



Ecodesign in project management: a missing link for the integration of sustainability in product development?



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ABSTRACT

Although ecodesign is a well-defined concept in the literature, the potential exists to increase its use and effectiveness in practice and in the company context. By searching for new approaches that could foster ecodesign application, this article explores the points of intersection between ecodesign and project management. The research approach combines a systematic literature review with a case study conducted at a consumer goods manufacturer that is recognised as a relevant benchmark in sustainability commitment and practices. The analysis of the literature reveals that project management principles are addressed in a limited manner in specialised articles on ecodesign, and no specific articles on project management were found that address issues of environmental product development and environmental sustainability. The case study indicates that environmental requirements interfere with project management, thus creating new challenges for the project teams. This study reveals that the gap identified between the two areas of knowledge can be considered as a missing link that, if filled, could enhance the effectiveness of ecodesign in the product development process. This new link would complement the current ecodesign approaches that focus on technical tools and organisational aspects by introducing original and useful guidelines for sustainable project management.

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1. Introduction

Ecodesign, which involves the application of life-cycle thinking in the product development process (PDP), should favour the development of more sustainable products (ISO, 2002). However, although this concept is already relatively mature, it has yet to be applied more widely in the corporate environment (Guelere Filho, 2009; Pigosso and Rozenfeld, 2012).

Much of the research on this subject has focused on the tools and methods aimed at environmental issues, albeit with limited success in terms of practical application in product development (Guelere Filho, 2009). Other issues addressed extensively are the challenges and strategies for integrating the environmental dimension into the PDP as a whole (Stevens, 2007).

In product development, which is defined as “the process of taking a product idea from planning to market launch and review of the product, in which business strategies, marketing considerations, research methods and design aspects are used to take a product to a point of practical use” (ISO/TR 14062, 2002), activities

are conducted at the project level with consideration that a project is “a temporary group activity designed to produce a unique product, service or result” (PMI, 2013).

Project management, another recognised area of knowledge that originated from the management discipline, has undergone significant scientific advances in the last decade (Carvalho and Rabechini, 2011). According to a broad survey and review of 200 papers conducted by Krishnan and Ulrich (2001) in the academic fields of marketing, operations management, and engineering design, project management is one of the three areas of decision determinants in product development (the other two areas are product strategy and planning and product development organisation).

Goffin (2010) insisted on the importance of project management for implementing innovations: “Turning an idea for innovation into reality is bound to be something of unique experience that must be treated as a *project*: a finite activity with its own objectives and resources, and above all its own leadership. Successful implementation of an innovation starts with good *Project Management*, nowadays properly regarded as a professional discipline in its own right” (p. 227).

Similarly, in their consolidated reference model for product development management, Rozenfeld et al. (2006) included project

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management explanations and recommendations for professionals and academics based on the internationally recognised Project Management Institute (PMI) principles and guidelines (p. 151).

Project management is defined as the application of knowledge, skills and techniques to execute projects effectively and efficiently (PMI, 2013). Specialists in this area view it as a strategic competency for organisations that could enable them to improve project results and institute values aligned with business goals. One of the most recognised frameworks, the Project Management Body of Knowledge or PMBOK (PMI, 2013), defines ten knowledge areas typical of almost all projects: Project Integration Management, Scope, Time, Cost, Quality, Human Resource, Communications, Risk, Procurement Management and Stakeholder Management. The ISO 21500:2012, a guide for project management, emphasises project competences and proposes similar categories (known as subject groups). The ISO 21500 standard is also comparable to other methods, i.e., ICB – The International Project Management Association Competence Baseline (IPMA, 2006) and Prince 2, developed by British organisations (OGC, 2009).

However, sustainability and environmental issues are not considered specifically or systematically in these existing frameworks.

Carvalho and Rabechini (2011) proposed an original initial approach to connect sustainability to both project management processes and project context, but the overall concepts do not provide guidance and solutions that are directly applicable to product development projects using ecodesign.

Building on the insight into a potential knowledge gap between ecodesign and project management, the aim of this paper is to identify the points at which these two fields of knowledge (ecodesign and project management) intersect. Based on a research approach that combines a literature review and a case study, this work attempts to determine whether the concepts and advanced practices of project management have been (or can be) applied to contribute to the effective integration of ecodesign into business processes. The case study involves a Brazilian consumer goods manufacturer whose product development activities have included an environmental dimension for several years. This research is a component of a larger research endeavour towards a more systematic and effective ecodesign integration and management framework that is applicable by companies.

This paper is divided into six sections. Section 2 describes the research methodology and details the protocol of the research strategy that combines a literature review and a case study. Sections 3 and 4 describe the research results. Sections 5 and 6 present a discussion and the conclusions, respectively, focusing on the implications of the intersection of the two concepts in the academic and corporate contexts as well as the challenges posed by effectively including the environmental dimension in project management for product development.

2. Research methods

This study explores the points of intersection between ecodesign – and project management-related knowledge via a multi-method combination of literature review and field research. According to Singhal and Singhal (2012a, b), there is an increasing interest in applying multi-methodological research in operations management.

In this study, several data collection methods were combined to achieve triangulation (Flynn et al., 1990; Voss et al., 2002). Such an approach aids in mitigating method weaknesses by combining complementary research methods.

Both research approaches, i.e., literature review and case study, were performed in an integrated manner (Bryman and Bell, 2011; Saunders et al., 2007). First, the conceptual framework was

developed as a starting point for case research (Voss et al., 2002; Carvalho, 2014) via a systematic literature review. This phase demonstrated the exploratory stage of this research field.

The literature review was performed to better explain the general constructs of ecodesign and project management and their relationships by merging bibliometrics and content analysis. Both methods are complementary (Carvalho et al., 2013). Whereas bibliometrics aid in understanding the publication patterns in the main databases, content analysis focuses in depth on the surveyed references.

Duriau et al. (2007) suggested that the value of content analysis lies in the recognition of the importance of language in human cognition. Content analysis allows analytical flexibility, but in general, it is conducted at two levels: the manifest content of the text that can be captured and revealed in a number of text statistics and the latent content and deeper meaning embodied in the text, which require additional interpretation.

Table 1 summarises the research plan, which consists of seven steps. The first stage of the research involved a systematic literature review to build the conceptual framework, and a case study was carried out in the second stage.

2.1. Literature review

The literature review consisted of four steps. First, a preliminary survey was carried out of the regulatory framework of ecodesign, which includes two documents recognised as technical references, i.e., ISO/TR 14062, (2002), and ISO 14006 (2011), to identify the presence of the project management concept in the introductory guidelines of ecodesign (step 1).

Step 2 consisted of a systematic review of the literature (Littell et al., 2008), involving a search for scientific papers published in two leading scientific databases: ISI Web of Science (<http://www.apps.webofknowledge.com>) and Scopus (<http://www.scopus.com>). The ISI Web of Science database was selected because it includes all of the journals that are considered for calculation of the impact factor by the Journal Citation Reports (JCR). Additionally, this database provides a detailed set of meta-data, which is essential for bibliometric analysis (i.e., abstracts, cited references, number of citations, authors, institutions, countries, and the journal impact factor) and is not readily available in other databases. Other databases were introduced to expand the article sample; however, the intersections among the search processes have become more extensive in each interaction (~68%), and thus, we decided to stop after the second database, i.e., Scopus, a database highly recommended for the field of ecodesign.

The search aimed to identify articles at the intersection of the two fields of knowledge of project management and ecodesign, as indicated in the introduction. The term “project management” was used in the streaming search, and multiple keywords pertaining to ecodesign were used due to the widely diverse vocabulary on this topic used in various parts of the world, namely: *eco-design*, *eco-design*, *design for environment*, *sustainable product development*, *sustainable product design*, *life-cycle design*, *life cycle design*, *green design*, *sustainable design*, *sustainable product development*, *life cycle engineering*, *design for sustainability*, and *environmentally conscious design* (ISO 14006, 2011; Pigosso and Rozenfeld, 2012).

