Sustainability in Product Development: A Focus Group into Sectoral and Firm challenges in Scottish Aerospace Industry.

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Abstract. Particularly in the aerospace sector, developing sustainable products and services is seen as the dominant challenge for the near future, especially environmental and social-economic impacts. Despite the aerospace sector already having a strong emphasis on systems engineering and life-cycle considerations, because of the nature of its complex products, such as aeroplanes and satellites, sustainability in product development is still in its infancy. So, how are companies dealing with the challenges of offering more sustainable products? To help answer this question, this paper describes the outcomes of focus groups with product developers and managers on how sustainability is understood and used in product development processes. We identified that there is a considerable difference between actual practice and what is described in reports and surveys. From those observations, we concluded that most of the difficulties in adding sustainability to product development practices come from a lack of knowledge or a weak knowledge of the conceptual bases on sustainability. Consequently, the definition of the sustainability concept needs to be better developed aiming at facilitating its understanding. Additionally, the financial-economic and environmental dimensions of sustainability are more often considered than the social dimension during product development. From observations of methods and tools used in product development processes, we identified a conflict between the description of how the environmental and social dimensions are considered and how they ought to be. Furthermore, we identified that often sustainability in product development processes are expressed as how it should be, instead of how it really is – as if it was justified through belief alone. Finally, for effective integration of sustainability in product development, it is necessary to consider the three dimensions (financial-economic, environmental and social) concurrently and on equal footing for the entire product life-cycle. Such implementations have the potential to allow companies to design new products that are economically profitable, ecologically friendly, operationally safe, socially fair and culturally accepted.

Keywords: Sustainability, Product Development, Sustainable Development, Triple Bottom Line, Focus Groups.

1 Introduction

With the aerospace sector regularly attracting headlines in various about its ability to address sustainability (such as the threats of space debris to the sustainability of space operations [1] and to our ability to monitor weather from space [2]; or the challenge to reduce greenhouse gas emissions of aircraft by 2050 [3]), a key aspect is how sustainability is addressed during product and service development in this sector. Even with available methods for managing sustainability, organizations are still facing difficulties in conducting sustainability activities [4; p.2680]. Additionally, sustainability conceptualisations, their definitions and interconnections are crucial for understanding and for better communicating the process of changes necessary for promoting sustainable development and sustainability [5; p.1884]. Hence 'much of the unsustainable activity that occurs in the world can be traced to organisations' [6; p.744], the successes of promoting sustainable development and sustainability depends on organisations actions. As organisations provide products, and essential product properties and characteristics are determined in early phases, it is important to integrate sustainability into processes for product development, a notion based on textbooks on product life-cycle management already appearing in the work of Harper and Thurston [7; p.31101/1] and Hallstedt [8; p.251] citing [9]. This instigates Hallstedt [8] to develop sustainability criteria and a related index for use during product development. Such studies cover mostly specific aspects of sustainability rather than cover all its dimensions. This is also reflected in findings related to implementation of sustainability in practice during product development in the automotive sector, where different perceptions of sustainability exist with particularly the social dimension receiving less attention, for example, [10; p.175]. However, these statements are derived from works in other sectors than aerospace, thus, raising the question of whether the full implications of the three dimensions of sustainability are accounted for in this industry and whether a similar varied interpretation of sustainability exists.

Studies into integrating sustainability during product development for the aerospace sector cover a wide range of topics. Some works have explored machine learning, e.g., Bertoni et al. [11], and others considered simulation modelling, for instance, the literature review by Jaghbeer et al. [12]. Hallstedt et al. [13] focus on value-driven design. However, these

publications seem to be part of a research programme at Blekinge Institute of Technology. Again, these publications take the life cycle as a starting point, thus, covering only part of the dimensions of sustainability. And, they leave open the questions of whether full implications of the three dimensions of sustainability are accounted for in this industry and whether a similar varied interpretation of sustainability exists.

Particularly for the aerospace sector, developing sustainable products and services is seen as a challenge for the near future, especially the environmental and social-economic impacts. Despite the aerospace sector already having a strong emphasis on systems engineering and life-cycle considerations, because of the nature of its complex products, such as aeroplanes and satellites, sustainability in product development is still in its infancy.

To this purpose, this study aims at excavating views of these involved in new product development in the aerospace industry and how they consider all three dimensions of sustainability. This paper starts by looking at the rationale and approach for the research methodology used in this research for the focus groups conducted in Scotland in 2019–2020. The following section provides a narrative analysis, whereas the final section presents the conclusions.

