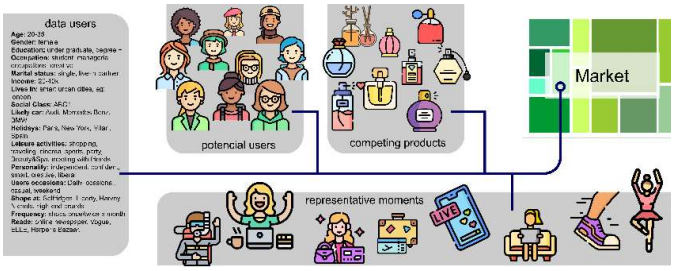
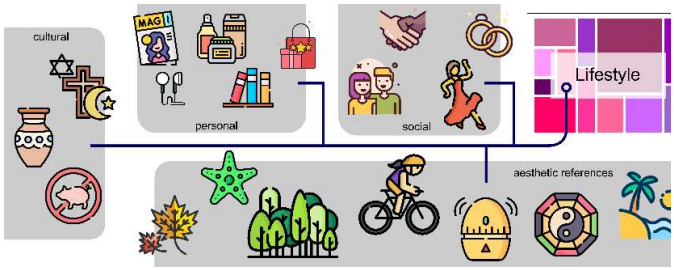
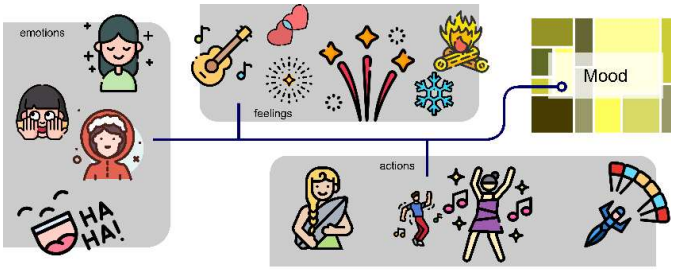
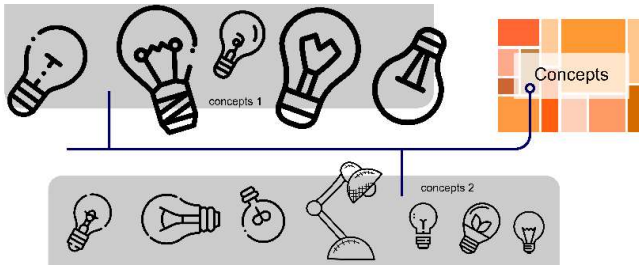
According to their typology, the specialised literature classifies IB dividing them into four categories (CASSIDY, 2008). Type 1 refers to the lifestyle and marketing boards. Boards are aimed at some unique target market and remain unchanged except by company determination or change in audience profile. They are the basis for all others. Type 2 refers to semantic, concept, style, theme, and idea boards. They focus on the experimental stages of the industrial design process and are geared towards experimentation and development of ideas, rustic or refined, generally without a specific product. Type 3, on the other hand, refers to style, theme, and manufacturing boards. They are more directed to the product, to develop initial ideas, similar to Type 2, but directed to a final product, still rustic or already refined. While Type 4 are boards of use and presentation, they are boards used to provide specific information about finished products to customers, marketing, and sales.

Subsequently to the classification into typologies, the indication of IB to be applied in the industrial design process was evidenced by Gade (2016). Thus, it is recommended to employ

marketing boards, lifestyle boards, semantic boards, concept boards, style boards, feature boards, technology boards, and presentation boards in the industrial design process. Lifestyle, concept, and presentation boards can also be presented in storyboard form.

Each IB has its distinct characteristics and objectives, although some confusion can still be seen in the images chosen for each (CASSIDY, 2008). Based on the list presented by Gade (2016), the boards are presented in Table 1 with their characteristics and a schematic process used for their composition.

Of all the boards presented, the only one to use abstract images is the semantic board. Abstract means a content that is related to meanings that exist only in the form of an idea, in semantic concepts, such as feelings (like nervous, longing, human warmth), senses (like agile, fast, robust, heat), or symbols (like religious, flags, brands). In this case, besides serving as a semantic reference, images are intended to reach a consensus about what certain concepts represent or mean. The other boards use literal media, presenting images with natural persons or objects to analyse and reference solutions for the product.