A filter was applied to the two databases specifically to retain scientific articles, aiming to analyse the most homogeneous set of publications previously approved by a peer review system.

In step 3, based on the group of articles identified, content analysis was used to ensure that the articles addressed the central topic of the research. The topics covered in the articles were encoded to analyse their distribution and evolution (White and McCain, 1998; Prasad and Tata, 2005; Carnevali and Miguel, 2008; Carvalho et al., 2013).

Table 1
Research plan for ecodesign and project management.

| PHASES | LITERATURE REVIEW | | | | COMPANY CASE STUDY | | |
|------------------------------------|---|--|--|---|--|--|--|
| Main Steps | 1. Preliminary analysis of ISO standards | 2. Search in publication databases | 3. Content analysis | 4. Content summary | 5. Documentary analysis of PDP | 6. Preparation of a questionnaire | 7. Field research and interpretation |
| Approaches and main activities | Word search in the ISO/TR 14062 and ISO 14006 standards | ISI Web of Science and Scopus + article filtering | Encoding of articles. Identification of the main articles. | Detailed analysis of the most relevant articles. | Survey and analysis of documents and procedures | Relevant themes and questions/relevant audience. Test and adjustments. | Application of the questionnaire to various actors in PDP. Analysis and synthesis. |
| Nature of the sought-after results | Occurrences of the expression “project management” | Number of papers on the two themes and at the intersection between project management and ecodesign. Identification of articles and extraction of information. | Graphics for interpretation; Identification of the most relevant articles. | State of research on the theme. Indication of the main project management and ecodesign constructs. | Description of PDP and project management practices involving issues of the environmental impacts of products. | Semi-quantitative questionnaire aimed at evaluating the effectiveness of current approaches, difficulties and improvement potential. | Relevance of the theme in PDP. Strong points and gaps. Clues for improvement. |

According to [Duriiau et al. \(2007\)](#), content analysis encompasses coding, analysis of content (frequency counts and cross-tabulations) and interpretation of results (theoretical framework). Once the reliability of the content analysis was addressed, particular care was devoted to the coding process, primarily through the use of multiple coders.

The initial content analysis (step 3) considered the general information on the articles (journal, year, authors, keywords and abstract). From this analysis, the most relevant articles were chosen according to their alignment with the research topic, i.e., consistently addressing the two issues of ecodesign (methods and integration) and project management.

This set of the most relevant articles was studied in depth in step 4. The content analysis and summary of this group of articles considered the articles' entire argumentation and examples to systematise and summarise the contributions to the two topics covered in the research, i.e., ecodesign approaches, project management approaches and points of intersection.

2.2. Case study

The purpose of the exploratory case study was to understand how these two topics of ecodesign and project management for

product development are integrated in the company context. Therefore, the second phase of the study aimed to analyse how the environmental dimension and ecodesign are integrated into the project management practices of product development in a company as well as to identify the challenges of this integration.

This qualitative study can be defined as exploratory and inductive, seeking to identify premises that could be further developed in subsequent research. It follows recommendations for the use of case studies for the identification of constructs on the path of theory building ([Eisenhardt, 1989](#); [Voss et al., 2002](#)). The selection of the company under study was based on the criterion of the relevance of ecodesign issues in the PDP and the access of researchers to various types of evidence and to the stakeholders involved, given that access to the organisation is a key aspect ([Bryman and Bell, 2011](#)).

The case study was conducted at a large Brazilian consumer goods company that is considered as a benchmark in environmental policies and practices, in line with its strong commitment in sustainability as recognised by different types of stakeholders and international rankings and prizes. The company's main line of business is focused on personal care. This case study was based on two types of evidence: documentary analysis (step 5) followed by interviews (steps 6 and 7).

To understand the degree of implementation of the guidelines by the product development public as well as its implications, i.e., the difficulties and potential improvement in project management practices associated with ecodesign, the interviews were based on the questionnaire presented in [Appendix 1](#).

In the process of designing the research instrument, the potential advantages and disadvantages were explored of both self-administered and interviewer-administered questionnaires as well as structured, semi-structured and conversational approaches ([Saunders et al., 2007](#); [Bryman and Bell, 2011](#)). The research protocol selected was the interviewer-administered questionnaire in a semi-structured approach that mixes open-ended and closed-ended questions.

As a classical research tool applicable to the areas of operations management, particularly for studying organisational and administrative processes ([Voss et al., 2002](#); [Eisenhardt, 1989](#)), this questionnaire addresses several aspects of project management and ecodesign (i.e., knowledge areas, success criteria and consideration of environmental issues) using a set of 16 open-ended questions. To answer these questions, the interviewees were asked to choose a completed project or one that was underway.

Finally, as suggested by several authors, a pilot test of the questionnaire was carried out ([Saunders et al., 2007](#), [Bryman and Bell, 2011](#)). An assessment of the face and content validity of the research instrument was conducted with scholars and practitioners. After a pilot test of the instrument, nine quantitative questions were included in the questionnaire to aid in objective interpretation of the number of PDP phases in which environmental issues are considered and the degree of interference of environmental issues with various aspects of project management. These questions are closed and use a Likert-type scale (0 = not considered; 5 = considered extensively).

This exploratory questionnaire was administered to a sample of ten representatives of the target audience via face-to-face interviews, with the aim of reaching the main functions involved in PDP: marketing (two people), product development (two people), packaging development (two people), other areas of the project teams (two people) and process management support area (two people).

The interpretation of the case study combined quantitative data from the questionnaires (as described above) with qualitative information and selected verbatim evidence from interviews and other observations from the field, following the classical recommendations for qualitative research methods ([Eisenhardt, 1989](#)). Data were analysed using descriptive statistics for closed-ended questions.

As several authors indicate ([Eisenhardt, 1989](#); [Voss et al., 2002](#); [Saunders et al., 2007](#); [Bryman and Bell, 2011](#)), certain aspects of the case study approach could limit generalisation of the findings because the focus is on a specific organisation and its characteristics and contextual conditions.

3. Results of the literature review

3.1. Step 1: preliminary analysis of ISO standards

A preliminary textual analysis was conducted on the technical standard [ISO/TR 14062](#) ([ISO, 2002](#)), which is one of the reference documents for the definition of ecodesign as the “integration of environmental aspects into product design and development”. The document extensively addresses the management question (the word is used 60 times). Although the guide “is written for those directly involved in the process of product design and development” (p. v), it uses the word “project” only four times. Therefore, it appears that the document scarcely addresses questions related to

(product development) projects themselves. Additionally, the expression “project management” is not used in this document.

This gap is confirmed in the standard [ISO 14006](#), “Environmental management systems – Guidelines for incorporating ecodesign” ([ISO, 2011](#)), as illustrated in [Fig. 1](#).

As shown, the concept of project management is not addressed formally in these two normative documents.

3.2. Step 2: search of publication databases

The exploratory search was extended to the academic literature. [Fig. 2](#) presents the quantitative results of the numbers of items found in the two consulted databases.

The search in ISI Web of Science did not produce any article that simultaneously mentions the two expressions “project management” and “ecodesign” or any other equivalent designation, as indicated in the section research method. However, the search in the Scopus database reported 42 articles that mention the two expressions, which represents a rather small fraction of less than 0.2% of the intersection of the two topics.

Therefore, the result of this quantitative survey of articles in the two databases indicates a certain gap between the two topics and the fields of knowledge with which they are associated.

3.3. Step 3: content analysis

Selected results of the content analysis of the set of identified articles are described below.

A reading of the abstracts revealed that although the articles were identified based on these two expressions (project management and ecodesign), a large number of the 42 articles were not directly connected with the two topics. It should be kept in mind that the search in the Scopus database considered the presence of search words in the titles and keywords of the articles as well as in the abstracts, but this did not ensure that the topics were central to the articles.