2 Design of Research Method

Because sustainability in product development is still a prospective nascent theme, we need to understand how sustainability is acknowledged and how it is integrated into product development processes. Considering that product development can be viewed as an ecosystem, put forward by Kinnunen et al. [14] based on interactions between sectors, companies, managers and product developers, we found focus groups an appropriate method to investigate our research objectives. The use of focus groups aims primarily at understanding the meaning and interpretations of a select group of people regarding a specific issue or set of topics [15; p.299, 16]. Thanks to group dynamics, focus groups usually results in the generation of deeper and richer data, which are lacking in one-to-one interviews [15; p.299]. As we want to explore and better understand how product developers and product development managers and related functions understand and use the concepts of sustainability during the product development process, this interpretive method is a good fit as interactions within the group help the participants to better express and clarify their points of view (the ‘group effect’). Moreover, the results of a focus group can generate theoretical generalisability, though not statistically validated, as put forward by Barbour [17; p.747–8]. Following Halldórsson and Aastrup's [18; p.329] thoughts, this leads to so-called correspondence with constructed realities by participants, in our case the focus group. Therefore, the outcomes of the adopted research method — focus groups — not only lead to insight into how product developers and product development managers understand and use the concepts of sustainability in the product development processes, but can also serve as a pretext for the development of specific conceptualisations based on existing theories and further studies.

2.1 Design of Focus Group

The focus group sessions were opened with a 30’ presentation of core concepts for sustainability, triple bottom line and product development, with their impacts on economic/financial, environmental and social dimensions. The purpose of these presentations was to get the participants acquainted with basic terminology as well as to provide a basic framework of sustainability. Following Barbour's [17; p.747] caution towards ‘stimulus’ material, its contents were about basic concepts of sustainability plus context for the study. This ensured that throughout the focus group and during interactions key concepts could be addressed in the same manner, thus avoiding confusion about terminology and context.

In the same line as proposed by Kitzinger [16; p.107], the group was divided into four subgroups to avoid participants from the same company or segment staying grouped and so minimising the probability of dominance of certain group members; the latter is a common disadvantage of focus groups. In each subgroup, a group discussion, led by a moderator and one observer (all appearing as authors of this paper), conducted a two-part session lasting 30’ each, totalling 60’. The two sessions were divided into two parts. The first part of the sessions discussed 'Which product development methods and tools are currently in use in their product development processes?' The second part of the sessions asked participants to 'List how the methods and tools listed in the first part can be used to address the economic, environmental and social dimensions of sustainability?'

To stimulate exploration, check understanding and promote discussion, self-adhesive notes and flip charts were used, which also served the purpose of triangulation. Therefore, our research design with four subgroups was not only aiming at increasing interaction between participants but also capturing data and information as much as possible through multiple media.

2.2 Profile of Participants

Potential participants were invited through the Centre for Engineering Education and Development (CeeD) Scotland, a regional business network, and the Higgs Centre for Innovation of the Science and Technology Facilities Council (STFC) – part of UK Research and Innovation. Hence, we applied convenience sampling based on experience and interest in the relevant subject area, which is common practice in focus groups [19; p.50–2]. Twenty-one participants represented six

different companies from the aerospace sector attended the first sessions. Furthermore, the organisations were small companies (7), medium-sized firms (2) and large corporations (4). Regarding their segments, the participants were from five aerospace industrial companies, three consulting companies, two business development organisations and representatives of three universities; see Table 1organisations and representatives of three universities; see Table 1.

Table 1. Profile of participants of the first session.

Function / Segment	CEO	Director	Manager	Academic	Other	Total
Industry	1	4			1	6 (29%)
Business Development		1	2		2	5 (24%)
Consultancy		2			1	3 (14%)
University				2	5	7 (33%)
Total	1 (5%)	7 (33%)	2 (10%)	2 (10%)	9 (43%)	21 (100%)

The participants came mostly from functions in organisations relevant to product development in the aerospace sector. Also, a CEO, six directors and three managers attended the focus group; however, all the participants were related to product development or sustainability.

In the second session, a total of nineteen participants represented twelve different companies from the aerospace sector. Furthermore, the organisations represented were small companies (5), medium-sized firms (1) and large corporations (6). Additionally, regarding their segments, the participants were from five industry companies, two consulting companies, two business development organisations and representatives of three universities; see Table 2.

Table 2. Profile of participants of the second session.