Board	Characteristics	Schematic process
Market	Identify users and products that represent specific markets. Images with potential users, at representative moments in their lives, and competing products.	
Lifestyle	Present aesthetic and personal references of a specific segment to identify the context in which they live, what they are using, wearing, and how they behave. Images with personal, social, and cultural objects from the selected segment.	
Mood	Identify emotions and feelings that can be added, implicitly or explicitly, to the product's aesthetics. Images that evoke actions, emotions, and feelings that align concepts.	
Concepts	Gather and organise the aesthetic concepts generated by the industrial design team. Images that compare, combine and experiment with different ideas and aesthetic concepts.	

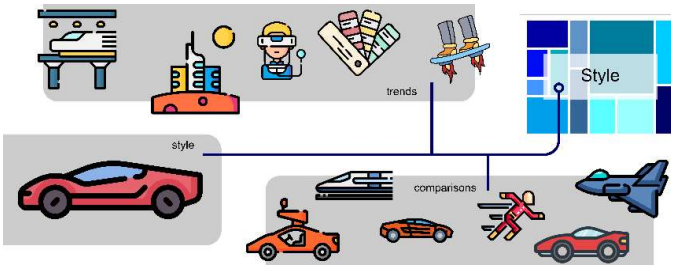
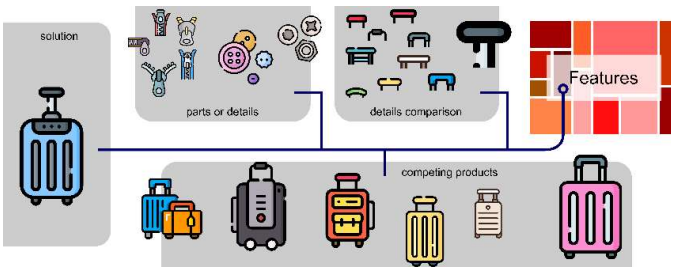
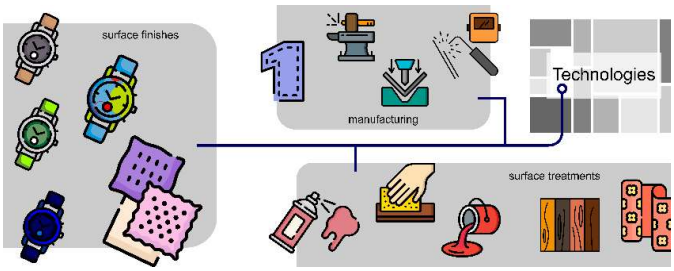
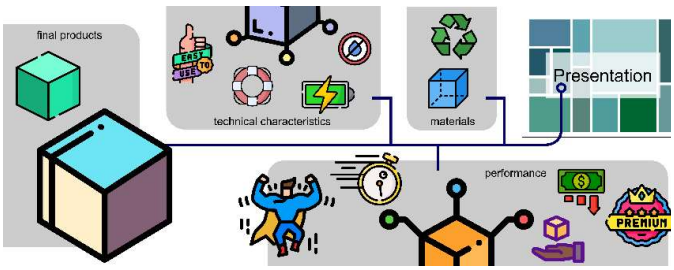
Style	Compare the proposed style with other similar proposals or objects that convey a similar style/aesthetic message to highlight their semantic proximity. Images of the final aesthetic object. Use of manufactured objects for comparison and trend study.	
Features	Perform a comparison between details of the chosen solution and the same details of competing products. Investigate features in existing products; Represent parts or details of the product.	
Technologies	Present options for surface finishes, such as colours, seams, appliqués, treatments. They contain images that show materials, roughness, and surface treatments. They may also show different manufacturing methods applied to similar parts.	
Presentation	Presenting the finished product to a specific audience. Images of the final product, with details, options, technical characteristics, performance, materials used.	

Table 1. Types of image boards, their main characteristics, and schematic process. Source: Authors (2022).

Methodological procedure

In order to identify recommended applications of IB in different PDP activities, this research was conducted in two stages (Figure 1). Quantitative surveys about the relationship between images, PDP tasks and IB were employed in both stages.