The selective search based on the abstracts of the articles in this content assessment step resulted in the identification of seven

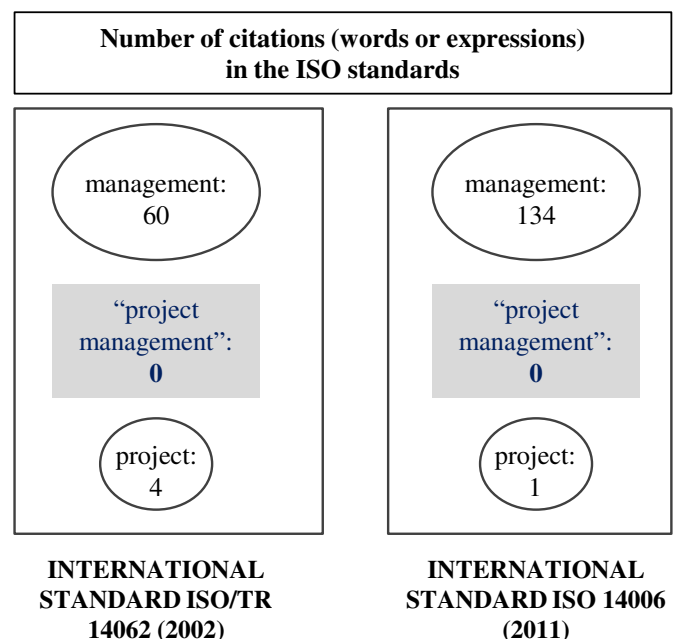


Fig. 1. Number of citations in the ISO standards related to ecodesign.

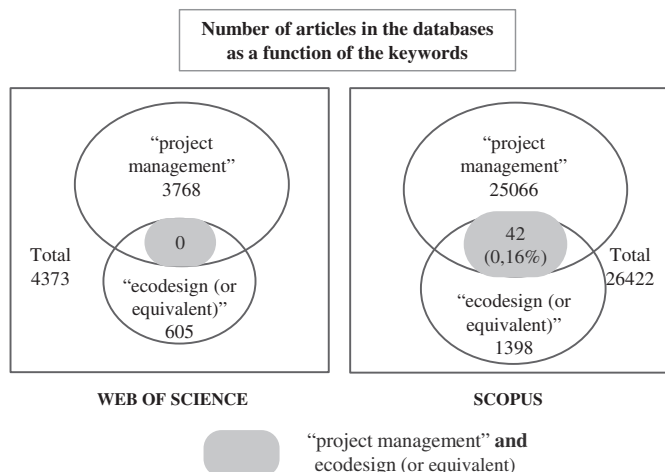


Fig. 2. Search of articles in databases (Searches carried out on 12 April 2012).

articles that actually address the research topic. The graphs below illustrate how the articles are distributed as well as the limited group of articles with the highest relevance.

Fig. 3 shows the temporal distribution of the articles, which reveals a higher incidence of publications in 2006. Among the observers of the topic sustainability, a frequent comment is that the year 2006 (which was marked by the global release of the documentary "An Inconvenient Truth" by Al Gore, former vice president of the United States) coincided with a significant increase in media coverage of the topic of climate change in world public opinion. In this series of articles, there is an apparent drop in publications in subsequent years, particularly after 2009. Similarly, in the limited group of the most relevant articles, five of the seven articles were published in 2006, and two thereafter.

Fig. 4, which classifies the publications according to the source of the articles, shows a clear distribution. Most of the articles come from 30 different journals with only one publication each from various sectors and specialties (note that none of them specialises in project management). In addition to these, only two journals include more than two occurrences, namely, *Construction Specifier*, with three publications, and the *Journal of Cleaner Production*, which contains nine publications. It is this latter journal, known as the main channel of dissemination of scientific articles on the subject of ecodesign, that is the source of six of the seven articles selected for detailed content analysis (although this criterion was not considered in the choice).

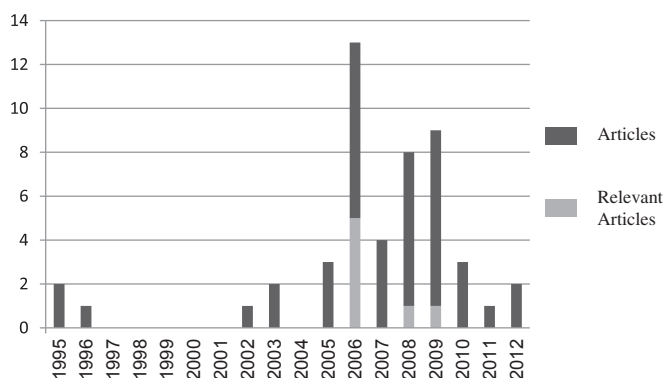


Fig. 3. Distribution of publications per year.

3.4. Step 4: content summary

For the content analysis, Table 2 summarises the main approaches and conclusions of the seven most representative articles.

The information was organised in three columns according to the topics *ecodesign approaches*, *project management approaches* and points of intersection between *ecodesign* and *project management*.

It should be noted that all of the articles contain case studies on a single company that illustrate the arguments of their authors.

In terms of ecodesign approaches, all of the articles refer to similar definitions and cite the technical standard ISO 14062 or reference publications on the subject. Moreover, the articles address the question of ecodesign tools as an important concern, which is viewed as the priority solution of needs. This finding is consistent with specific publications on the topic (Guelere Filho, 2009; Pigosso and Rozenfeld, 2012). The tools mentioned are guidelines and checklists, Life Cycle Assessment and other qualitative methods (Tingström et al., 2006; Vezzoli and Sciama, 2006; Tingström and Karlsson, 2006; Knight and Jenkins, 2009).

With respect to the above-mentioned project management approaches, it was noted that the authors address the topic in a limited manner, with few references to knowledge, key concepts and international standards. The Stage-Gate product development model is cited formally in two articles (Knight and Jenkins, 2009; Tingström et al., 2006) and indirectly in two others (Ny et al., 2008; Tingström and Karlsson, 2006). Only rare mention is made of such knowledge areas in project management as Scope, Cost, Communication, Time and Human resources. Topics such as Acquisitions, Quality and Risk are completely absent.

Finally, in analysing the approaches of the two topics, the proposals of the articles are quite restricted, generally remaining in line with the recommendations of ISO/TR 14062. This standard, as discussed at the beginning of our paper, presents only an introduction to ecodesign at a global level of the development process and does not specifically address project management issues.

In general, the articles reflect the literature on ecodesign, focus primarily on technical issues, and display little proximity to and familiarity with issues related to project management.

For the four cases reported as successful in integrating ecodesign with product development processes, the following comments are relevant:

- The most advanced and complete case of ecodesign integration (Tingström and Karlsson, 2006) does not provide concrete evidence of this situation, particularly with respect to project management practices.
- Three cases correspond more closely to pilot projects conducted by external experts (Knight and Jenkins, 2009; Vezzoli and Sciama, 2006; Tingström and Karlsson, 2006) but do not report true integration replicated by development teams and their practices.

The case reported by Ny et al. (2008) primarily addresses a strategic approach aimed at pre-development with a method for senior management sensitisation and mobilisation and possible implications for portfolio management, which are not described. The same gap has been noted in the Technology Roadmapping (TRM) literature (Carvalho et al., 2013).

This synthesis shows that few aspects of project management were addressed in these articles, although these were the only articles found in the literature search that mentioned the topic of project management together with ecodesign (or equivalent) in the abstract.