Function / Segment	CEO	Director	Manager	Academic	Other	Total
Industry		2	4		1	7 (37%)
Business Development			1		3	4 (21%)
Consultancy		1	1			2 (11%)
University			2	4	0	6 (32%)
Total	0	3 (16%)	8 (42%)	4 (21%)	4 (21%)	19 (100%)

In addition, concerning the size of the focus group, the division into smaller subgroups was beneficial, because smaller groups consisting of five to six participants provide more room for each individual to contribute, to interact optimally, and to explore relevant themes in more detail, hence generating more relevant data [20; p.67–8].

Thus, the size and composition of the focus group ensured sufficient content validity [21; p.303–4]. Thus, the composition of our focus group contained participants representing relevant functional perspectives for product development and sustainability. Hence it is important to highlight that in both sessions we had representatives from industry, business development agencies, consultancy and university, which brings sectoral representativeness for our sample. For instance, from the 40 participants of the two sessions, 33% were from the aerospace industry. Moreover, our sample was composed of a total of 25 companies from the Scottish aerospace industry. Hence, it assures our sample representativeness of the Scottish aerospace firms.

2.3 Data collection and analysis

The group discussions were transcribed by the moderator and the observer independently during the sessions. Directly after the sessions, the post-its, flip charts and notes were collected and a meeting with the moderators and the observers promoted a discussion to compare the information collected and the perceptions, to increase reliability and internal consistency (commensurate with Kidd and Parshall's [21; p.299] recommendation for ‘debriefing’). The data were grouped to identify the dimensions of the triple bottom line, methods, tools and difficulties to address sustainability in product development. In the weeks following the session, the authors used the transcriptions and other data to code the findings using the categorisation of the debriefing session. The coding was done by two researchers working independently and results compared afterwards.

3 Results

This section will discuss the perceptions of the participants regarding how they understand the sustainability concept. Additionally, we present the results of the discussion about which challenges they face and which methods and tools are being used to embed sustainability in their product development processes.

3.1 Results of Subgroup Sustainability Concept Session

At the start of the sessions, before presenting any formal concept of sustainability, we asked participants 'What does sustainability mean to you?' This question aimed at capturing how the conceptualisation of sustainability is understood by practitioners and decision-makers in product development. The key points of the discussion are summarised in Table 3. Although participants reacted quickly and without hesitation, responses, in general, deviated from the complete description of the conceptualisation of sustainability. Taking the World Commission on Environment and Development (WCED) [22] definition of sustainable development, which is one of the most accepted definitions, only 37% of the answers were compatible with this definition. Although, responses that reported correctly WCED´s definition confounded sustainable development and sustainability as the same concept. Although, sustainability is a state to be achieved while sustainable development comprises the path that takes to such sustainability state. The predominant aspect in the answers was the focus on financial/economic aspects and on the idea of sustaining the business or the product over time, which represented 73% of the answers. Furthermore, 54% of the replies focused on the environmental dimension of sustainability. By contrast, only 9% of the responses focused on the social dimension of sustainability.

Table 3. Aspects of sustainability covered by the response to 'What does sustainability mean to you?'

According to	WCED	Financial /Economic	Environmental	Social	Focus on 'sustaining over time'
Number of answers (%)	4 (36%)	8 (73%)	6 (55%)	1 (9%)	8 (73%)

Next, it was put to the participants 'Which dimensions of sustainability impacts are being considered during the product development at your organisation?' The responses to this question are presented in Table 4.

Table 4. 'Which dimensions of sustainability impacts are being considered during the product development at your organisation?'

Sustainability dimension	Financial /Economic	Environmental	Social
Average of answers (%)	80%	90%	80%

According to the participants', the financial-economic and social impacts are considered on 80% of the product development process, while the environmental impacts are considered on 90%. Although, when the same participants described their views about the sustainability concept, the social dimension was considered only in 9%, the environmental dimension on 55% and the financial-economic dimension in 73% of the instances. Hence, this difference between the reported coverage of the three dimensions of sustainability in the product development processes and the inclusion of all three dimensions when defining sustainability maybe points to a lack of knowledge or a weak knowledge of the conceptual bases on sustainability.

Subsequently, participants were asked 'What are the challenges for implementing sustainability in your daily activities?' The responses were registered and then grouped into common factors, from which the results are presented in Table 5.

