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PLM Functionalities in the Fashion Industry. Preliminary Results of a Classification Framework

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Abstract. As widely known, Product Lifecycle Management (PLM) is a set of business solutions and tools for the management of the entire lifecycle of a product, from its conception to its disposal. Despite PLM was born in traditional contexts, recently it is increasingly used in other sectors such as the fashion industry, even if it shows several features that distances it from the traditional approach to PLM deployment. Request for customized products, rapid changes in customer's preference and the consequent shorter product lifecycles make the fashion environment very complex. Within this scenario, PLM has the potential to enable fashion industry to reduce time to market and to increase competitiveness in the global scenario, but quite often clear guidelines are not available. Literature is not exhaustive, as we can't find articles covering the whole set of functionalities. Quite often only few features have been mentioned and the same functionalities have been differently called. To overcome this gap, the purpose of this research is the definition of a framework on PLM functionalities in fashion, classified according to the macro-processes where they are involved. The result is an overview of the PLM functionalities organized in macro-processes, moving from the development of the creative idea to the arrival in the stores, validated by experts of PLM software houses working within the fashion industry. From a managerial point of view, it represents a clear guideline to support companies and vendors to identify the whole range of PLM functionalities and the processes positively involved during their implementation.

Keywords: Fashion, Product Lifecycle Management, Framework, Functionalities.

1 Introduction

PLM is a well-known software adopted into traditional industries, like the manufacturing one. In literature, several papers related to PLM functionalities, PLM adoption level in real case studies and advantages achievable by PLM software implementation can be found [1][2][3].

Due to its peculiarities, this paper is focused on the fashion industry, where PLM means clear visibility into the Product Development phase, sourcing, and pre-production processes and a more collaborative approach, through every phase of the lifecycle. In

particular, several sectorial features make fashion and traditional industries different, such as the list and definition of the PLM functionalities to be adopted and the segment of the value chain where they should be implemented.

Going deeper into details, the fashion industry is characterized by not repetitive and standardized processes [4], often recognized as led by creativity, exclusivity and other qualitative criteria, different from the traditional principles of cost reduction and profit maximization. Thanks to the so-called “digital revolution”, PLM systems can be used in fashion [5] since the beginning of the product lifecycle, integrated with 2D and 3D software, starting from the definition of samples and collection details to the retail level and further, involving user experience applications in the middle of life of the product. Every fashion item is highly customized and realized in small lots or, at least, as unique creation. Its product lifecycle is very short (i.e. it may last up to six months) and, consequently, product details and catalogues are frequently updated, at least twice per year. Moreover, PLM users in the fashion industry are most of all designers and stylists, making the definition of dedicated software interfaces and functionalities suitable for these creative users, used to navigate on graphics and photo editing software, more challenging for the solution providers. In addition, a clear overview of the PLM functionalities available for the fashion companies will help them to better understand the benefits reachable through PLM solutions.

Therefore, the aim of this study is to present a comprehensive classification of PLM functionalities in the fashion industry, starting from a literature review and proposing a framework based on the SCOR model and validated by PLM software vendors.

The paper is structured as follows: in Section 2, the objective of the work and the adopted methodology are described; Section 3 collects the results coming from the literature review and the proposed framework; finally, main conclusions and future research directions are outlined in Section 4.

2 Objectives and Research Methodology

Even if PLM definition and related issues have been deeply analyzed in the literature, there is still a gap between industrial and academic point of view, especially in the definition of the key functionalities of a PLM software. During last years, the Industry 4.0 revolution has pushed PLM software houses towards the introduction of new functionalities that cover a wider range of supply chain (SC) processes, especially in the fashion industry. According to this, the main objective of this work is the identification of a framework to guarantee a well-structured overview of the PLM functionalities commonly used within the fashion sector. In addition, each functionality has been linked to one or more macro-processes that characterize a fashion product SC, aiming to understand which company roles and departments should be involved during the implementation of a PLM solution.

In order to achieve the described results, two different steps have been carried out.