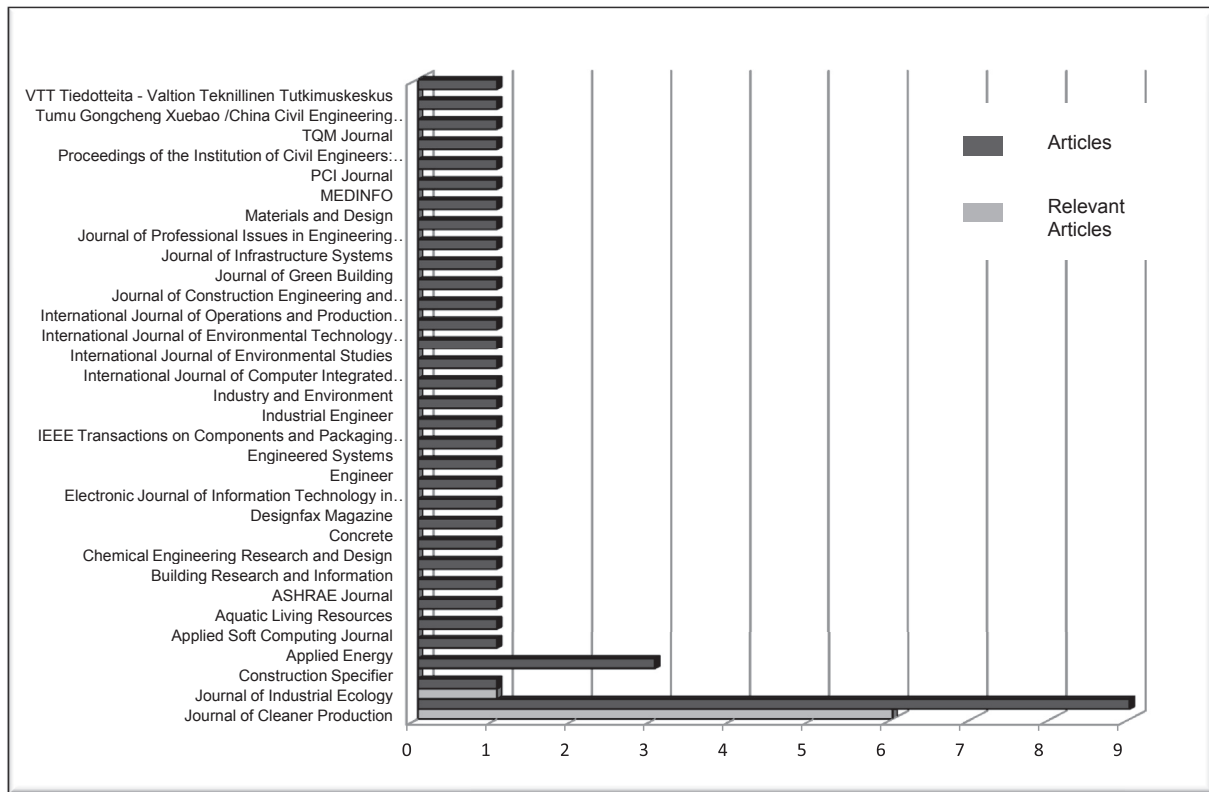


Fig. 4. Distribution of publications by journal.

The results of this systematic literature search in and review of article databases can be compared with the general recommendations and best practices found in reference publications on ecodesign. Such classical documents generally insist on ecodesign tools and PDP management as a whole (ISO, 2002; ISO, 2011; Brezet and Van Hemel, 1997; Charter and Tischner, 2001; Fiksel, 2001; Stevels, 2007).

These books and standards address the integration of environmental considerations in product development and often refer to recognised best practices of innovation management, i.e., the Stage-Gate process (Cooper, 2008). However, these materials do not approach the specific question of project management, as also verified in the exploratory textual search described in step 1.

Furthermore, in parallel to this research on ecodesign and project management, a wider review was carried out in our laboratory on the scope of Sustainability and project management (Martens et al., 2013). We found that the subject of Environmental sustainability is infrequently addressed in the literature on project management. Few reviewed articles and examples of applications were found, primarily in the specific sector of civil construction projects (Robichaud and Anantamula, 2011). The convergences and differences will be further commented in the discussion section.

In this context, a case study exploring the relationship between ecodesign and project management can be considered as a new approach to the area of ecodesign management.

4. Results of the case study

The case study involved a Brazilian manufacturer of consumer products that is one of the leaders in its area of action in the Brazilian market. This company is known for its leading role in sustainability issues in Brazil and for considering environmental issues

in its product development activities for several years. Founded in the late 1960s, the company has shown significant growth over four decades. In recent years, the company has sought to shift to a more process-oriented management style, which it formally adopted in 2008. As a result, the company analysed and formalised its core business processes, including the product development process.

This process, which the company revised in 2010 and which it refers to as a “product funnel”, is briefly described based on the available documents that outline the internal guidelines. More specifically, an analysis is carried out of how the company considers the dimension of environmental sustainability and its connections with the guidelines for project management.

4.1. Environmental dimension in the product development process (PDP)

The case study begins with the investigation of the company documents related to the PDP (step 5).

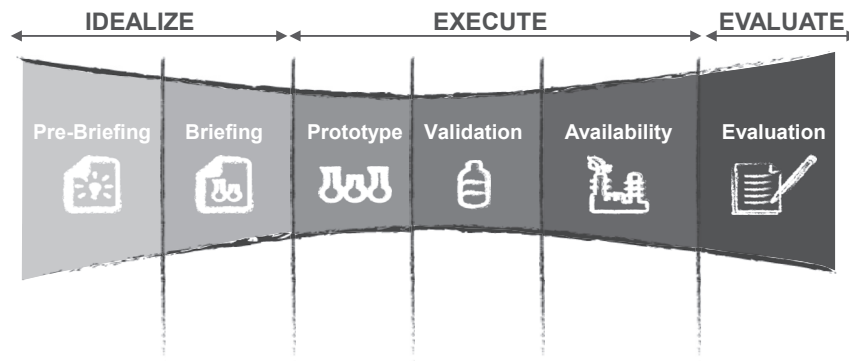
The company's PDP structure, known internally as the “product funnel,” is illustrated in Fig. 5. The structure consists of three macro-phases (Idealize, Execute and Evaluate), which in turn are subdivided into six phases (Pre-Briefing, Briefing, Prototype, Validation, Availability and Evaluation), similar to the divisions and classical terminology in the context of consumer products (Rozenfeld et al., 2006). There are certain similarities between Fig. 5 and the processes of ISO 9004:2009, although the precise origin of this figure was not informed by the company.

The main company supporting documents for this process consists of responsibility matrices and lists of requirements per phase.

The responsibility matrices describe the main duties of the various participants of the project (or project team) throughout the phases of the funnel. Within the company, the project teams are led by members of the marketing teams, who assume a dual role in

Table 2
Cross-reference analysis of articles on ecodesign and project management.