Table 5. Factors that represent difficulties for implementing sustainability in product development daily activities'

Factors	Financial /Economic	Environmental	Social	Short time orientated	Complexity	Convenience	Culture
Occurrences (%)	12 (44%)	2 (7%)	4 (15%)	5 (19%)	8 (30%)	7 (26%)	4 (15%)

From the responses to the question, most (44%) focused on financial-economic challenges such as the cost to implement sustainability practices. In addition, the complexity related to sustainability practice was present in 30% of the reactions. With 26%, the convenience factor appears as the third most mentioned factor, meaning that their product development processes focus on sustainability practices only when it would be convenient. The orientation on short term results appears in 19% of the answers, contrasting with the inherently long-term orientation that characterises sustainability. Tied in fifth place, the social and cultural challenges appear with 15%, reporting difficulties in engaging people and building a culture towards sustainability in their product development processes. Finally, 7% reported environmental aspects as a barrier to implementing sustainability in the daily activities for product development. This is compatible with the reporting that the

environmental dimension is covered in 90% of the cases of product development, as here it is reported that environmental dimension represents fewer difficulties for implementing sustainability in daily activities for product development.

3.2 Results of the Subgroup Methods and Tools to Embed Sustainability in Product Development

After discussing the concept of sustainability and its three dimensions, the subgroups were asked to list which methods and tools they use to address the economic, environmental and social dimensions. First, the participants were asked to describe which methods and tools they use in their product development processes. Additionally, the participants were asked to note how those tools and methods could be used to address additional aspects or dimensions of sustainability. The data was recorded on flipcharts by the subgroups, in turns of 45' for each dimension of sustainability. At the end of the three turns discussing the economic, environmental and social dimensions, the researchers transcribed the data from the flipcharts to spreadsheets to allow a better analysis of the data. Subsequently, the results of the analysis of the data are presented.

Initially, the participants recorded 35 methods and tools as actually in use for the economic/financial dimension. Although, after analysis by the researchers, it was identified that 11 (31%) methods and tools were incorrectly classified as related to the economic/financial dimension of sustainability as shown in Figure 1.

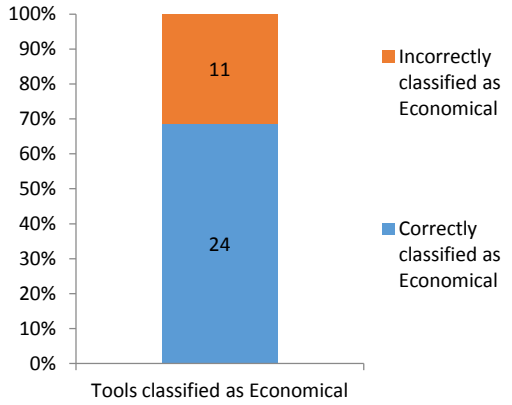

Fig. 1. Tools used to address economic dimension of sustainability

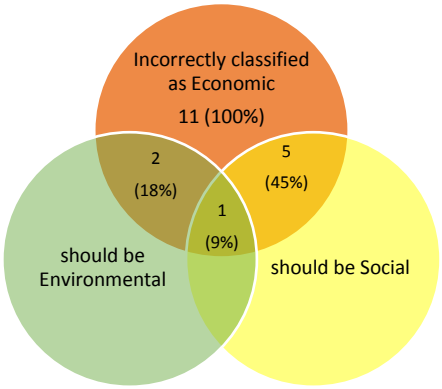

Fig. 2. Tools incorrectly classified as related to the economic dimension of sustainability.

As can be seen in Figure 2, from the 11 methods and tools incorrectly classified as related to the economic dimension, two (18%) should be classified in the environmental dimension, five (45%) should be classified as related to the social dimension and one (9%) should be classified in both environmental and social dimensions.

Next, the participants recorded 27 methods and tools as actually in use for the environmental dimension. Although, after analysis by the researchers, it was identified that 8 (30%) methods and tools were incorrectly classified as related to the environmental dimension of sustainability as can be seen in Figure 3.

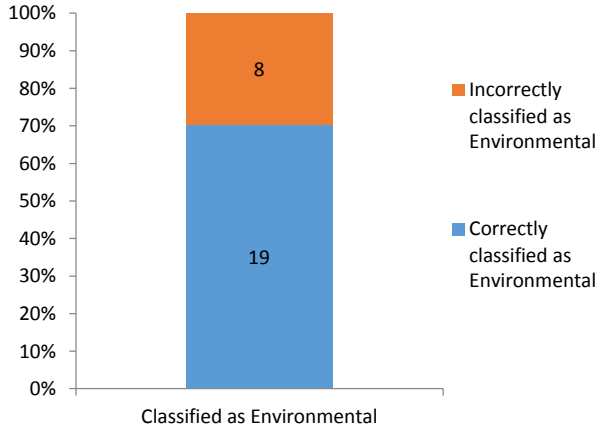

Fig. 3. Tools used to address environmental dimension of sustainability

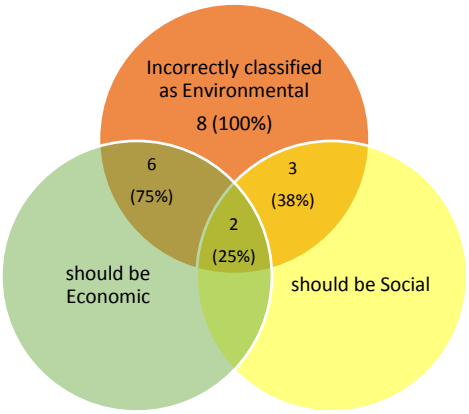

Fig. 4. Tools incorrectly classified in environmental dimension of sustainability.