Firstly, a literature review on PLM functionalities has been conducted to identify the proposed PLM functionalities list. This step includes the rationalization of different nomenclatures found in literature for a single functionality according to its description,

resulting on a complete and clear overview of the PLM functionalities available for the fashion industry. Secondly, the identified functionalities have been classified according to the processes where they are involved, then validated through the involvement of experts of PLM software houses.

3 Findings

3.1 PLM Functionalities

The literature review has been conducted on papers related to PLM functionalities with a specific focus on the fashion system, due to the evidence that there is a lack in a unique definition of the overall functionalities of a PLM software for that industry. More specifically, a single reference that exhaustively collects all the functionalities has not been found, while each paper is focused on a selection of them. In addition, a specific functionality is often differently named in different papers, making the identification of a complete and clear set of unique PLM functionalities for the fashion industry difficult to figure out.

Due to this evidence, the first goal of this work has been the definition of a comprehensive framework of the PLM functionalities in the fashion industry based on the literature review, as shown in Table 1. The description of every PLM functionality has not been reported due to space limit.

Table 1. Proposed classification of PLM functionalities based on literature review

PLM functionality	References	Description
Bill Of Material Management	[6][7][8]	BOM management includes structured archiving of all the information, management and communication of change requests.
Business Intelligence	[9][10]	BI tools integrate all data into the PLM by creating interactive, easy-to-use boards and reports
Calendar Management	[7][8][11][12]	Calendar Management allows to define the timing of the various phases of the life cycle of a product.
Collaborative Tool	[6][7][9][10][13]	Collaborative Tools allow to manage all communication and sharing activities in a single connected digital space.
Collection Book	[8]	Collection Book allows the creation of digital catalogues.
Colour Management	[8][9][10][11][12][13][14]	The Color Management functionality has multiple goals: to define standards for the color definition, to manage the color-material association, to manage the color-product association

Composition and Care Label	[8]	Composition and Care Label is a functionality that allows the creation of labels, according to labeling regulations.
Costing	[8][9][11][12]	Costing functionalities allow to define a cost estimate from the early stages of product development to the production.
Integration Software	[9][10][11][12][13]	Integration software functionalities allow the exchange of information with other business management systems and design tools.
Line Planning	[9][12]	The line planning is the process where the number of products that will be sold is determined
Material Management	[8][9][10][11][12][13][14]	Material Management is the functionality that allows to define material libraries.
Order Collection	[8][11]	Order Collection collects all sales information into a one centralized location.
Product Data Management	[6][8]9][10][11][13]	PDM is one of the core functionalities of the PLM, where all the data regarding the product are stored.
Portfolio Management	[12]	Portfolio Management defines the criteria for selecting products and innovation projects to be carried out.
Project Management	[12]	Project Management provides the functionalities to implement project management according to the principles of the PMI (Project Management Institute).
Quality Management	[11]	The product Quality Management and compliance with standards module assures the constantly evolving and updating of the standards.
Range Planning	[11][12]	The objective of this process is to assure that the product range is balanced in terms of styles, colors, sizes, price ranges and stocks.
Report	[12]	Report features allows users to reorganize product and financial data into customized documents to be shared within the organization.
Request For Quotation	[8][9][11]	RFQ defines standard supplier selection procedures.
Size Range Management	[10][11][14]	Size Range Management functionalities permit to interface PLM with CAD tools managing size-product association

Storyboarding	[8][10][11][13]	It allows the creation of digital storyboards to be shared with stakeholders inside and outside the company.
Supplier Auditing	[9][12]	Supplier Auditing allows to keep up-to-date suppliers reports.
Sustainability and Compliance	[10][14]	This set of features guarantee the compliance with internal and external standards and regulations.
Technical Sheet Management	[8][10][13]	Technical Sheet Management produce technical data sheet with production cycle specifications.
Trend Analysis	[10][12][13][14]	Trend Analysis allows to identify the trends in the specific company sector, considering the target audience.
Visual Merchandising	[12]	Visual Merchandising allows brands and retailers to create virtual stores, visualizing the layout and generating interactive planograms.
Workflow	[6][7][10][12][13]	Workflow module allows the definition of workflows and to define and execute stored procedures.

