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Organising Sustainability Competencies through Quality Management: Integration or Specialisation

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Abstract: A significant step in integrating environmental sustainability into daily operations is through product development. One way to achieve such integration of environmental considerations into product development is by relating sustainability competencies to practices of Quality Management. However, practices seem to vary for how competencies within environmental sustainability are organised in order to make sustainability more actionable. This study explores two ways of organising sustainability competencies in product development: integration and specialisation. The organisation of sustainability competency is illustrated through two cases; one case in which sustainability is integrated with the quality management competency, and the other in which a new competency focusing on sustainability has been added as a separate function in product development. It is suggested that the organisation of sustainability competency influences the extent of environmental impact. Further, trade-offs, such as material source versus weight may not be exploited when sustainability is integrated as one area of responsibility for another specialty competency, suggesting a lack of sufficient competency within environmental sustainability to recognise potential trade-offs between—for example—quality and environmental impact.

Keywords: sustainability competencies; sustainable product development; quality management; organising; integration; specialisation

1. Introduction

There is increasing focus on sustainable practices in most types of organisations. One key question for managers is to convey sustainability principles into their practice. Here, a central theme is the notion of sustainability as an integral aspect of daily operations, and that it is possible to achieve this by integrating sustainability work into established methodologies, for example, Quality Management (QM) [1,2]. Interestingly, QM is often the focus of similar discussions in organising quality work. Early proponents argued that quality was a value shared by everyone in an organization [3] and, therefore, should not be organised into separate functions or dedicated, professional roles. However, with the development of QM in practice, a separate quality function and competency, led by quality managers, emerged and still exists [4]. How this competency will develop needs further investigation: integrating with business management, disappearing, becoming a mobile competency of quality experts, or developing as a competency critical to the organization [5]? As a competency, the journey of quality might have similarities with that of sustainability. Will the organisation of sustainability competency face the same dilemma: balancing between specialisation and integration, and even integration with QM? Moreover, how can QM provide tools, practices, and even organisational positions supportive of sustainability competency?

An important decision for managers is if they should achieve operationalization of environmental sustainability through product development, and if they should organise sustainability competencies as an integrated part of existing structures and competencies, or as a specialised organisational unit. The need to address environmental requirements in the development and manufacture of products has gained much attention, and prior research has elaborated upon the challenges that organisations face in operationalization of sustainability and in the application of environmental requirements to daily operational tasks. [6] introduced the term "knowledge worker" to emphasise the need to build the capability to deal with the complexity and uncertainty that environmental sustainability entails. The focus on individual managers and their behaviour, as the constituent components of a competency, is also in line with [7], who state that behavioural and human factors require more focus to improve sustainable development. [1] acknowledge the inter-relationship between environmental performance improvement and improvement in other areas, such as quality performance. [8] observe that organisational practices of implementing sustainability practices vary and call for discussions of the organisational implications of sustainability. The framework for implementing a sustainability-oriented approach by [9] also acknowledges the interdependencies across firms' processes, and organisational complexities influencing the effectiveness of environmental initiatives.

Recently, [10] state that it is not sufficient to focus on the output of new product development (NPD) itself and that operationalization of sustainability in relation to—for example—product design and organisation, is not well understood. They (ibid.) call for more insight into the interface between NPD and other functions, that is, a cross-functional, integration approach. According to [11], one way to address such challenges is to integrate environmental requirements into existing management philosophies and engineering methodologies. On the other hand, sustainable product development may also be achieved by adding a new specialty competency on sustainability within product development [12].

The integration of environmental requirements in product development is a necessary step in the operationalization of sustainability; however, organising this integration for the greatest impact on environmental sustainability is not yet fully understood. This study defines integration as "continuous interdisciplinary sharing of data, knowledge and goals among project participants" [13] (p. 31). The strategies and mechanisms for integration of knowledge applied in this study's analysis are adapted from [14], and [15]. Against this background, the purpose of this study is to explore two ways of organising sustainability competencies in product development: integration and specialisation. It investigates the use of QM for organising sustainable product development through illustrative studies of two firms: one in which sustainability competency is integrated with other specialty competencies in product development and another in which sustainability is a specialty competency in its own right.