As can be seen in Figure 4, from the 8 methods and tools incorrectly classified in the environmental dimension, six (75%) should be classified in the economical dimension, three (38%) should be classified in the social dimension and two (25%) should be classified to both economical and social dimensions.

Finally, the participants recorded 24 methods and tools as actually in use for the social dimension. Although, after analysis by the researchers, it was identified that 8 (33%) methods and tools were incorrectly in the social dimension of sustainability as can be seen in Figure 5.

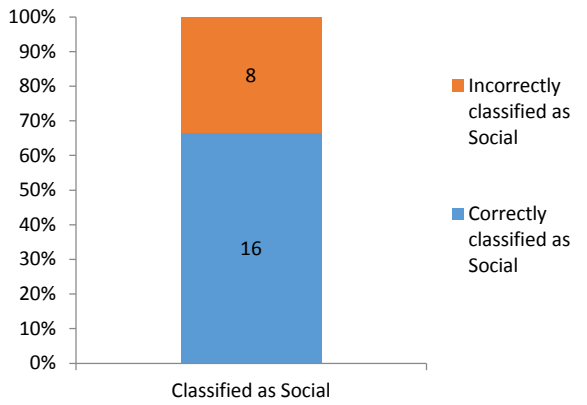

Fig. 5. Tools used to address social dimension of sustainability

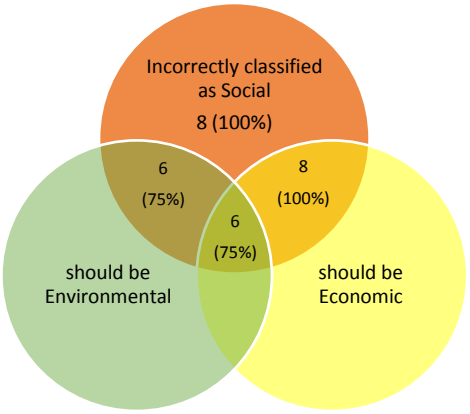

Fig. 6. Tools incorrectly classified as related to social dimension of sustainability.

From Figure 6, it can be seen that from the 8 methods and tools incorrectly classified in the social dimension, all 8 (100%) should be classified in the economic dimension, six (75%) should be classified in the environmental dimension, and similarly, six (75%) should be classified in both economic and environmental dimensions.

In summary, from the analysis of Figure 7, it can be observed that the participants had more difficulty classifying methods and tools for the social dimension, followed by the economic dimension, and slightly less with the environmental dimension.

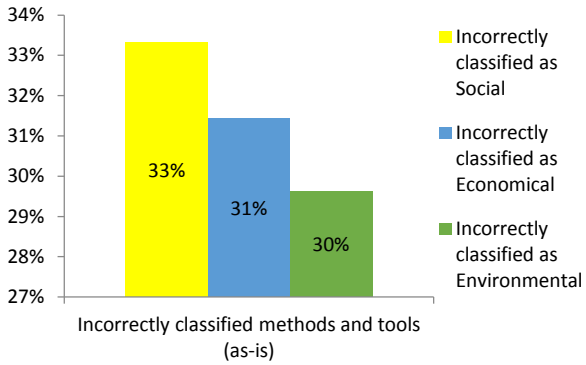

Fig. 7. Incorrect classifications of current methods and tools in sustainability dimensions (as-is)

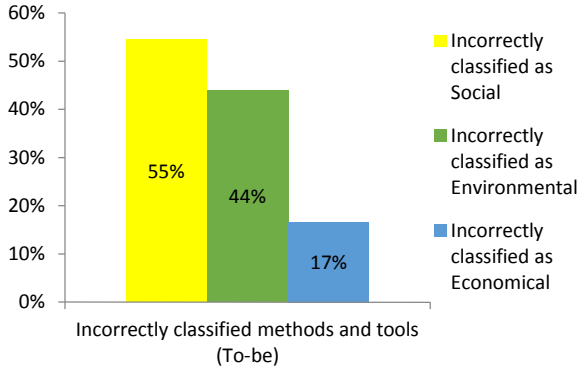

Fig. 8. Incorrect classifications of expanded uses of methods and tools in sustainability dimensions (to-be)