| Article | Case presented | Ecodesign approach | Project management approach | Ecodesign and project management |
|--------------------------------|--|---|--|--|
| Knight and Jenkins, 2009. | Manufacturer of gas and vapour detection equipment | Barriers: Lack of tools and pressures in PDP. Techniques: Checklists, guidelines, and MET matrix (material, energy and toxicity). Adoption of ecodesign depends on identifying the right tools (usable and useful). | Stage-Gate PDP. Internal public skeptical of change in PDP. Pressures occur during the PDP, so the staff must make efficient use of available time . | Ecodesign “thinking and analysis” requires several suitable methods and their application to each of the different PDP phases . Pilot project and creation of customised tools . Full integration represents a future challenge. |
| Ny et al., 2008. | Matsushita Group, Japanese multinational manufacturers of electronic products | General method for sustainable product development (MSPD) of the NGO The Natural Step: <ul style="list-style-type: none"> • Provides basic knowledge on sustainability/systemic perspectives and life cycle and product development methodology; • Provides a strategic approach for the development of sustainable products; • Helps prioritise in the short and medium term. | The TSPD can be used in the initial phases of the PDP to create a vision of the current situation and future options to shift product categories toward sustainability. General conclusions applicable to more detailed phases of the concurrent engineering process cannot be reached because they involve rather specific aspects for each development project. | Main challenges of sustainability and opportunities for a product category in the early stages of development . Facilitated communication and commitment of top management to support sustainability efforts in product development. |
| Tingström et al., 2006. | ABB, a large Swedish company in energy and automation technology (B to B). | Associated qualitative tables (TSPD). Developers require information, support by specialists, and checklists to integrate environmental issues throughout the process. The “ Sustainability Tool Site ” on the intranet: Lists of restricted materials, LCA, and Environmental product Declarations (EPD) to assist in product development and management processes. Guidelines and checklists , essential and effective tools for development processes. Guidelines should inspire and indicate solutions that have the highest potential for environmental sustainability. The guidelines must be evaluated on a case-by-case basis. | Product development as an interdisciplinary activity; Stage-Gate model with a clear focus on evaluation of the project as it passes through its phases. Top management is involved in decision-making in these Gates. | Interviews revealed a common understanding of the meaning and content of this methodology. <i>A sample result is shown in a project but without evidence of integration and use.</i> |
| Vezzoli and Sciamma, 2006. | Necta Vending Solutions, Europe's leading manufacturer of food and beverage machines | Guidelines and checklists, essential and effective tools for development processes. Guidelines should inspire and indicate solutions that have the highest potential for environmental sustainability. The guidelines must be evaluated on a case-by-case basis. | Guidelines are procedures to guide the decision-making process according to the objectives considered. In ecodesign, the decision-making process is related to design activities, from briefing to conceptualisation and development. <i>PDP is not described; the term “project management” is not used.</i> | Checklist created as an operational tool to integrate the guidelines as a mandatory step of the PDP . Quite positive feedback on the method used by the company, but it is rarely adhered to by those responsible at Necta. After the initial project , a second project with another typology was hired for consulting. |
| Tingström and Karlsson, 2006. | International Swedish company Volvo Wheel Loaders AB/automotive equipment | Methods: LCA and EEA (environmental effect analysis/qualitative method) in three combinations . Explanation of difficulties encountered: Environmental assessment tools are analytical , while development is synthetic and multidimensional . | To incorporate environmental considerations into PDP, specify the relevant environmental information in the form of documents and other forms of project information. <i>Discusses little and mentions “project management” only once.</i> | A key to real transformations of design practices is to bring up environmental issues for discussion by product development teams . |
| Zwolinski et al., 2006. | | REPRO2 tool for remanufacturing restrictions in development; <i>A highly technical and specific approach.</i> | <i>Does not address aspects of project management. The expression “project management” is not used.</i> | <i>Not addressed.</i> |
| Johansson and Magnusson, 2006. | B To B Communications product development, with environmental requirements. | Despite the large number of tools , environmental considerations are not a component of the product development practice. Ecodesign research should expand its technical and regulatory guidelines to include managerial and organisational aspects . | Limited knowledge of organisational aspects related to environmental issues in product development. Originality: Approach at the project level . Focus on how the project was organised , with the introduction of a specific “Green” sub-project . <i>Project management only of organisational issues.</i> | Mobilising effect and channels of communication. Risk of confusion as to who is responsible for compliance with environmental requirements. A platform that fosters networking among environmental experts and the organisation of product development. |



Approval requirements are divided into:



Fig. 5. The “product funnel” representation of the company's PDP.

most projects. Only a few strategic projects have a dedicated project manager allocated to them who is separate from the marketing manager.

The lists of requirements per phase describe the activities to be performed and the deliverables required for approval in the gates or phase passages.

According to the representative of the area of process management, this PDP was inspired by the creation and revision of knowledge on project management from the Project Management Institute (PMI), in order to incorporate best practices of project management. However, these best practices are not described explicitly in the PDP documents (during the period when the interviews were being held, the company began to improve its organisation via creation of a Project Management Office to support the development projects, formalise its project management practices, and provide user training).

The company's funnel and project guidelines contain orientations that primarily focus on the classical dimensions of project management: scope and product specification and performance, cost and financial performance, and timing.

The guidelines also formally include a topic that relates to the product's environmental impact, beginning in the briefing phase. The area responsible for analysing this topic is marketing, with representatives from the areas of product development and packaging development playing a “supporting role.”

A specific company document known as “guidelines for product launches” establishes “guidelines for approval of stages in the product funnel based on equivalent carbon emissions.” This indicator is obtained by means of an internal tool, i.e., the environmental calculator, which was developed via LCA (Life Cycle Assessment) methodologies and is used by employees in the areas of product and packaging development. These guidelines imply the need for a new product to have a carbon footprint that is smaller than or equal to a reference product, and the definition of this reference is highly important for comparisons. The document precisely defines the references for each type of project (product improvement, product line extension, new category or brand).

4.2. Analysis of the questionnaires

The last two steps (6 and 7) of the research plan involve an analysis of the interviews and tabulation of the questionnaires.

The answers to the initial questions indicated that the interviewees have a good understanding of the environmental impacts of the products and project management.

Thus, most of the interviewees linked environmental impacts to the concept of product life-cycle and spontaneously mentioned their considerations of the various stages of the production chain. However, the interviewees admitted that in the company context, the main focus is on the carbon footprint, which is used as the main indicator of the environmental performance of the company's projects.

Similarly, the concept of ecodesign is relatively well understood, although the term is rarely employed in the company's day-to-day operations:

“Product design aimed at reducing environmental impacts, with the same value proposition.” (Marketing coordinator)

All of the interviewees showed a correct and full understanding of project management issues because they are members of the development teams or project leaders. Moreover, four of the ten interviewees reported that they obtained training in project management, citing the guidebook Project Management Body of Knowledge – PMBOK (PMI, 2013).

The projects chosen by interviewees for comment (eight different projects in all) were of various archetypes or categories used in the company, but this parameter seems little related to variations in the responses. However, the attributes of the sub-brands of the products seem to have a certain amount of influence on the teams' involvement in environmental issues:

“Some sub-brands raise this [environmental] concern more strongly.” (PDP management coordinator)

The main results are summarised in Table 3, which describes the quantitative data and lists interpretive comments. In addition to the average of the results of the ten interviewees, the average results of projects linked to sub-brands with or without environmental appeal were also calculated.

Table 3 indicates that environmental issues are considered in virtually all of the phases of sub-brand projects with environmental appeal, either due to the need to meet the requirements in the funnel or to internal interest in the project:

Table 3

Summary of the findings obtained from the questionnaire at the company.

| Questions | Mean SB+ | Mean SB– | Mean | Standard deviation | Comments |
|--|----------|----------|------|--------------------|--|
| Years of experience in the company | 5.7 | 4.0 | 5.4 | 3.7 | |
| In how many phases of the product funnel do you consider environmental issues? | 5.7 | 4.5 | 5.5 | 1.0 | There is near consensus on the consideration of environmental issues in all the phases |
| Are environmental criteria considered in the project's scope and success criteria ? | 4.3 | 4.0 | 4.2 | 0.6 | This aspect of project management is more closely related to the environmental dimension |
| Are environmental issues considered in decisions pertaining to the product's supply chain? | 2.4 | 0.0 | 1.9 | 1.4 | This aspect of project management is less related to the environmental dimension and is not considered in incremental projects |
| Are environmental issues considered in the decisions concerning the technologies chosen or developed for the product? | 3.6 | 3.5 | 3.6 | 0.5 | There is a strong relationship |
| Do environmental issues affect quality issues throughout the project? | 3.4 | 0.0 | 2.7 | 1.9 | An intermediate relationship; strong in projects with environmental appeal |
| Do environmental issues affect cost issues throughout the project? | 3.7 | 1.0 | 3.2 | 1.4 | An intermediate relationship; strong in projects with environmental appeal |
| Do environmental issues affect deadlines throughout the project? | 2.4 | 0.5 | 2.1 | 1.6 | An intermediate to low relationship; stronger in projects with environmental appeal |
| Do environmental issues affect risk issues throughout the project? | 2.9 | 1.0 | 2.4 | 1.4 | An intermediate to low relationship; stronger in projects with environmental appeal |
| Do environmental issues affect aspects of communication and human resources throughout the project? | 3.4 | 0.0 | 2.7 | 1.5 | An intermediate relationship; strong in projects with environmental appeal |

Caption: SB+: sub-brand project with environmental appeal; SB–: sub-brand project without environmental appeal; Likert scales 0–5, except for the first 2 questions.