3.2 Classification of PLM Functionalities per SC Process

PLM software allows to manage processes along the entire product lifecycle. According to this, the PLM functionalities listed in Table 1 influence specific processes that characterize the fashion SC. In order to clarify which processes within this industry can be supported by PLM tools, a classification of functionalities by macro-processes has been developed.

To identify the macro-processes to be included, the SCOR (Supply Chain Operations Reference) model developed by the Supply Chain Council has represented the starting point for the framework definition. In fact, SCOR aims to create a reference model to describe the SC processes, independently of the specific industrial sector.

After an overview of the PLM functionalities in the fashion sector listed in Table 1, a first evidence is that they are quite relevant to support companies in managing their relationship with suppliers (i.e. “Source” phase in the SCOR model) and their production processes (i.e. “Make” phase in the SCOR model). On the other hand, the application of the same PLM functionalities does not cover the “Deliver” phase in the SCOR model related to internal and external logistics, but impacts the downstream processes related to the order collection and retail activities.

In addition, the SCOR model focuses on operational processes, without taking into account the upstream SC related to the design phase, in which PLM solutions play a key role.

Table 2 - Proposed classification of PLM functionalities per SC process

PLM functionality	Transversal	Design	Prototype, Sampling & Engineering	Sourcing	Production	Ordering & Retail
Colour Management		x	x	x	x	
Line Planning		x				
Material Management		x	x	x	x	
Range Planning		x				
Storyboarding		x				
Trend Analysis		x				
Bill Of Material Management			x	x	x	
Size Range Management			x		x	
Technical Sheet Management			x		x	
Request For Quotation				x		
Supplier auditing				x		
Composition and Care Label					x	
Collection Book						x
Order Collection						x
Visual Merchandising						x
Business Intelligence	x					
Calendar Management	x					
Collaborative Tool	x					
Costing	x					
Integration Software	x					
Product Data Management	x					
Portfolio Management	x					
Project Management	x					
Quality Management	x					
Report	x					
Sustainability and Compliance	x					
Workflow	x					

In fact, the implementation of tools that enable and support companies to innovate in order to rapidly react to market changes, realizing new products or customizing the

existed ones, represents a critical success factor especially in dynamic industries such as the fashion one.

More specifically, fashion products are usually characterized by short lifecycles (i.e. from one week to a season), even if a small percentage of total production is usually represented by the carry-over products, which have a longer lifecycle. In this context, the complexity to be managed during the New Product Development (NPD) phase increases due to the need to reduce the time from conception to production. Following [15], they proposed to split the NPD process in the fashion industry into the following phases: Design, Prototyping, Sampling and Engineering.

For all these reasons, the macro-processes adopted to classify the identified PLM functionalities are *Design, Prototyping, Sampling and Engineering, Sourcing, Production, Ordering and Retail*. Table 2 shows the proposed framework, where each PLM functionality is clustered according to the macro-processes impacted by its implementation. *Transversal* column is selected for the PLM functionalities that impact on all the SC processes.

In the following paragraphs, the results shown in Table 2 are discussed, grouped by SC process.

Design

Design is the first SC process moving from upstream to downstream along the SC. It represents the initial point of the NPD phase, where creative idea starts.

Due to the fact that the decisions taken at this level can determine the success or failure of a product on the market, a crucial aspect of the Design process is to observe, store and share in a collaborative environment customers' needs, requirements and trends. This is the reason why *Trend Analysis* and *Storyboarding* are linked to this process. Moreover, in this phase *Line Planning* and *Range Planning* activities are used in order to simplify the forecasting and planning activities and to define the collection details in terms of product mix for each market. *Colour Management* and *Material Management* are other two PLM functionalities to be used starting from the Design process. The relevance of these two functionalities since the very early stages of the NPD is related to the evidence that just few years ago storyboards were realized by designers and stylists on polystyrene panels, where fabric cutouts of various colors were attached. Nowadays, this activity is usually digitized but the scope is the same: the only difference is that, instead of physical samples, digital contents are collected and stored. Moreover, colours managed through the Colour Management functionality can be selected starting from standard colour palette (e.g. Pantone), in order to guarantee the alignment between the brand owner and its suppliers.