This study contributes to the research on integrating sustainability into daily operations efforts in the organization and presents a perspective on "sustainability competency" by building upon the conceptual synergies of QM and product development. In particular, the paper explores how this can be achieved through two distinct ways of organising sustainability competencies. Thus, the paper responds to the call for studies on organisational implications of sustainability in general [8] and, in particular, furthers the understanding of somewhat contradictory views on how to organize sustainability in product development integrated into existing engineering methodologies [11], or added as a a new, but separate, specialty competency [12]. The next section in this paper highlights the theoretical underpinnings of the analytical framework, which is followed by the methodology section and the findings from the case analysis. The paper ends with the discussion and conclusion.

2. Theoretical Background and Analytical Framework

This study builds a conceptual framework on how to organise sustainability competency, by combining product development and QM. A widely used approach to operationalize sustainability is conceptualising the performance of an organisation's activity in terms of the triple bottom line (TBL).

Environmental and social dimensions of performance are measurable in terms of the organisation's economic performance [16]. In the industrial context, the term "green" is often used interchangeably with TBL, implying the application of environmentally and socially sensitive practices to reduce the negative impact of manufacturing activities, while also harmonising the pursuit of economic benefits [17]. Despite this broad approach, research on sustainable development in industrial applications has primarily focused on environmental sustainability [18]. In addition to this vertical depth of sustainability (predominant environmental focus) is the interaction with other organisational processes such as QM and product development–a notion that can be considered as the horizontal range of sustainability. [19] also reflects such an integrative approach, both vertically and horizontally, indicating that the approach and methods to achieve sustainability—economic, environmental, and social—must integrate processes, sectors, and industries to create active synergies. Similarly, [20] state that sustainability objectives must integrate into business models, management processes, and other day-to-day activities of organisations for successful implementation. Further, in addition to the implementation of various sustainability initiatives, [7] highlight the role of individuals in driving sustainable operations management, as an area of future research.

2.1. Sustainability and Product Development

Owing to the demand for sustainable products by consumers, end-users, and policy-makers in the past decade, more studies address environmental issues in the context of the development and manufacture of products [10,21–31]. This increasing demand applies to manufacturers whose responsibility does not end with product sales. Rather, the scope of responsibility has widened to include selecting non-hazardous and renewable raw materials in product development and establishing end-of-life strategies to handle products beyond the use phase in the life cycle.

Whereas TBL has a strong relationship with performance, other approaches to environmental sustainability in industry are more concerned with activities such as production, and in particular, earlier stages, such as product development and "eco-design" [18]. Common initiatives herein include improvement of the energy and resource efficiency of production processes and product systems, implementation of preventive strategies, use of cleaner production technologies and procedures throughout the product life cycle, and minimisation or avoidance of waste [1,18,32,33].

2.2. Sustainability and QM

The notion of integrating environmental requirements into existing tools and methodologies [34], and with QM in particular [1,2], is not new. At a fundamental level, [35] and [32] refer to a "conceptual similarity" between pollution prevention (in which product development is a key) and Total Quality Management (TQM). Since then, several studies have advocated the integration of environmental requirements with existing product development practices and tools, such as creating environmental milestones and review questions [36], adapting QM tools and practices such as zero waste [37–39], inter-functional collaboration for sustainable product innovation [12], and a life cycle approach supporting sustainable product development [40]. More recently, a review by [41] suggests themes through which QM can support the integration of sustainability considerations in product development. Overall, in its focus on improvement of e.g., resource efficiency QM facilitates an integrated approach to sustainability. More specifically, QM is supportive to the integration of management systems to achieve sustainability goals and by supporting implementation of environmental management systems [41]. Although evidence on combining QM tools and practices with sustainability approaches, such as life-cycle analysis [41], exists, the current body of knowledge is predominated by this rather high-level approach in organisations in its focus on integration of systems and system implementation. In particular, the lack of integration between environmental requirements and daily operations is an ongoing challenge for organisations [41,42]. Despite the conceptual synergies of, for example, environmental efforts and QM [41] and product development, these sustainability efforts are often concentrated around environmental experts organised as an independent competency, separated from daily operations in product development [43]. This is somewhat in contrast with the notions that firms' existing practices in product development and QM, both individually and in combination, have the potential to provide a path towards environmentally-sustainable actions. In summary, despite agreements on the potential created through conceptual similarities between QM and sustainability, operationalizing this into action remains a managerial challenge.