[Consideration of the] “*Environmental Impact is a requirement; we seek solutions to meet the requisite of not increasing the environmental impact, per product family, per year.*” (Marketing coordinator)

“*The motivation came from the sponsor, starting in the pre-briefing phase; the project was created with the need for sustainability; it sought lower environmental impact, which was a success criterion.*” (Engineering manager)

This finding is consistent with the documents of the PDP requirements in which environmental standards are still optional in the pre-briefing phase. Thus, for the projects related to a sub-brand with higher sustainability concerns, the project teams consider environmental issues starting at the beginning of projects, i.e., in the pre-briefing phase.

Additionally, the dimension of “project scope/success criteria” consistently appears as the one most connected to environmental issues.

“*[The project's sub-brand] has a sustainability flag, so it incorporated environmental deliverables, seeking to be at the forefront in aspects of design with less environmental impact.*” (O&L coordinator)

Next, the dimension “technology” is the topic that implies a stronger consideration of environmental issues:

“*The main challenge of the project is to render feasible the technology of the use of recycled (material) at the industrial level.*” (Packaging development researcher)

However, environmental issues were also strongly related with the other dimensions of project management in the case of projects with environmental appeal, particularly with Cost, Human Resources, Quality, Deadlines and Risks:

“*Environmental issues have created differences; nobody wanted to take responsibility. It required much more work time, efforts and perseverance, and new competencies; we had to carry out*

additional environmental impact studies with a consultant. There is insufficient knowledge and training even in the R&D area that participates in the team.” (Packaging development researcher)

“*The schedule was set up to address multiple challenges considering environmental issues, which entailed a longer duration.*” (Packaging development researcher)

“*Recycled material technology entails a risk, and solutions were sought to mitigate the risk.*” (Packaging development researcher)

“*With high environmental goals, there is a risk they will not be met; this was discussed by the team.*” (Packaging development researcher)

Various difficulties in and suggestions to improve the way in which environmental issues are addressed in project management were also expressed. These comments reflected not only awareness that the supply chain as a whole is insufficiently considered but also the need for greater integration of the various knowledge areas:

“*There are several challenges for a more complete vision expanded to the various dimensions; to establish the supply chain more firmly, and the issue of trade-off among the various dimensions, and to integrate everything.*” (PDP management coordinator)

“*The teams have too little understanding about environmental impacts to have any greater concern.*” (Formula development researcher)

“*The teams engage in extensive but inconclusive discussions. They would need to be able to make more holistic decisions.*” (Engineering manager)

5. Discussion of the results

A systematic literature review revealed that the publications found in two of the main databases of scientific articles are notably limited in the number of papers on the topic of ecodesign and project management (42 articles, only seven of which are more

consistently linked to both topics). These papers originate from a restricted group of research on ecodesign, published primarily in a specialised journal, the *Journal of Cleaner Production*, in 2006 and subsequent years.

The set of seven articles analysed in detail primarily covers “classical” topics in ecodesign literature, i.e., the choice and adaptation of tools aimed at issues of the environmental impacts of products (guidelines, environmental assessment methods such as LCA, and qualitative methods), and more generally, the introduction of environmental considerations in the development process. The approaches reported in these papers are quite consistent with the general recommendations and best practices found in other reference publications on ecodesign, (ISO, 2002; ISO, 2011; Brezet and Van Hemel, 1997; Charter and Tischner, 2001).

In the few articles we identified, project management issues and knowledge with a focus on the feasibility and effectiveness of ecodesign were reported only quite superficially; in fact, even if the expression is used, the principles or issues of project management (i.e., project Integration management, Scope, Time, Cost, Quality, Human Resource, Communications, Risk and Procurement management) were not specifically addressed. Furthermore, the environmental and technical aspects that are classically considered in ecodesign tools and practices refer only to the Scope dimension of project management, but more detailed organisational considerations and practices at the project level were not found in these publications on ecodesign.

However, more advanced knowledge of project management has not resulted in scientific articles on the topic of environmental sustainability in product development projects, thus characterising a potential knowledge and application gap (Martens et al., 2013).

Although the literature review revealed little material on the topic of project management insofar as it pertains to ecodesign, the case study conducted in this work sought to explore the relevance of the intersection of the two fields of knowledge because the absence of previous studies or publications on a new area does not mean that the topic would be meaningful and pertinent.

In the context of a company that shows a fairly high maturity relative to considerations of environmental criteria in its PDP, this study indicates that environmental issues may affect not only technical issues but also the main dimensions or knowledge areas of project management as they pertain to the Project Management Body of Knowledge (PMI, 2013).

The interviewees showed a good understanding of the two topics and the ability to answer general and specific questions.

The company's efforts to integrate environmental sustainability in its PDP over recent years are reflected not only in the process via environmental requirements that are known and applied in almost all phases of the funnel but also in the various dimensions of the projects and their management, particularly in projects in which this environmental dimension provides a differential advantage in marketing (linked to the most involved sub-brands).

However, this integration continues to pose a challenge for the teams, for project management and for the process as a whole:

“We are still little prepared to incorporate ecodesign in our day-to-day routines; there is a gap between strategy and implementation / execution, where the deadlines are too short.” (Marketing coordinator)

Several relevant suggestions for improvement were identified that can be addressed by the company in the future with the support of the teams involved in Sustainable Technologies and PDP management.

The most critical aspects for integrating environmental issues into the discipline of project management (where the company

showed the largest gap) appear to involve decisions concerning the product supply chain, the quality throughout the project, timing issues and risk-related issues throughout the project.

However, this exploratory research does not allow for conjectures as to whether these dimensions of project management (i.e., term, risks, and supply chain) can potentially incorporate or interfere with the environmental dimension. The fact that this relationship was not observed in the context of this company does not rule out its potential relevance in another context.

At the same time, the findings of this study led us to propose that an intermediate approach systematised at the project management level could strongly complement classical ecodesign guidelines and practices and significantly strengthen their effectiveness, as illustrated in Fig. 6.

This proposition is aligned with and goes beyond the best practices of ecodesign management exposed in the reference book from Charter and Tischner (2001, p. 229):

“There will be various stages to the product development process, and the environmental considerations should be integrated at each stage or ‘gate’. The difficulty is balancing and prioritising the importance of environmental considerations against other factors, such as cost, quality and performance.”

Similarly, in the same edition, Fiksel (2001, p. 185) exposes the same type of statement:

“An ecodesign organisation must incorporate sustainability awareness systematically into the daily work of development teams. This is a logical extension of the modern practice of integrated product development (IPD) whereby cross-functional teams begin at the conceptual design stage to consider life cycle issues, including quality, manufacturability, reliability, maintainability, environment and safety. For example, many companies use a ‘stage-gate’ process, requiring that a product satisfy a variety of performance criteria before passing on to the next stage of development.”

This material, as reflected in the literature review and Stevels' views (2007, 2012), also details the technical and tool issues as well as global PDP integration issues but does not mention the possible necessity of stretching ecodesign into the scope of project management.

Our finding and proposition is quite consistent with other general recommendations for “good innovation management”, as stated by Goffin and Mitchell (2010, p. 26): “Innovation management often requires managers to match ‘technical’ expertise, in areas such as technology, project management and finance, with ‘soft’ skills in managing people and creativity”. However, when Goffin (2012) recently discussed sustainability in product development, although he recognised that “organisations need to make significant modifications to NPD processes to achieve sustainable innovation”, he still focused on recommendations at the PDP level based on a Stage-Gate model and did not mention project management implications.

In addition, it should be noted that project management issues extend beyond the direct framework of projects to the dimensions of portfolio management and innovation strategy and are directly linked to the effectiveness of sustainable innovation, as commented by an interviewee in the company:

“Portfolio and sales mix strongly influence the requirements; our vision is slightly nearsighted; more innovation is needed to reduce environmental impacts.” (marketing coordinator).