Finally, participants discussed how the methods and tools in use in their product development processes could expand the focus on sustainability. Hence, the participants recorded their opinions about how each method or tool could be used and classified according to the dimensions of sustainability. As a result, it was observed that 17% of the answers were incorrectly classified in the economic dimension. Particularly, for the environmental dimension, 44% of the answers were incorrectly classified. Likewise, 55% of the methods or tools were incorrectly classified in the social dimension. In summary, the comparison is presented in Figure 8. Hence, it is important to compare how the participants classified the methods and tools regarding sustainability dimensions considering current use (as-is) and expanded or future use (to-be); the results are presented in Figure 7 and Figure 8 respectively.

4 Concluding Remarks

This paper investigated how companies are dealing with the challenge of offering more sustainable products. To help answer this question, this paper described the outcomes of research with Scottish aerospace firms. The research used focus groups with product developers and managers to collect observations about how sustainability is understood and used in product development processes. Thus, the from the focus group of aerospace Scottish sector, indicate that there is a considerable difference between actual practice and what is described in reports and surveys.

From the focus group observations, we concluded that most of the difficulties in adding sustainability to product development practices come from a lack of knowledge or a weak knowledge of the conceptual bases on sustainability. Taking the WCED [22] definition of sustainable development, which is one of the most accepted definitions, only 37% of the answers were compatible with this definition. Although, responses that reported correctly WCED definition confounded sustainable development and sustainability as the same concept. From the responses of the participants, we could conclude that it was not clear to them that sustainability is a state to be achieved while sustainable development comprises the path that takes to such sustainability state. By contrast, the predominant aspect in the answers to "What does sustainability mean to you? was the focus on financial-economic aspects and on the idea of sustaining the business or the product over time, which represented 73% of the responses. However, 54% of the answers focused on the environmental dimension of sustainability. By contrast, only 9% of the answers focused on the social dimension of sustainability. From these observations, we concluded that the financial-economic and environmental dimensions of sustainability are more often considered while the social dimension is not considered, or not correctly considered, in product development processes. For example, similarly to Gmelin and Seuring [10; p.175], we identified that social aspect is currently rather scarcely supported in product development. Although, considering the statement that sustainable new product development is dependent on cost awareness, and environmental issues plus the awareness of social attributes [10; p.175], our study concluded that sustainable new product development is also dependent on knowledge of sustainability conceptualisation.

Furthermore, we identified a conflict between the description of how the environmental and social dimensions are considered. For instance, the comparison of how the participants classified the methods and tools regarding sustainability dimensions considering current use (as-is) and expanded or future use (to-be), presented a higher occurrence of incorrect classifications on social and environmental dimensions for the expanded or future use. Hence, this leads to the conclusion that participants have more difficulty classifying methods and tools for use in the future for social and environmental dimensions. Hence, it can be deduced that the use of methods and tools in practice helps to understand and contextualise the use and classification of methods and tools for each dimension of sustainability. Although, the lack of knowledge or a weak knowledge of sustainability concepts can explain the difficulty of envisioning the future or expanded use of current methods and tools. For instance, this can be supported by the previous discussion about the sustainability concept. When, particularly, the social dimension was considered only in 9% of responses, the environmental dimension on 55% and the economic or financial dimension on 73%. In summary, this can be explained by a lack of knowledge, or a weak knowledge, of the conceptual bases on sustainability, resulting in incorrect classifications regarding the social and environmental dimensions.

Although, when considering the economic dimension, it was observed that participants classified the methods and tools incorrectly more in the current than in the future use. Compared with the answer to 'What are the difficulties for implementing sustainability in your daily activities?', the largest fraction of them (44%) focused on economic or financial difficulties such as the cost to implement sustainability practices, followed by the complexity related to sustainability practice on 30% of the answers. In conclusion, although more familiar with the economic/financial dimension, the participants still face difficulties on the current use of methods and tools to address this particular dimension. As a practical implication, we also concluded that the sustainability and its dimensions concept needs to be better developed and understood in product development processes.

Additionally, we identified that usually sustainability in product development processes are expressed as how it should be instead of how it really is – as if it was justified through belief. Hence, this difference between the reported coverage of the three dimensions of sustainability in the product development processes and the inclusion of the three dimensions of sustainability altogether when defining sustainability points to a lack of knowledge or a weak knowledge of the conceptual bases of sustainability. Consequently, there is a need for better development of sustainability and triple bottom line concepts. It matches the systematic literature review from Souza and Dekkers [23; p.1334] conclusion that `most tools and methods consider only economic and environmental dimensions. Just a few tools cover the social dimension or the three dimensions all together´.