2.3. Two Types of Organisation of Sustainability Competencies: Specialisation or Integration

Sustainability has been conceptualized in relation to types of competencies that are necessary for managers engaged in sustainable management practices [44,45]. To make such categorisation more "meaningful" and to operationalize these competencies, they must be connected to "core tasks" in the organisation [45]. In doing so, this study explores the intersection of QM, product development, and environmental sustainability, as illustrated by two alternative approaches to organising sustainability competency: specialisation and integration. In this study, the integration of competency refers to situations in which an expert in QM and product development also includes environmental sustainability into his/her portfolio. Here, the same individual internalises environmental sustainability with the principles of QM. In contrast, the specialisation of competency views sustainability as an area of expertise that is organised by assigning the role of sustainability to one individual expert, who then interacts with other functional experts in QM and product development.

According to [42], there are three main barriers to the implementation of sustainability initiatives in organisations: lack of integration and systematic implementation, lack of continuity, and resistance to change. The organisation of sustainability competency refers in particular to the first. When environmental requirements are left as a stand-alone entity outside the product development process, greater efforts are required from designers and engineers responsible for the actual design to learning about these requirements and implement them [46]. This is referred to here as the specialised organisation of sustainability competency. In particular, specialty competency refers to situations in which one person with expertise in, for example, QM, and another expert in environmental sustainability, work together. They bring their unique competencies into the context of product development. Here, environmental sustainability presumes interaction and coordination among individual experts. In contrast, integration competency refers to situations in which one person with competency in QM is also responsible for, and possesses knowledge of, environmental sustainability in product development. The same individual internalises environmental sustainability with the principles of QM. Environmental requirements are integrated into existing practices and tools through conceptual synergies. Monitoring product weight on a control chart, for example, is by nature a task for QM, but is fully aligned with environmentally-sustainable objectives, such as increased energy and resource efficiency.

The integration of environmental requirements into existing practices and tools is also a way to promote ownership of the improvement task and increase responsibility and buy-in among employees in an organisation [43]. Such an integrated approach to the organisation of sustainability competency enables those involved in product development to directly take ownership of environmental requirements for product development. Members of development teams are, in terms of product knowledge, often better equipped to make design decisions than external environmental experts hired to assist in projects on a short-term basis. This argument is in line with the findings of [42] (p. 174), who state that "the most evident barrier is the lack of integration and systematic implementation, given that these (sustainability) programs are usually implemented exclusively by environmental departments, which is problematic since this department does not have the authority and expertise necessary to apply to the entire company". To explore the two types of organisation of sustainability competencies further, this study builds upon the five strategies of knowledge integration in the context of new product development by [14]: organisational structures, substitute knowledge by access to knowledge, competency to fill in the knowledge gap, decomposition, and physical and virtual artefacts. The integration strategies by [14] are aligned with the integration approach. To complement this view on functional integration, the framework is extended by integrating strategies adapted from [15]. Table 1 summarises these six strategies of functional integration of knowledge; competence is defined in this study based on [14] (p. 1034) that "to be able to apply some knowledge means to have a competence or capability". This approach was chosen as it builds up on the resource-based view, and relates to the organisation of product development. The co-location strategy suggested by [15], who studied the product development interface, was chosen as this resonates with the specialisation approach.

Table 1. Strategies for integration of knowledge into production management (adapted from [14,15]).

Strategy	Examples of How Strategies Are Operationalized
Organisational Structures	Multifunctional teams, concurrent engineering, coordinating groups, matrix organisation, cross-functional project teams
Substitute Knowledge by Access to Knowledge	Gatekeepers; new managerial roles such as platform or program managers
Competency to Fill in the Knowledge Gap	Previous experiences are used to fill knowledge gaps
Decomposition	Integration through standardised interfaces allows for decomposition of complex designs or tasks
Physical and Virtual Artefacts	Use of artefacts to elaborate, develop, test, and industrialise concepts, which will be exploited by product managers later
Co-location	Relocation of personnel and physical facilities, personnel movement

First, *organisational structures,* as an integration mechanism, refers to conditions that support knowledge integration by, for example, providing incentives that foster coordination between specialists, but do not equate to creating knowledge integration [14]. Accordingly, to cultivate knowledge integration, it is necessary to organise individuals with particular competencies (as functional specialists) into a group. Second, *substituting knowledge by providing access to knowledge* is based upon the strength of "knowing-whom" rather than "know-how". Such a relational strategy also requires the organisation of people with competencies (specialists) into a group where discussion and exchange of knowledge is practicable. Third, *the competency to fill in knowledge gaps* may be applicable in a group where specialists have worked together previously, and therefore, possess the knowledge required to fill in the gaps (rather than just transfer knowledge) based on past experiences. However, this approach poses a challenge to any newcomers in the group of specialists [14]. Fourth, *decomposition* refers to knowledge integration by dividing it into smaller tasks that can be delegated to individuals. This relies upon contemporary coordination and standardisation. Fifth, *artefacts* can be an architecture that can relate to different subsets of knowledge; hence, it is used to structure and store knowledge from individuals. Finally, organising a group of specialists into one unit may not prove to be a successful integration strategy if there is a lack of cooperation amongst them [15]. Reducing the physical distance between team members through *co-location* is one way to increase communication, contributing to the success of a development project.