In the first stage, the participants were asked, through an electronic form with 44 questions (one for each activity), to indicate in which of them it was possible to understand that the use of images adds value to its execution, answering: yes, no or no formed opinion. Then, in the second stage, from the results collected and filtered previously, another questionnaire with 96 questions (linking the 12 selected activities with each of the 8 types of IB) was submitted to the participants. They were asked to evaluate the applicability of IB in the PDP activities, answering: yes, no or no formed opinion.

For both stages, the qualified majority was adopted as a criterion for inclusion of the results, which indicates a minimum standard of 2/3 positive indications for each question presented.

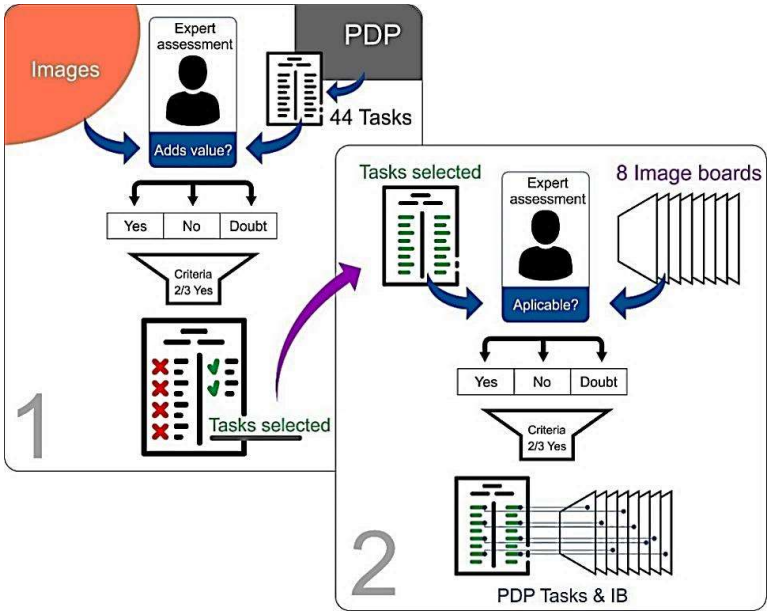


Figure 1. Research stages diagram. Source: Authors (2022).

The PDP model used in this research was the model presented by Ulrich, Eppinger, and Yang (2020), which is in its seventh edition (Table 2).

Product Development Process						
Phases	**Planning**	**Concept Development**	**System-Level Design**	**Detail Design**	**Testing and Refinement**	**Production Ramp-Up**
Tasks	•Articulate market opportunity. •Define market segments. •Consider product platform and architecture. •Assess new technologies. •Identify production constraints. •Set supply chain strategy.	•Collect customer needs. •Identify lead users. •Benchmark competitive products. •Investigate feasibility of product concepts. •Develop industrial design concepts. •Build and test experimental prototypes. •Estimate manufacturing cost. •Assess production feasibility.	•Develop plan for product options and extended product family. •Develop product architecture. •Define major sub-systems and interfaces. •Refine industrial design. •Preliminary component engineering. •Identify suppliers for key components. •Perform make-buy analysis. •Define final assembly scheme.	•Develop marketing plan. •Define part geometry. •Choose materials. •Assign tolerances. •Complete industrial design control documentation. •Define piece-part production processes. •Design tooling. •Define quality assurance processes. •Begin procurement of long-lead tooling.	•Develop promotion and launch materials. •Facilitate field testing. •Test overall performance, reliability, and durability. •Obtain regulatory approvals. •Assess environmental impact. •Implement design changes. •Facilitate supplier ramp-up. •Refine fabrication and assembly processes. •Train workforce. •Refine quality assurance processes.	•Place early production with key customers. •Evaluate early production output. •Begin full operation of production system.