Similarly from the conclusion that 'sustainability in principle is an integration of economic, environmental and social dimensions, its interrelations are a crucial subject that deserves more attention from researchers [23; p.1334] our work concludes that there is a need for improving the understanding of how sustainability and triple bottom line concepts translate in practice to product development processes.

Finally, for effective consideration of sustainability into product development, a new set of methods and tools are not necessary. Although, a new set of sustainability knowledge is required. For instance, it is necessary to consider the three dimensions (financial-economic, environmental and social) at the same time and with the same importance, considering the entire product life-cycle. Although, the knowledge and skills for developing sustainable products are new, or not well understood, in most company cultures and by its employees. However, for the delivery of more sustainable products, organisations must ensure that sustainability concepts are known and understood throughout the product development processes. Such implementations have the potential to allow companies to design new products that are economically profitable, ecologically friendly, operationally safe, socially fair and culturally accepted.

4.1 Implications for Practice

In line with the conclusion of Souza and Dekkers [23; p.1334], to advance the development and use of appropriate methods and tools, it is necessary to expand current conceptualisations of new product development and lean product development; alternatively, a new process model that addresses the sustainability processes on product development needs to be created. As a result of observations of methods and tools used in product development processes, we identified that there is a considerable difference between actual practice and what is described in reports and surveys. Hence, from the conclusion that most of the difficulties in adding sustainability to product development practices come from a lack of knowledge or a weak knowledge of the conceptual bases on sustainability, it calls for efforts to increase knowledge of sustainability conceptualisation in organisations from the aerospace sector. For example, it was observed that many practitioners consider sustainable development and sustainability as the same concept. Although, it was expected that practitioners had a clear understanding that sustainable development comprises the path that takes to sustainability, what is a state to be achieved.

Consequently, it is crucial to establish what is sustainability in its three dimensions. For instance, the 2030 Agenda for Sustainable Development as the deadline is an important motivator for a fast move towards sustainability. Although a fast move is important, more important is to make sure the move is made in the right direction. For that purpose, developing the understanding of sustainability conceptualisation is a key element to assure moving in the right direction.

4.2 Limitations

The inferences and recommendations were mostly derived from a small focus group, though exceeding minimum requirements. Nevertheless, more focus groups could have given a better representation of the perspectives of all actors in the Scottish aerospace sector. A second limitation is the representation of firms being a convenience sample. However, it can have little impact since all types of relevant actors were represented and possibly differences in perspectives were not related to the characteristics discussed earlier. Another limitation is that perhaps the perceptions about the inclusion of sustainability in product development are influenced by the settings of the myopic innovation system [24]. A fourth limitation comes from the application of selective coding. Another limitation is that only responses in the focus group setting were recorded, causing possibly tensions between theory-in-use and espoused theory. Finally, considering the intersection of matching conclusions with the work of Gmelin and Seuring [10] that used an automotive industry sample, it can lead to the question of generalisation of the validity beyond aerospace sector. Therefore, findings may extend to similar sectors, and possibly even beyond for particular aspects of our research.

4.3 Directions for Future Research

Hence, further research could benefit from extending our approach to other sectors and countries. Such studies might highlight differences and may shed light on sector or national factors that determine differences.

Furthermore, the inclusion of views from other actors may portray a more complete picture of the context of sustainability in product development. Such insight will complement the views of actors directly involved in developing processes, methods and tools for sustainable products development.

Finally, more critical research about sustainability conceptualisation is needed. The definition of sustainability has been adopted, although without progress on its development and understanding. For example, Glavič and Lukman [5] review sustainability terms and their definitions, although does not supply a definition for sustainability itself. It becomes apparent that the scope of the term sustainability needs to be more clearly defined, for example, how it differs from sustainable development and how it includes its three dimensions. Given the view of (Scottish) aerospace sector towards sustainability, more research is needed about understanding how the academic literature can contribute to overcoming the challenge of adding sustainability to product development.