3. Methodology

3.1. Research Design and Sampling

This study involved the analysis of practices and activities in a product development setting, where environmental sustainability is addressed on par with other requirements, such as quality. In particular, the integration of sustainability competency was investigated, and a case study approach was found suitable to understand the dynamics and contextual depth within such a contemporary setting [47]. By focusing on particular instances in an organisation, the cases were used as illustrations [48] to describe two distinct situations. The study followed [49] and [50] in that two cases were selected, each representing a particular way of organising sustainability competencies.

The two cases are both of Swedish manufacturers with long traditions and core values that embed QM principles. Alpha is a large manufacturer in Sweden with employees in more than 30 countries and production facilities located in four countries. Product development teams are divided according to types of products. Engineers are assigned to one or more projects at a time, depending on number of active projects. Typically, the product development teams must strictly adhere to product and project requirements and timelines, as instructed by customers. Beta is an organisational unit of a large manufacturer that has production facilities in 18 countries. The company operates on the premise of three core values, namely, quality, safety, and environment. In Beta the study focuses one product development team consisting of the product development manager and five members, which focuses on one particular brand of products.

The selection of cases was based on purposive sampling around settings. First, cases were selected that represented "transparently observable" practices of improving environmental sustainability, which is why project-based organising were considered. Second, polar types [51] or maximum variation [52], was used as a sampling strategy to capture differences in the organisation of sustainability competency. Although both companies regard sustainable development as a strategic issue, they were selected based on differences in their organisation of sustainability competency: one where sustainability competency is integrated with other existing functional competencies and the other where sustainability is a specialty competency in its own right. At Beta, one individual specialises in sustainability. Alpha has a more generalist approach, and the individual working on sustainability has other roles, such as quality management. That is, no dedicated person is responsible for sustainability, rather, internal consultants that focus on quality improvements are expected to consider this in their work. Both cases have an in-house product development and production unit, and both produce products that have a great impact on environmental sustainability. Alpha operates in a project-based structure with robust design methodology (RDM) specialists organised as a group under Design for Robustness (DfR). Here, sustainability competency is not a specialty but is integrated with other competencies such as QM (of which RDM is a subset). Beta, on the other hand, has appointed an environmental specialist co-organised with specialty competencies in production, reliability, safety, and quality. Yet, in this broad setting, environmental sustainability is still considered a separate specialty competency.

3.2. Data Collection

The data were collected through semi-structured interviews, to allow the interviewees to decide what and how much they wanted to discuss the topics included [53]. The underlying research problem was exploring the use of QM tools and practices to support sustainable product development. For both cases, the semi-structured interview guide was designed to capture activities and practices directly related to sustainability. As the sampling aimed to capture variations in practices, a set of questions was developed for this for each organization studied. For Alpha, focus was on already established practices in QM, and this was explored in relation to sustainability and the expected impact. In Beta, the questions took notice of the more dispersed approach to sustainability, and covered areas such as the goals of the co-organization of quality and environment in production development benefits and challenges of the co-organization, and the results of the initiative. At Alpha, interviews were conducted with 13 personnel from the product development projects, chosen for their roles in a range of active projects at different stages of completion. These roles comprised of leaderships roles with responsibilities for the overall project (2), manufacturing (2), design (4), quality (2), procurement (2), and cost (1). Further, two specialists from Design for Robustness (DfR) were interviewed to capture the perspective of the QM specialists. In total, 15 interviews were conducted, of which all but one were conducted face-to-face, and the one remaining was a telephone interview. Each interview lasted between 30 and 60 min, and all interviews were recorded and transcribed in preparation for data analysis. Beta had a product development team configuration with specialty competencies, and all six team members were interviewed. The participants represented various competencies or knowledge in the areas of Quality, Environment, Safety, Reliability, and Production (5), and included the manager of the team (1). Achieving theoretical saturation helped determine the number as well as the range of roles and responsibilities among respondents in both organisations. The interviews were conducted face-to-face and lasted between 45 to 60 min. All interviews at Beta were recorded and transcribed.