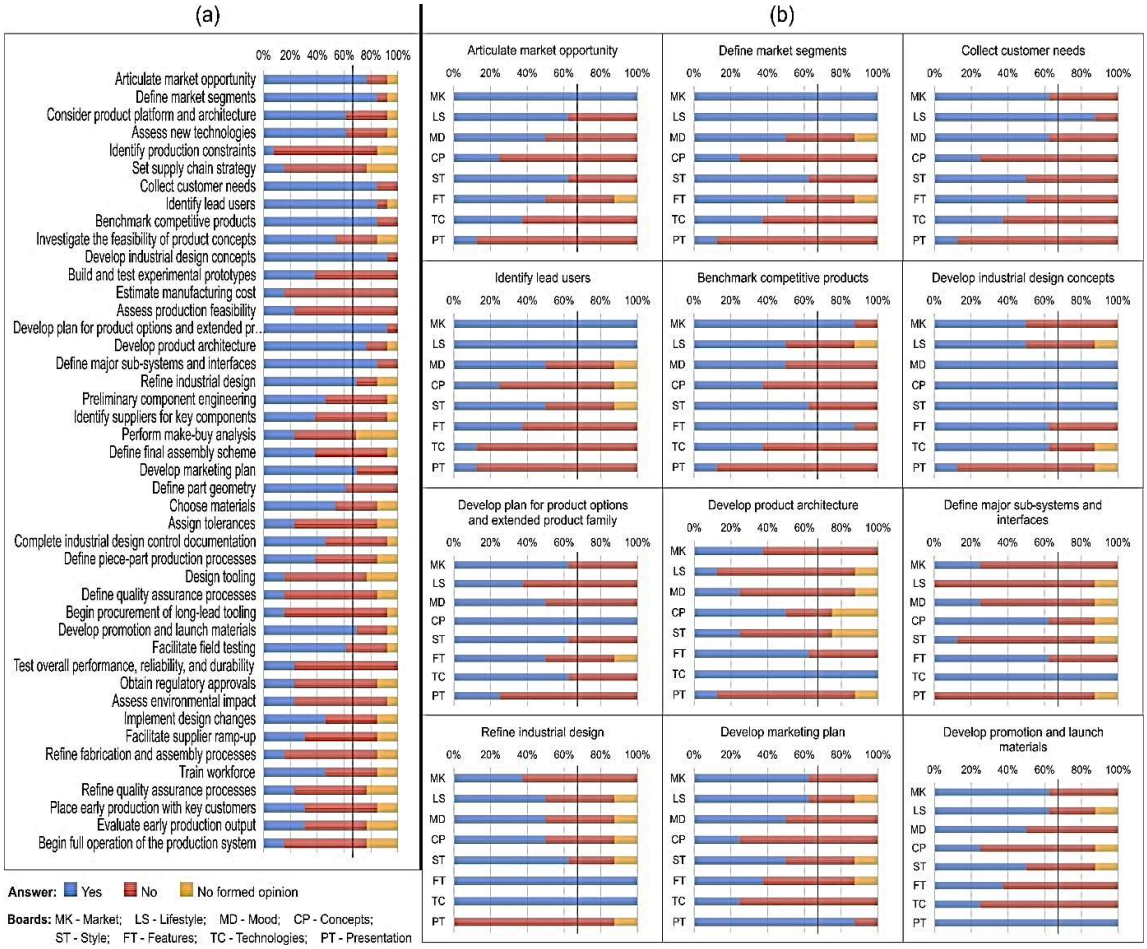
Table 2. PDP tasks from Ulrich, Eppinger, and Yang (2020) model.

Results

PDP expert professionals were interviewed for the research development (13 and 8 participants, in the first and second stages, respectively). In this sense, 61.5% of respondents work in the engineering area, and 83.3% have 10 years or more experience with disciplines and research involving the PDP structure.

In general, the images present contributions in most of the evaluated activities analysed (Figure

2). Based on the acceptance criteria adopted, in stage 1 (Figure 2a), there were 12 activities (27.3% of the total) where it was understood that images add value during their development process. At the same time, 7 of these activities (15.9%) had an approval rating of 4/5 (80%), indicating a clearer perception of the use of images in the activities. Furthermore, it is worth mentioning that 2 of these activities (develop industrial design concepts, and develop plan for product options and extended product family) had an approval higher than 90%, indicating that, for these, the use of images is understood as a positive factor by almost unanimity of the participants. In step 2 (Figure 2b), the results presented point to the associations between the PDP activities and the IBs. Applying the acceptance criterion adopted, each of the activities was associated with one or more IB (Figure 3), leaving space for the use of different IB in the same project activity. In 83.3% of the activities presented, there was unanimity of the respondents in the association with at least one IB.



Note: The vertical black line in the results bars indicates the 66.7% position.

Figure 2. Results from 2 steps research: (a) step 1 – all tasks X images; (b) step 2 – selected tasks X IB. Source: Authors (2022).

With this identified result, it was possible to understand that the application of IB can be directed to different areas, going beyond the traditional ones, marketing and design.