Prototyping, Sampling and Engineering

Colour Management and *Material Management* are also used in the Prototyping, Sampling and Engineering processes. In fact, while the Design phase aims to define the range of colours and materials to be used in each collection, starting from the Prototyping process specific colours and materials will be associated to each item of the developed collection in order to realize prototypes and samples.

Under this macro-process can be found the functionalities of *Size Range Management*, *Technical Sheet Management* and *Bill Of Material (BOM) Management*. In fact, during these processes technical sheets are defined to provide guidelines for the realization of each collection item and the sizes per article to be produced are defined. Moreover, a first version of the BOM per item is developed, updated during the subsequent process after technical and functional controls and sales force feedback.

Sourcing

Within this group, the already mentioned functionalities of *Colour Management*, *Material Management* and *BOM Management* are also included. On the one hand, both the colour and material master data include the possibility to declare the preferred supplier per coloured material (e.g. black calfskin). On the other hand, information about the list of suppliers enabled to realize a specific item can be included within its BOM. Moreover, the unit consumption per coloured materials included in the BOMs crossed with the collected orders give to the sourcing department the exact quantities of coloured materials to be purchased.

Request For Quotation (RFQ) and *Supplier Auditing* functionalities are specific for the Sourcing process, supporting companies in suppliers' management and evaluation. In fact, the first one supports the collection of the quotations per item of each supplier belonged to the company supply base, while the second one sums up the results of the assessment on suppliers' service levels.

Production

As the previous process, also the Production phase is covered by already mentioned functionalities, such as *Colour Management*, *Material Management*, *Technical Sheet Management*, *Size Range Management* and *BOM Management*. In fact, these functionalities are initially involved in previous SC processes but then updated according to the results of technical and functional controls and sales force feedback. For example, some coloured materials can result unfeasible for the realization of some collection articles or reviews to some samples are requested during the sales campaign.

Composition and Care Label functionality is used within the Production process to create the template and information to be included on the product labels, such as materials composition and other product-specific details.

Ordering and Retail

Collection Book and *Order Collection* features are classified into the Ordering and Retail macro-process, representing the workplace where all the information needed for the sales campaign are stored, pre-orders are filled and orders are collected, during trade fairs such as the Milan and Paris fashion weeks or directly in showrooms. These features are usually supported and integrated with digital catalogues and mobile apps. Moreover, the digital catalogues used in both the physical and digital store are based on the collection book developed in the PLM. In addition, retail managers' activities focused on making retail spaces more attractive and pleasing for customers, encouraging their impulse to buy, are supported by the *Visual Merchandise* functionality, related to the definition of store layout and items display.

Transversal

In addition to the ones described above, twelve functionalities are classified as “Transversal”, highlighting that their adoption impacts on all the SC processes.

According to the evidence that one of the objectives of PLM software is to support the coordination of cross-functional teams, features such as *Collaborative Tool* allow different actors to manage updated information in a single digital space.

Another core element of PLM is *Product Data Management (PDM)*, that enables the data collection in a structured master data and allows to present product-related information in different views, according to the template configured for the logged user profile.

Integration Software is another transversal functionality, due to the fact that it impacts on different SC processes according to the software to be integrated with PLM. For example, it impacts on the NPD phase, interfacing PLM with CAD and CAM tools, on the Prototyping, Sampling, Engineering and Production processes, when PLM is interfaced with the company’s ERP, on the Ordering and Retail macro-process where it is integrated with order collection software.

Another cross-process functionality is *Costing*, used from the Design phase, to support in a structured way the definition of the product target cost, to the Ordering and Retail process when the final price, based on the final production cost, has to be included in the collection catalogue. Using this PLM feature, cost analysis is carried out starting from the estimated material consumption calculated from CAD models crossed with the supplier pricing information stored within PLM software.

Quality Management and *Sustainability and Compliance* functionalities impact on the whole SC, as the compliance with quality standards, sustainability codes of practice and current regulations must be ensured at every stage of the process.