3.3. Data Analysis

The data were analysed using NVivo10 software, developed by QSR International (UK), designed to support the analysis of rich qualitative data [54]. Before starting the NVivo analysis, two authors read the interview transcripts individually to identify themes and keywords. Due to the differences amongst the two cases, a first step in the analysis entailed an open coding [52] of the respondents view of sustainability and QM. Initially, the data was coded by topics such as QM, robust design, and sustainability, which provided the basis for NVivo coding [55,56]. Responses from all the interviewees were then analysed according to these codes. Under each code, various sub-themes were addressed, such as tools used in the product development process based on specialties (including QM tools), and the meanings of terms (e.g., sustainability). The codes that emerged from this were then combined into broader themes. For Alpha, the central categories were "sustainability" and "QM tools", which resulted in two key themes, namely understanding of sustainability, and the usage of QM tools in product development work. For Beta, the central categories emerging from this were "quality", "environment", "benefits", "challenges", and "improvement", and the central theme as co-organization of competences in product development. A next step was axial coding in which categories relevant to the purpose of the study were selected for further elaboration and related to the conceptual logic in Figure 1. Hereby, causal conditions of organizing sustainability competence and achievements in terms of environmental sustainability were explored. The interpretation of data and collection of additional material ended where a point of theoretical saturation was reached [57]. In addition to coding, cross-case synthesis [58] was used as an analytical technique along the dimensions in the conceptual logic in Figure 1. During the analysis, this was visualised in a table, that displayed data in form of quotations from individual respondents before the data was reduced into the features presented in Table 2 below. This enabled cross-case conclusions in terms of e.g., what challenges are common or unique, respectively in the two cases. The study refers to trustworthiness [59,60] as criterion guiding the research quality. Transferability of the results was enhanced through verification with both practitioners and academics, and through the use of multiple respondents in each organisation. Use of an interview protocol with common themes and questions contributes to the dependability (replicability) of the data collection method. By engaging two members of the research team in the analysis, the risk of subjectivity and idiosyncratic interpretations was mitigated. Finally, credibility has been established through the description of the procedures in data coding and analysis, and through debriefing of findings to both academic peers and practitioners.

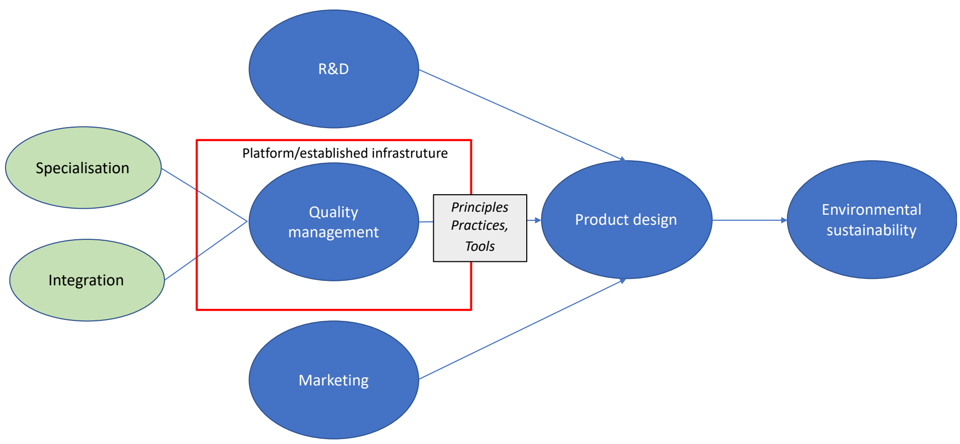

Figure 1. Conceptual logic.

Table 2. Distinctive features of the two cases, Alpha and Beta.

	Alpha	*Beta*
Organising sustainability competency	Integration	Specialisation
Environmental considerations	Operationalized outside-in through customer requirements	Strategic efforts, emerge inside-out through product development
Access to environmental knowledge	Dominated by functional competencies such as QM and customer requirements	Co-organisation of individuals creates forum of specialists
Organization of competency	In accordance to customer requirements	In accordance to specialists
Trade-offs	Not addressed	Addressed systematically

4. Findings

To elaborate further on the two ways of organising sustainability competencies, the findings from the two cases are described separately.