The results showed that the IB could contribute significantly to different activities of the PDP collaborating with visual, symbolic and semantic information that assists in decision making. Table 3 suggest the contributions that an IB can offer to the proposed PDP activity.

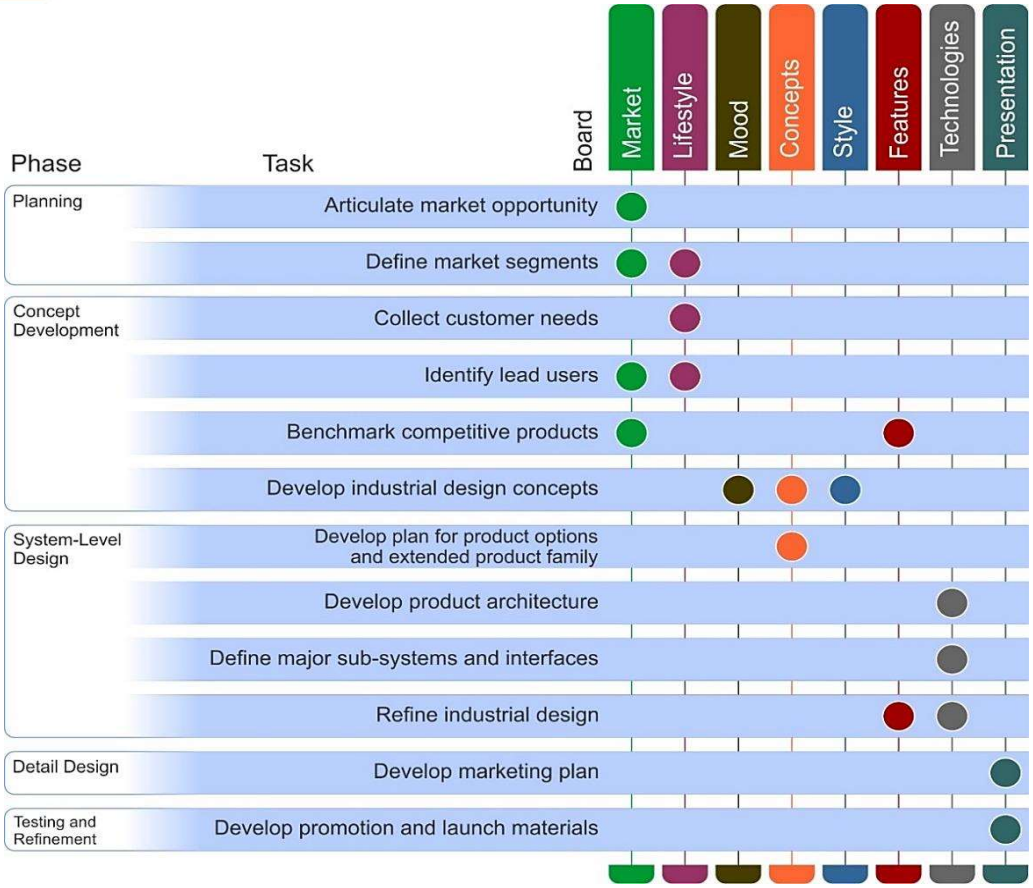


Figure 3. Associations between IB and PDP. Source: Authors (2022).

IB type	PDP activity	IB contributes with images that present…
Market	Articulate market opportunity	products that serve a market segment, including alternative solutions and services.
	Define market segments	visual and style characteristics of the possible products and their respective user profiles.
	Identify lead users	the profile and behaviour of the most significant users for the defined market segment.
	Benchmark competitive products	the essential competing products of the defined market segment with their styles, variations, derivations and forms of use.
Lifestyle	Define market segments	moments of the target audience's daily life, aesthetic and symbolic references to personal products.
	Collect customer needs	primary products, services and brands used by the defined audience profile.
	Identify lead users	personal and cultural references of lead users.
Mood	Develop industrial design concepts	emotional and sentimental references, aligning and marking out abstract elements that should be associated, followed or avoided.
Concept	Develop industrial design concepts	the conceptual studies developed by the design team, sharing ideas about the aesthetic, symbolic and functional form of the final product.
	Develop plan for product options and extended product family	studies of derivations of the main concepts (product family), with optional elements added and possible applications to encourage discussions on alternatives.