Workflow is the functionality used to define and apply automatic procedures with the aim to simplify and increase the productivity of the teamwork, reducing the occurrence of errors and the related costs. For example, automatic alerts can be sent to the involved users once some events occur, such as the formalization of the collection plan and the validation of the final version of the BOM. In the same way, BOM managers can be informed regarding the changing requests received and can be forced to approve or refuse them within a specific range of time.

Another functionality is the *Calendar Management*, that allows to schedule all the activities along the SC processes in order to meet the deadlines from the concept definition to the collection of the sales force feedback.

Portfolio Management enables the management of new product development projects. In fact, the existent product portfolio, such as the potential investment on innovative products, can be evaluated to establish the priorities based on objective decisional criteria. Moreover, this functionality supports the monitoring of sales growth and related ROI, considering each product or groups of them, in order to identify the best and worst performers.

The last two cross-process functionalities are *Report* and *Business Intelligence (BI)*. Reports feature supports users to collect, analyze and presents data in different formats, in order to be easily understood by different departments with different competences

and focus. For example, reports can be used to analyze sales, production, raw material consumption, costs, comparing actual values with planned ones or data of previous years. On the other hand, BI functionality strongly supports in decision-making processes, enabling users to achieve information about the performance of different SC areas. An example of BI implementation is to identify which products receive the highest number of change requests in order to investigate the reasons behind and try to solve them. Moreover, this feature can be used in the Sourcing phase to identify similar components in order to choose, for example, the cheaper ones. For both these functionalities, customized dashboards can be configured by vendors through a deep business analysis.

4 Conclusions and Future Developments

The main result of the present study is a framework on PLM functionalities in the fashion industry, classified according to the SC processes they impact. The framework is based on the evidences collected from the literature and the review of the processes included in the SCOR model, readapted to a dynamic context such as the fashion one. Once developed, the framework has been validated through structured interviews to experts from PLM software companies, both in terms of PLM functionalities nomenclature and classification per macro-process.

Among the identified functionalities, some of them are vertical in one process, while other cover more than one or, at least, the entire SC.

On the one hand, *Line Planning*, *Range Planning*, *Storyboarding* and *Trend Analysis* have a vertical impact only on the Design phase, such as *RFQ* and *Supplier Auditing* on Sourcing, *Composition and Care Label* on Production and *Collection Book*, *Order collection* and *Visual Merchandising* on Ordering and Retail macro-processes.

On the other hand, some functionalities, called “Trasversal” in the proposed framework, cover all the SC processes, mainly due to their nature. Examples of them are *Collaborative Tool* and *PDM*, based on the development of unique workspace and data library respectively, principles that can be applied by definition to all the SC processes. In the same way, *Reports* and *BI* modules can be used to analyse data coming from different departments, from style to sales offices.

Finally, other features occupy an intermediate position, covering more than one SC process but not all of them. These functionalities are *BOM Management*, *Colour Management*, *Material Management*, *Size Range Management* and *Technical Sheet Management*, that cover the Prototyping, Sampling and Engineering and the Production processes. This result is partially due to the fact that the realization of a fashion item includes a step-by-step evolution from the prototype, to the sample, to the final product, that forces to manage several versions of product-related documents, such as BOM and technical sheet, and their update along the SC.

From a scientific point of view, the proposed framework overcomes the gap in the literature related to a missing complete overview of all the PLM functionalities in the fashion industry, realized in the present work starting from the evidences coming from the literature review.

From a managerial point of view, the classification of the PLM functionalities by SC process included in the proposed framework represents a clear guideline to support companies and vendors during the implementation of PLM software, making the identification of the key users to be involved easier.

Future research will be focused on the development of an extended version of the proposed framework to investigate new challenges and features PLM software providers are working on, for example related to the Industry 4.0 (e.g. chatbots, AI, VR, AR). Updates and integrations to the present framework will be based on the evidences coming from secondary sources and semi-structured interviews to an experts' panel with members coming from fashion industries and software houses.

Moreover, the present work has constituted the starting point for an ongoing research related to the definition of a comprehensive framework for PLM adoption within fashion companies, starting from the analysis of the requirements up to the deployment of the selected software.

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