4.1. Integration of Speciality Competencies: Alpha

In the product development teams at Alpha, the interviewees found it difficult to explain sustainability in accordance to their daily activities in product development; their commitment and strict adherence to the customer requirement of limited product weight represented several contributions to sustainability–"*if we go above the target weight, we have to pay a penalty to the customer. It is a strict requirement*" (Cost Leader). Still, the focus of the team of experts is on activities related to their original specialty competencies, i.e., QM and the fulfilment of customer requirements. If that, by implication, contributes to sustainability, it is considered beneficial; however, it is not the primary motivation or the explicit focus. However, the type of products under development allows for positive contributions towards environmental sustainability, although the development team's focus is on other competencies and their related requirements. A manufacturing leader explains, "*the weight and the fuel efficiency are probably the biggest requirements from our customer. Efficiency here is maybe more from a money standpoint than environmental, I would say. You can call it environmentally friendly but for us it was also a business idea. These days it goes hand in hand, especially in a very fuel intensive industry*".

Besides customer requirements that impact environmental sustainability, "*we have environmental requirements on the components, we cannot use hazardous chemicals and such. The component itself is on a product that should be "green" so that has some kind of environmental aspects at least*" states a Design Leader. However, the same interviewee states that it still "*flows down from the requirements; it is taken care of there. I think that is basically why we do not reflect over that as something unique*". The lack of focus on environmental sustainability is further illustrated by examples of trade-off situations and the priority between, for example, components with impact on the environment and other performance requirements. This is summarised by another Design Leader, who states, "*our customers have sort of a black list of materials that you are not allowed to use in the components. Yes, for us, the environmental part is to make the product as light as possible. A lighter product uses less fuel. We have a "not to exceed" weight requirement*".

4.2. Separation of Speciality Competencies: Beta

In this environment, product development is arranged as a co-organisation of individuals with separate specialty competencies, in which the joint consideration of quality and environmental requirements began as early as 2013. The main reason for the introduction of co-organisation of competencies was to mesh with the organisational core values of quality and environmental care adopted throughout the organisation, nationally and globally. The idea of adopting the core values in everyday product development activities was initiated by the manager of the product development team. When asked during the interview for the reason behind his action, he responded "*the idea behind this was to create and centralize a specialty competencies team within product development, and it was by chance that the environmental specialist requested to be a part of this group at the same time. I was lucky*". When the environmental specialist was asked why it is important for someone with her specialty competency to be working with other specialists in product development activities, she replied, "*the whole organisation is very focused on environmental issues, so the whole organisation strives to reach legislated emissions and fuel-efficient products. But to me, environmental issues also include the kind of materials we use to develop and manufacture our products. That's where I come in*".

Apart from competencies in QM and environmental sustainability, the product development team contains specialists of other competencies, such as safety, reliability, and production. In general, these specialists expressed a common understanding of the desired outcome of the co-organisation of competencies. The reliability specialist's response, which was similar to others, was "*this allows us to have a good and extended communication within a specialised group of people. Then I think we can make good, or better, cross-functional decisions*".

The challenges of co-organising competencies are numerous. Some originate from the perspective that the co-organisation effort—two years from its inception—is still seen as a new way of work. One challenge was further strengthening the integration of competencies by formalising knowledge sharing between competencies and lessons learnt from completed projects. Some interviewees felt that a true relationship was missing between the product development team and other specialists of the same speciality competency within the organisation's global network. An example was the lack of direct and timely involvement of a team of specialists conducting product Life Cycle Assessment (LCA) within the organisation's global network in product development efforts. One reason for this could be the geographic expansion of Beta's locations. Another reason could be that the tasks of environmental specialists are related to local regulations, which may differ from the focus of the global LCA team.

5. Discussion

Based on evidence from the interviews, as elaborated above, an overview of the organization of sustainability competencies in the two cases is presented in Table 2. The findings above show that there are several distinctive features of Alpha and Beta in terms of the considerations of environmental requirements, the access to knowledge concerning the environmental requirements in product development, the motivation to integrate or specialize the competencies, and the management of trade-offs.

Two main contrasts were identified between the two cases that contribute to the understanding of integration and specialisation as ways of organising sustainability competencies in product development: explicit or implicit consideration of environmental impact, and strategically- or operationally-driven environmental requirements.

5.1. Explicit or Implicit Consideration of Environmental Impact

First, environmental considerations are explicitly addressed from the outset in Beta's product development process. On the other hand, in Alpha, they are implicit in that they are derived from customer quality requirements rather than articulated as environmental requirement.