Style	Develop industrial design concepts	future aesthetic styles and trends for visual comparison and evaluation of aesthetic suitability with market projections.
Feature	Benchmark competitive products	details and technical solutions of competing products for qualitative analysis and assist in selecting or comparing solutions to the project.
	Refine industrial design	present or details of these for comparative analysis. Its purpose is to assist in selecting or comparing the solutions used in the product details under development.
Technology	Develop product architecture	different product architecture solutions (modular or specialist) to help in its structural definition.
	Define major sub-systems and interfaces	fixing elements and the effects of different manufacturing techniques favouring the choice of visually attractive solutions but associated with ease of operation (ergonomics), manufacturing processes, and maintenance.
	Refine industrial design	contributes to choosing materials and defining the final part geometry. It can present samples of surfaces, colours, finishes and surface treatments, including different versions of the product,
Presentation	Develop marketing plan	the finished product, showing details that indicate performance, options, finishes and superior technical specifications.
	Develop promotion and launch materials	the finished product and in situations of use by the target audience, highlighting functionality, ergonomics, aesthetics and symbology

Table 3. IB contribution to the PDP activities. Source: Authors (2022).

In this sense, from the simplified visualisation of the PDP proposed by Ulrich, Eppinger, and Yang (2020), the IB appear arranged in different process moments. The scientific community already widely accepted that IB has been applied in target audience study and aesthetic definition (CASSIDY, 2011). These areas were the first to incorporate images in their procedures since they work with sensory elements, and visual aesthetics is a relevant aspect of the boards.

However, since IB appears in distinct moments of a PDP, it becomes evident that beyond the most general applications, IB can also be helpful for the engineering area, complementing data and technical information with visual elements that contribute to the decision-making processes (ENDRISSAT; ISLAM; NOPPENEY, 2016; ZABOTTO et al., 2019).

Besides, IB uses have been facilitated by the digital revolution from the mid-1990s with graphic interfaces on computers, facilitating their application in multidisciplinary areas. More recently, access to image banks on the internet and cameras (including cell phones) has become widespread. The tools for selecting, treating, composing, and sharing images have made the activity of creating boards an increasingly simplified procedure. A board can now be quickly made available on different types of devices and easily shared, enabling group or individual, remote or in-person analysis, including virtual reality experiments (LUCERO, 2015; RIEUF et al., 2017).

In applying this tool, the project's benefits are the availability of visual information as additional reference points to the technical information that usually guides the project activities' decision-making processes. The images presented by a board allow a project team to quickly consult and compare the options selected for implementation in the product, aligning concepts and giving direction.

Conclusion

Based on a survey conducted with quantitative questionnaires for PDP experts, relationships between image use, IB type and PDP activities were identified. The use of images can contribute to the development of about 27% of the PDP activities listed in the research. In this sense, it becomes evident the importance of using images during the PDP activities.

Different PDP activities are associated with different types of IB. Thus, the possibility of using different IB in the same project activity was a behaviour identified.

IB can also be helpful for the engineering area, complementing quantitative data and technical information with qualitative visual elements contributing to the decision-making processes. It is applied in comparative analyses between technical profile alternatives where finishing details and ergonomics are among the characteristics to be considered.

On the other hand, it is relevant to point out IB applications in activities beyond those already developed by marketing and industrial design. It is a tool that provides support, in the form of images adequately selected and organised, to the quantitative and qualitative tools present in engineering activities. This behaviour affects how information about a project circulates among its stakeholders and reflects in its development form, increasingly supported by images that present each of the countless details that compose it. In this sense, the use of images to illustrate alternative solutions for a product, as well as aesthetic and constructive details, is a resource increasingly and better used given the easy access to image editing, presentation, and sharing applications.

The use of images may add value in developing activities and influence the decisions made. In this direction, a similar behaviour was identified in a study where the ease with which mental images come to mind and the positive affective consequences generated were shown (MAIER; DOST, 2018).

The application of IB in design areas, especially engineering, can be better studied with further experimental research to verify its effectiveness and acceptance as a support tool. The IB, bringing visual elements into engineering, can be studied in applications involving projects with different methods (e.g., Design for X) or different tools (e.g., Pugh's matrix), evaluating its contribution to each case and proposing adaptations in the use procedures.

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