In Fig. 6, initial dimensions of project management are proposed that could foster ecodesign application, i.e., Integration (in the meaning used in the PMBOK), Success factor and tradeoffs, and Teamwork, which reflect certain important aspects of project management for which environmental considerations could be

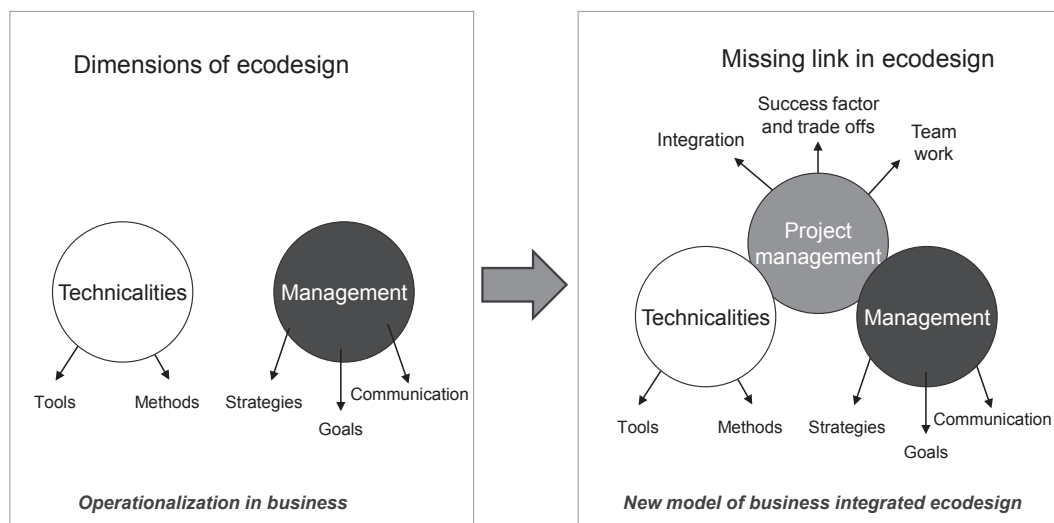


Fig. 6. The potential role of project management in ecodesign. (Figure on the left is from [Stevens, 2012](#)).

systematically included in concert with comments collected in the interviews.

In other words, it can be observed that the management of projects aimed at more sustainable products or services should include new principles that are not embedded in current project management best practices that traditionally ignore environmental sustainability. This new practice would generalise what certain authors have already proposed in the more advanced green building development sector, the existence of barriers in current project management principle that prevent “the ability to deliver a green project within acceptable cost constraints” ([Robichaud and Anantatmula, 2011](#)). New project management principles should be brought in, e.g., the participation of a wider range of stakeholders in the early stage of the development projects may bring new practices that remodel the projects as a whole, such as the so-called “Charette Procedure” (collaborative multi-stakeholder session) found in the construction sector.

Thus, this proposition of considering project management adaptation as a necessary link in the effectiveness of ecodesign offers a promising opportunity and a challenge for future research in sustainability management in the continuation of the investigations presented here.

We propose that this “knowledge gap” can be transformed into a real “link” between the “Technicalities” level and the “Management” or PDP level of ecodesign that generally follows a Stage-Gate model in companies ([Goffin and Mitchell, 2010](#); [Katz, 2011](#)), as described briefly in the case study in Section 4 and Fig. 5. This observation is in good agreement with the principles of innovation management as exposed by [Cooper \(2008, p. 217\)](#): “Stage-Gate is a macroprocess – an overarching process. By contrast, project management is a microprocess. Stage-Gate is not a substitute for sound project management methods. Rather, Stage-Gate and project management are used together. Specifically, project management methods are applied within the stages of the Stage-Gate process”.

6. Conclusions

Reinforcing the argumentation drawn in Section 3, our analysis of the literature indicated that project management concepts and practices applied to the context of considering environmental sustainability in product development (ecodesign) have been reported only incipiently in scientific papers.

Because the reference documents on project management (i.e., those of the PMI) have yet to address sustainability issues in detail, it can be concluded that a gap exists between the two areas of knowledge discussed in this work, i.e., project management and ecodesign.

However, the case study presented in Section 4 showed that a deepening of the relationships between the environmental dimension and project management provides relevant indications of the challenges faced by innovation project teams.

Considering that one of the main objectives of ecodesign research is to identify solutions to increase the effectiveness of the integration of ecodesign in PDP and that this is also the expectation of companies involved in the topic, this knowledge gap may open up promising perspectives for the construction of knowledge and practical recommendations and guidelines for ecodesign management at the project level.

This view arose from a different route than the main research and practices observed in ecodesign, which have focused primarily on technical aspects and tools and secondarily on certain issues related to company strategy and management, e.g., as described in the ISO standards.

This study therefore puts forward a new proposition that the integration of the environmental dimension into the project management of new products could increase the effectiveness of ecodesign applied in companies. Such a view can be treated as quite new in the field of ecodesign literature, although it is completely coherent with good innovation management practices and was confirmed by the exploratory case study.

Thus, the inclusion of the original project management guidelines that consider environmental sustainability issues could aid in increasing the effectiveness of ecodesign integration and implementation for project managers and team members. The lack of such specific guidelines can be presumed as a limiting factor for projects and companies that attempt to consider environmental aspects as a performance factor expected for their activities.

However, the limitation of this study is its solely exploratory and qualitative nature. Although it applied a systematic search in large databases, the literature review led to a notably small sample of papers. Additionally, the case study was conducted in a point-wise manner and involved a single company, which limits its generalisability as recognised by experts, and the qualitative interpretations of the content analyses of the articles and the questionnaires involve a certain degree of subjectivity.

For a more in-depth consolidation, this preliminary study may be extended to several applications by replication in various companies in future. Such additional research would be helpful to explore and define the relevant variables for ecodesign-oriented project management and to attempt to visualise how such an extended project management approach could improve the environmental performance of product development.

Nonetheless, the knowledge gap and the associated new insight presented in this article can be acknowledged as a relevant though modest contribution to the construction of a broader framework for the full integration of ecodesign in new product development. Investigation into this topic will be continued and integrated in a wider diagnosis and review of ecodesign implementation challenges and models and will be associated with an Action Research program in the search for greater effectiveness of such all-inclusive integration and a better understanding of associated success factors.

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Appendix 1. Questionnaire

Questionnaire for interviews on project management and ecodesign

Date of the interview

Name

Position

Area

Years of experience in the company

0.0 This questionnaire addresses environmental issues and project management in the product Funnel.

What do you understand from the following terms: environmental impact of products? ecodesign?

0.1 What do you understand from the term project management?

1 In your current work context in the company, are you involved in issues related to environmental impact in product development and/or ecodesign? How?

2 In your current work context in the company, are you involved in issues related to project management for product development? How?

3 In what phase(s) of the project Funnel do you consider environmental issues? Indicate a number and offer a comment.

0 = None; 6 = All

Next, choose a specific project that has been completed or is ongoing.

4 What is the name of the project?

What category of archetype?

Has it been completed or is it ongoing?

5 Are environmental criteria considered in the scope and success of the project? How? What is the source of this (eventual) interest (e.g., sponsor)? Give examples.

0 = Not considered; 5 = Strongly considered (*this scale is used in questions 5 to 12*).

6 Are environmental criteria considered in the decisions concerning the product's supply chain (e.g., raw materials,

suppliers and third parties, transport, etc.)? How? Give examples.

7 Are environmental criteria considered in the decisions pertaining to technologies chosen or developed for the product (e.g., transformation of raw materials, formulation, packaging design, industrial process, etc.)? How? Give examples.

8 Do environmental issues interfere with quality issues throughout the project? How? Give examples.

9 Do environmental issues interfere with cost issues throughout the project? How? Give examples.

10 Do environmental issues interfere with term-related issues throughout the project? How? Give examples.

11 Do environmental issues interfere with risk-related issues throughout the project? How? Give examples.

12 Do environmental issues interfere with aspects of communication and human resources along the project (e.g., competencies, teamwork)? How? Give examples.