References

1. World Economic Forum: Space Sustainability Rating, https://www.weforum.org/projects/space-sustainability-rating

2. Villazon, L.: Does the debris around Earth affect the atmosphere?, https://www.sciencefocus.com/space/does-the-debris-around-earth-affect-the-atmosphere/
3. Losada, P., Aaronson, M., Brimmer, A., Hangai, Y., Rein, J.: The Sustainability Opportunity for Aerospace, https://www.bcg.com/publications/2020/sustainability-opportunity-for-aerospace-industry
4. Souza, J.P.E., Alves, J.M.: Lean-integrated management system: A model for sustainability improvement. J. Clean. Prod. 172, 2667–2682 (2018). https://doi.org/10.1016/j.jclepro.2017.11.144
5. Glavič, P., Lukman, R.: Review of sustainability terms and their definitions. J. Clean. Prod. 15, 1875–1885 (2007). https://doi.org/10.1016/j.jclepro.2006.12.006
6. Etzion, D.: Management for sustainability. Nat. Sustain. 1, 744–749 (2018). https://doi.org/10.1038/s41893-018-0184-z
7. Harper, S.R., Thurston, D.L.: Incorporating Environmental Impacts in Strategic Redesign of an Engineered System. J. Mech. Des. 130, (2008). https://doi.org/10.1115/1.2829858
8. Hallstedt, S.I.: Sustainability criteria and sustainability compliance index for decision support in product development. J. Clean. Prod. 140, 251–266 (2017). https://doi.org/10.1016/j.jclepro.2015.06.068
9. McAloone, T.C., Tan, A.R.: Sustainable product development through a life-cycle approach to product and service creation: An exploration of the extended responsibilities and possibilities for product developers. In: Proceedings of Eco-X Conference : Ecology and Economy in Electronix. pp. 1–12. , Vienna, Austria (2005)
10. Gmelin, H., Seuring, S.: Achieving sustainable new product development by integrating product life-cycle management capabilities. Int. J. Prod. Econ. 154, 166–177 (2014). https://doi.org/10.1016/J.IJPE.2014.04.023
11. Bertoni, A., Hallstedt, S.I., Dasari, S.K., Andersson, P.: Integration of value and sustainability assessment in design space exploration by machine learning: an aerospace application. Des. Sci. 6, e2 (2020). https://doi.org/10.1017/dsj.2019.29
12. Jaghbeer, Y., Hallstedt, S.I., Larsson, T., Wall, J.: Exploration of Simulation-Driven Support Tools for Sustainable Product Development. Procedia CIRP. 64, 271–276 (2017). https://doi.org/10.1016/j.procir.2017.03.069
13. Hallstedt, S.I., Bertoni, M., Isaksson, O.: Assessing sustainability and value of manufacturing processes: a case in the aerospace industry. J. Clean. Prod. 108, 169–182 (2015). https://doi.org/10.1016/j.jclepro.2015.06.017
14. Kinnunen, T., Sahlman, K., Harkonen, J., Haapasalo, H.: Business ecosystem perspective to new product development. Int. J. Bus. Dev. Res. 1, 6–22 (2013)
15. Kitzinger, J.: Qualitative Research: Introducing focus groups. BMJ. 311, 299–302 (1995). https://doi.org/10.1136/bmj.311.7000.299
16. Kitzinger, J.: The methodology of Focus Groups: the importance of interaction between research participants. Sociol. Heal. Illn. 16, 103–121 (1994). https://doi.org/10.1111/1467-9566.ep11347023
17. Barbour, R.S.: Making sense of focus groups. Med. Educ. 39, 742–750 (2005). https://doi.org/10.1111/j.1365-2929.2005.02200.x
18. Halldórsson, Á., Aastrup, J.: Quality criteria for qualitative inquiries in logistics. Eur. J. Oper. Res. 144, 321–332 (2003). https://doi.org/10.1016/S0377-2217(02)00397-1
19. Liamputtong, P.: Focus Group Methodology: Principles and Practice. SAGE Publications Ltd, 1 Oliver's Yard, 55 City Road, London EC1Y 1SP United Kingdom (2011)
20. Krueger, R., Casey, M.A.: Focus Groups: A Practical Guide for Applied Research. SAGE Publications, Thousand Oaks, CA (2015)
21. Kidd, P.S., Parshall, M.B.: Getting the Focus and the Group: Enhancing Analytical Rigor in Focus Group Research. Qual. Health Res. 10, 293–308 (2000). https://doi.org/10.1177/104973200129118453
22. World Commission on Environment and Development: Our Common Future. (1987)
23. de Souza, J.P.E., Dekkers, R.: Adding Sustainability to Lean Product Development. Procedia Manuf. 39, 1327–1336 (2019). https://doi.org/10.1016/j.promfg.2020.01.325
24. Patel, P., Pavitt, K.: National Innovation Systems: Why They Are Important, And How They Might Be Measured And Compared. Econ. Innov. New Technol. 3, 77–95 (1994). https://doi.org/10.1080/10438599400000004