Lack of integration and systematic implementation has been identified as a challenge in the inclusion of environmental requirements in the daily operations of product development [42,46]. Beta has addressed this challenge through co-organisation of competencies, in which the consideration of environmental requirements appears to be natural in daily product development activities, as this is the responsibility of the environmental specialist. Co-organisation has created a forum for specialists with varying competencies to recognise and share day-to-day responsibilities to ensure that both quality and environmental requirements are considered. Beta's co-organisation effort is an example of a multifunctional team in alignment with the integration strategy of "organisational structures" [14]. This strategy supports the balancing of environmental requirements on par with quality requirements and, thus, facilitates the joint consideration of requirements specifically related to environmental sustainability and other product requirements.

At Alpha, it is evident that the product development team is not explicitly aware of the link between their own specialty competency and environmental sustainability, although such links exist.

Therefore, the full potential contribution is likely not exploited. In Beta, trade-offs between various requirements are explicitly discussed, as the co-organisation effort allows team members to evaluate decisions based on the competency of each member, and not just on individual judgement in isolation. However, at Alpha, the trade-offs are not fully exploited. As Alpha belongs to an energy-intensive industry, product weight is a critical requirement with sustainability implications. Customers naturally impose weight requirements based on the notion that a heavier product consumes more fuel and, therefore, has a higher operational cost. However, could customer demands result in the opposite, for example, in using scarce resources to provide desired product properties, such as low weight? Such trade-off discussions are not evident at Alpha. This could be due to a lack of sufficient competency in sustainability, or because trade-offs are more likely when different specialty competencies meet in interpersonal exchange of knowledge and experience. One strategy, in the case of Alpha, could have been to "substitute knowledge by access to knowledge" [14], as is done at Beta, where the product development manager acts as a gatekeeper to ensure that the goals of each competency are assessed during gate reviews, as per the practices in a traditional product development team.

The implication of this first contrast is that a well-executed specialty competency, which builds upon the vertical depth of expert knowledge, but requires good coordination between individuals, could provide a stronger case for improvement than an integrated competency in which the individual is expected to possess knowledge of both QM and environmental sustainability (i.e., horizontal range). Integration of competencies requires in-depth knowledge of both QM and environmental sustainability, as opposed to coordination and other integration strategies, and entails higher degree of autonomy. In specialisation, the need is greater for various integration strategies, such as sharing of knowledge. In the latter case, QM can enhance integration efforts, using established tools that are relevant for both competencies.

In contrast, for an integration strategy to be effective, it is a matter of increased knowledge in an additional subject area. The proposition based on these cases is to have experts with competency on sustainability working together with QM experts to achieve joint consideration of quality and environmental requirements, and moving to an integration strategy when sufficient knowledge has been created in the organisation. Such an evolutionary approach suggests that speciality competence evolves into integrated competency. In both situations, the proposition presumes that sustainability competency is organised in the same way as QM in the organisation. For example, specialty competence presumes that QM exists as an expert function rather than throughout the organisation. The suggestion to align sustainability competency with QM is in line with [4]'s observation of how QM develops as a profession in the organisation. It begins as a specialty function, which evolves to become more pervasive in advanced forms; that is, it is seen as an integrated skill of individuals across various functions in the organisation although supported by specialists.

5.2. Strategically- or Operationally-Driven Environmental Requirements

Second, Beta is an example of environmental requirements cascading down from the strategic to the operational level, as environmental care is established as one of the core values in the organisation. This is in line with [36] (p. 9), who suggests that "*An essential responsibility for management is to establish clear environmental goals not only for the development organisation as a whole, but for the individual product development projects as well. This implies that environmental considerations should be addressed as a business issue, that is, the environmental considerations must be balanced with commercial aspects. It also implies that eco-design should not only be treated on an operational level, but also on a strategic level*". Hence, the strategic long-term plans are systematically formulated based on customer requirements and legislation for environmental care, and then cascaded down to the operational level. Further, [36] stated that an environmental expert is required, as part of the multifunctional product development team and environmental considerations should be integrated into the existing product development process.