13 Are there any difficulties or needs for improvement to better address environmental issues in the management of the project? What are they?

14 Can you offer any suggestions for improvements in the way environmental issues are addressed in the management of the project? What are they?

References

- Brezet, H., Van Hemel, C., 1997. a promising approach to sustainable production and consumption, UNEP. United Nations Environment Programme. Industry And Environment (Paris), Rathenau Instituut (The Hague), Delft University Of Technology (Delft) ecodesign.
- Bryman, B., Bell, E., 2011. Business Research Methods, third ed. Oxford. University Press, Oxford.
- Carnevali, J.A., Miguel, P.A.C., 2008. Review, analysis and classification of the literature on QFD-Types of research, difficulties and benefits. *Int. J. Prod. Econ.* 114, 737–754.
- Carvalho, M.M., 2014. An investigation of the role of communication in IT projects. *Int. J. Oper. Prod. Manag.* 34 (1), 36–64.
- Carvalho, M.M., Rabechini Junior, R., 2011. Fundamentos em Gestão de Projetos: Construindo Competências para Gerenciar Projetos (Foundations in Project Management: Building Skills for Managing projects), third ed. Atlas, São Paulo.
- Carvalho, M.M., Fleury, A., Lopes, A.P., 2013. An overview of the literature on technology roadmapping (TRM): contributions and trends. *Technol. Forecast. Soc. Chang.* 80, 1418–1437.
- Charter, M., Tischner, U., 2001. Sustainable Solutions, Developing Products and Services for the Future. Greenleaf Publishing, Sheffield.
- Cooper, R.G., 2008. Perspective: the Stage-Gates idea-to-launch process – update, what's new, and NexGen systems. *J. Prod. Innov. Manag.* 25, 213–232.
- Duriau, V.J., Reger, R.K., Pfarrer, M.D., 2007. A content analysis of the content analysis literature in organization studies research themes, data sources, and methodological refinements. *Organ. Res. Methods* 10 (1), 5–34.
- Eisenhardt, K., 1989. Building theories from case study research. *Acad. Manage. Rev.* 14, 532–550.
- Fiksel, J., 2001. Measuring sustainability in ecodesign. In: Charter, M., Tischner, U. (Eds.), Sustainable Solutions, Developing Products and Services for the Future. Greenleaf Publishing, Sheffield.
- Flynn, B.B., Kakibara, S.S., Schroeder, R.G., Bates, K.A., Flynn, E.F., 1990. Empirical research methods in operations management. *J. Operat. Manag.* 9, 250–284.
- Goffin, K., 2012. Sustainability and new product development. Chapter 6. In: Cranfield on Corporate Sustainability, pp. 105–118.
- Goffin, K., Mitchell, R., 2010. Innovation Management. Strategy and Implementation Using the Pentathlon Framework. Palgrave Macmillan, Basingstoke.
- Guelere Filho, A., 2009. Integração do ecodesign ao Modelo Unificado para a Gestão do processo de Desenvolvimento de Produtos: estudo de caso em uma grande empresa de linha branca (ecodesign Integration to the Unified Model for Product Development process management: a case study in a large company of white line appliances). PhD Thesis. Universidade de São Paulo, São Carlos.
- IPMA – International Project Management Association, 2006. ICB – IPMA Competence Baseline. Versão 3. IPMA, Nijkerk.
- ISO 9004, 2009. Managing for the sustained success of an organization – a quality management approach. Geneva.
- ISO 14006, 2011. Environmental management systems – Guidelines for incorporating ecodesign. Geneva.
- ISO/TR 14062, 2002. Environmental management – integrating environmental aspects into product design and development.

- Johansson, G., Magnusson, T., 2006. Organising for environmental considerations in complex product development projects: Implications from introducing a “green” sub-project. *J. Clean. Prod.* 14, 1368–1376.
- Katz, G., 2011. Rethinking the product development Funnel. *Visions*.
- Knight, P., Jenkins, J.O., 2009. Adopting and applying eco-design techniques: a practitioners perspective. *J. Clean. Prod.* 17, 549–558.
- Krishnan, V., Ulrich, K.T., 2001. Product development decisions: a review of the literature. *Manag. Sci.* 47 (1), 1–21.
- Littell, J.H., Corcoran, J., Pillai, V., 2008. *Systematic Reviews and Meta-Analysis*. Oxford University Press, New York.
- Martens, M.L., Brones, F., Carvalho, M.M., 2013. Lacunas e tendências na literatura de sustentabilidade no gerenciamento de projetos: uma revisão sistemática mesclando bibliometria e análise de conteúdo (Gaps and Trends in the Sustainability Literature on Project Management: a Systematic Review Merging Bibliometric and Content Analysis). *Rev. Gestão Proj.* 4 (1), 165–219.
- Ny, H., Hallstedt, S., Robèrt, K.-H., Broman, G., 2008. Introducing templates for sustainable product development: a case study of televisions at the Matsushita Electric Group. *J. Ind. Ecol.* 12, 600–623.
- OGC, Office of Government Commerce, 2009. *PRINCE2 – Projects in Controlled Environments*. OGC, Londres, 342 p.
- Pigosso, D., Rozenfeld, H., 2012. Métodos e ferramentas de ecodesign: revisão bibliográfica sistemática (Ecodesign Methods and Tools: a Systematic Literature Review). *Produto Produção* 13, 16–33.
- PMI – Project Management Institute, 2013. *A guide to the Project Management Body of Knowledge*, fifth ed. PMI.
- Prasad, S., Tata, J., 2005. Publications patterns concerning the role of teams/groups in the information systems literature from 1990 to 1999. *Inf. Manage.* 42, 1137–1148.
- Robichaud, L.B., Anantatmula, V.S., 2011. Greening project management practices for sustainable construction. *J. Manage. Eng.* 27, 48–57.
- Rozenfeld, H., Forcellini, F.A., Amaral, D.C., De Toledo, J.C., Da Silva, S.L., Alliprandini, D.H., Scalice, R.K., 2006. *Gestão de desenvolvimento de produtos – uma referência para a melhoria do processo (product development management – a reference for process improvement)*, first ed. Saraiva, São Paulo.
- Saunders, M., Lewis, P., Thornhill, A., 2007. *Research Methods for Business Students*, fourth ed. Pearson Education Limited, Harlow, Essex.
- Singhal, K., Singhal, J., 2012a. Imperatives of the science of operations and supply-chain management. *J. Oper. Manag.* 30, 237–244.
- Singhal, K., Singhal, J., 2012b. Opportunities for developing the science of operations and supplychain management. *J. Oper. Manag.* 30, 245–252.
- Stevens, A.L.N., 2007. *Adventures in ecodesign of Electronic products (1993–2007)*. Delft University of Technology, Enschede: PrintPartners Ipskamp.
- Stevens, A.L.N., 2012. Personal Communication.
- Tingström, J., Karlsson, R., 2006. The relationship between environmental analyses and the dialogue process in product development. *J. Clean. Prod.* 14, 1409–1419.
- Tingström, J., Swanström, L., Karlsson, R., 2006. Sustainability management in product development projects – the ABB experience. *J. Clean. Prod.* 14, 1377–1385.
- Vezzoli, C., Sciamia, D., 2006. Life Cycle Design: from general methods to product type specific guidelines and checklists: a method adopted to develop a set of guidelines/checklist handbook for the eco-efficient design of NECTA vending machines. *J. Clean. Prod.* 14, 1319–1325.
- Voss, C., Tsikriktsis, N., Frohlich, M., 2002. Case research in operations management. *Int. J. Oper. Prod. Man.* 22, 195–219.
- White, H., McCain, K., 1998. Visualizing a discipline: an author co-citation analyzes of information science, 1972–1995. *J. Am. Soc. Inf. Sci.* 49, 327–355.
- Zwolinski, P., Lopez-Ontiveros, M.-A., Brissaud, D., 2006. Integrated design of remanufacturable products based on product profiles. *J. Clean. Prod.* 14, 1333–1345.