In this study, the co-organisation of competencies at Beta is identified as a step forward in the inclusion of environmental considerations in product development. However, at Alpha, the same requirements cascade from customer demands, and are therefore, not highlighted as a strategic effort, that is, formulated by the company itself. In Alpha's product development efforts, there is no direct focus on sustainability. Therefore, the contribution to sustainability within product development appears non-systematic. Nevertheless, it is a contribution all the same. The collaboration with customers in terms of control of specifications and hazardous materials implies a consideration of the negative environmental impact of manufacturing activities, which is synonymous with "green production" [17]. However, these case findings indicate that to ensure a true "eco-design", environmental sustainability requirements must be formulated as *strategic effort* by the company and not just emerge as customer requirements. Further, a systematic assessment of trade-offs amongst different specialty competencies should, in such a case, be led by a gatekeeper (e.g., a manager within product development) to ensure that quality requirements are challenged and do not overrun environmental requirements at decision points in the product development process.

5.3. Cross-Case Challenges and Similarities

A similarity between the cases lies in the challenges faced by the product development teams in the lack of communication and interaction, and knowledge-sharing between team members. The co-organisation of competencies alone is insufficient as an integration strategy if there is lack of true cooperation among team members [15]. In Beta, the barrier to cooperation is mainly due to the lack of coordination between competencies which, in turn, is attributable to time constraints. These findings indicate that interaction between team members could be further improved to strengthen the co-organisation effort. Interaction and networks have been highlighted as important attributes for knowledge distribution and flow [14,15]. The tools and practices of QM can further the horizontal scope of sustainability in the organisation. These findings offer a further insight into the quest of [10] for a more cross-functional understanding of product development. Finally, while [1] view "sustainability practices as a quality-enabler", the conceptual logic and the empirical evidence suggest a more bilateral approach; QM can be seen as a basis of conveying environmental sustainability principles into practice, not only through tools and methods, but also by providing organisational structure for various types of sustainability competencies.

6. Conclusions

The integration of environmental requirements into product development has long posed a challenge to practitioners and researchers. The results underline the importance of understanding the conceptual synergies between product development and QM. The cases presented in this study illustrate two ways in which QM could support such integration of environmental requirements into product development efforts. First, integrated competencies represent individuals that possess skills in various functional areas. Here, trade-offs between quality and environmental impact are very seldom discussed and explicitly handled. Rather, the perceived environmental impact is implicit, in that it materialises as a positive side effect of QM efforts. Second, a separation of specialty competencies, rely upon in-depth knowledge and skills of each individual in one functional area, such as QM, product development, or environmental sustainability. Here, the operationalization of sustainability is achieved through effective co-organisation in teams of experts from different areas, and effective coordination of trade-offs through gate-keeping activities. Experts in one area appear better equipped to identify trade-offs between environmental sustainability and other product characteristics in the decision-making process. Based on this study, a set of four propositions are suggested so as to inform managerial implications. The first appreciates the professional depth of QM managers, as well as the ability of these to coordinate others in the organisation.

Proposition 1: Sustainability competencies benefit from vertical depth of QM professionals, and their ability to coordinate other areas of expertise horizontally in the organisation.

Based upon the cross-case synthesis, we suggest that when considering the implementation of sustainability into daily operations, the two distinct approaches of organising sustainability competencies should be seen in terms of maturity.

Proposition 2: From an evolutionary perspective, when sufficient knowledge has been created in the organisation, specialty competencies (as in Beta) should precede the integration of specialty competency (Alpha) in order to pervade more product development projects with environmental sustainability considerations.

Moreover, focus on the organisation of sustainability competencies paves the way for a higher-level problematization, away from principles themselves towards conveying these into practice.

Proposition 3: Whereas the process from the strategic to operational level guides managers in "what" to do, the evolution from speciality to integration provides guidance on "how" to make sustainability more actionable.

Whereas sustainability requirements from external stakeholders, such as customers and governmental legislation, are important to organisations, these need to be complemented by the organisation's own strategic commitment.

Proposition 4: To ensure that environmental requirements are prioritised on par with other product requirements, these must be clearly stated by the company, rather than emerge only implicitly through customer requirements. The way by which sustainability competencies are organised can be seen as a means of enabling such strategic focus.

The propositions derived from this study may be confined to certain limitations, such as the lack of generalizability of the findings and the subjective biases of analysing interviews in a qualitative study. Further, the focus of only two in-depth case studies puts limitations on theory-building that is based upon cross-case analysis, as well as the external validity of the results. One area of future research could be to advance the results further by investigating a larger number of organizations within and outside the manufacturing sector. Another area of future research could be to explore and analyse the co-organisation of competencies in product development where environmental requirements are introduced at the operational level, not at the strategic level. A third area of future research could be an in-depth study of an organisation that has deliberately and explicitly adopted several knowledge integration strategies, and study the activities supporting such strategies.

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