Product Life Cycle Management: Relationship between Product Lifecycle Management Centric Information and Product Quality

Waseem Ali Tipu[*],Fawad Haider[†] ,Muhammad Imran[‡]

Abstract

Product Lifecycle Management (PLM) is a phenomenon to manage business activity from its idea all the way through its life till it is retired and disposed of. This study aims to find out the relationship between PLM-centric information attributes and product Quality during the use phase of a product. An adapted questionnaire was used for data collection. A quantitative research method and convenient sample technique is used; however special attention is given to include various sectors of the industry. Finally, 149 complete questionnaires were used for statistical inference. Empirical evidence showed a statistically significant impact of Product usability (i.e. 64.9%) and product maintenance (i.e. 59.3%) but an insignificant impact of product awareness (i.e. 40.7%) on product quality. This study is an addition to existing knowledge on the subject in general and the impact of PLM-centric information during the use phase in particular. This study can be applied by industrialists and PLM experts to enhance as well as maintain product lifecycle management in the use phase.

Keywords: product lifecycle management, product lifecycle management theory, product awareness, product response, product usability, product maintenance system, product quality

Introduction

Product Lifecycle Management (PLM) is "a basic commercial/ business methodology and a dependable systematic arrangement of professional solution. It solves problems starting from manufacturing, supervision, distribution, and decay of that specific product by incorporating all characters and facets of information" (Sodhro, Pirbhulal & Sangaiah, 2018). Product Lifecycle Management (PLM) is the business activity of managing a company's products from the very first product idea all the way through until it is retired and disposed of. (Stark, 2022; Liu et al., 2020). The product's lifecycle comprises five phases (Fig. 1) and in each phase, the product is in a different state.

[*] Ph.D. Scholar at Department of Management Studies, Bahria Business School, Bahria University Islamabad Campus, Pakistan

[†]Ph.D. Scholar at Department of Mechanical Engineering, HITEC University Taxila

[‡] Assistant professor, Department of Management Sciences, Qurtaba University of Science and Information Technology, Dera Ismail Khan, Pakistan

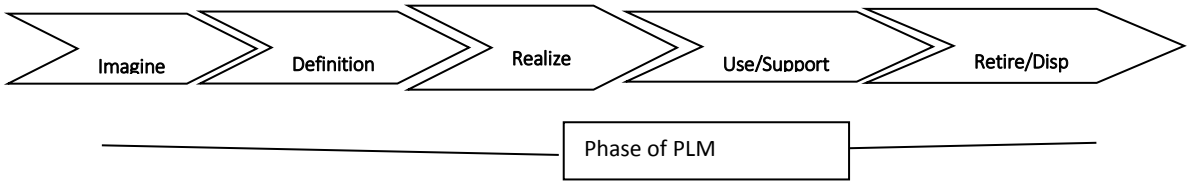


Figure 1: Phases of Product Lifecycle Management

Source: Stark, J. (2016). Product lifecycle management. In Product Lifecycle Management (Volume 2) (pp. 1-35). Springer, Cham.

It is just an idea in people's heads during the imagination phase but in the definition phase, the idea is converted into a detailed description. The product exists in its final form/ shape by the end of the realization phase and during the support/ use phase, the product remains with the customer for usage. Finally, the product enters into a phase where it does not remain useful and thus retires by the customer as well as disposed of by the user/ customer. Specific activities linked with the specific phase of the product's life cycle varies from one industry sector to another. It is very important to manage a product throughout all the phases and ensure that everything works well. In this way, the product makes good money for the company as the product has been managed throughout its lifecycle i-e "from cradle to grave" (Stark, 2016).

PLM encompasses the management of the complete procedure of arranging ideas, conceptualization, plan, approval, generation, and administration of a product by incorporating different controls, work processes, and frameworks over a complete product life (Kung, Hung & Wu, 2015). To acquire precise and productive help from PLM, it is compulsory that a product must be dealt with a complete information picture encompassing a complete life span with the help of an information model (Milicic et. al., 2017).

In the present-day environment, the initial phases of PLM have grasped the eyes of industrialists and academicians because of their more impact on the design and developmental aspect of a product. The user phase has remained away from eye focus because of the "lack of information during the use phase". In this phase product remains with the consumer and information gathering during this phase is a bit difficult task (Wellsandt, Hribernik & Thoben, 2015).

Different researchers have perceived and explained quality differently. Quality threshold lies with the image/ perception of the user and can be ascertained by feedback. The quality of any product can be

dependent on the information about the usage of that product (Zhang et. al., 2019). Owing to a lack of information, the quality of any product becomes questionable and thus it seems difficult to manage the product's life throughout its life span. Many researchers have applied and discussed PLM-centric data/ information and management for product optimization as well as for product quality management (Gao, Souri & Keates, 2017; Arthur, 2017; Eickhoff, Forte & Göbel, 2022).

PLM is a subject of great concern in the modern-day business world. Companies need to have mechanisms for the new trend with the advent of modern technology. However, there is a lot of potential for improvement, especially concerning product quality or quality management as it is the less researched context in PLM (Zhu, Giddaluru, Elsouri & Gao, 2022). So, there is a requirement to formulate the mechanism to establish and monitor product quality throughout the life cycle. This study focuses on product quality during the use phase, which is again a less researched area in PLM (Wellsandt, Hribernik & Thoben, 2015). Rachuri et al., 2008 have explained the PLM-centric information attributes as product awareness, product utility/ usage, and product maintenance. According to Paavel, Karjust, and Majak (2017), PLM-centric information needs to be explained throughout the product life so that it can help the product as well as its quality management. Basing on the gap we can formulate our research question as follows:

RQ1: Is there any relationship between PLM-centric information attributes and product quality?

In order to meet the requirement of the research question, we can further break down the research question attributable to PLM-centric information attributes (i.e. product awareness, product utility/ usage, and product maintenance).

RQ1(a): Is there any relationship between product awareness and product quality?

RQ1(b): Is there any relationship between product utility/ usage and product quality?

RQ1(c): Is there any relationship between product maintenance and product quality?

Literature Review

PLM is a business strategy to maintain the company's product throughout its life. PLM oversees the product from its beginning through its progress, evolution, and maturity until the end of the product's life. The key objective of PLM is to increase product revenues, reduce product-related costs, exploit the value of the product portfolio, and amplify the

estimation of present and future products for both customers and shareholders. (Vezzetti et. al., 2014). PLM is considered the best business movement that can deal with the product of an organization over a complete lifecycle in the best way. Product lifecycle management (PLM) has appeared as a dynamic authoritative and mechanical methodology in a recent couple of years. It empowers the agents for the management of a product with powerful administration regarding that product for assembling and building a business (Deuter & Rizzo, 2016).

Product lifecycle management (PLM) provides a strategic solution to manage information about a product throughout the product's lifecycle (Stark, 2016). PLM is very much possible and executable due to the latest advancement in technologies in the field of information and communication. In order to support the PLM system information, systems have been designed which are termed "PLM systems". These PLM systems support the firms to share knowledge and information irrespective of organizational boundaries (Tai, 2017). The emergence of the PLM system has provided a platform for inter-organizational and integrative internet-based information sharing. This platform facilitates the conception, alteration, and exchange of information all over the product lifecycle (Stark, 2016). PLM system also empowers firms to manage product portfolios and their information by supporting the description and adjustment of workflows during the development of a product (Tai, 2017). Therefore, proper product life cycle management is needed to monitor losses and performance degradation. PLM is a great business activity that integrates the management of information facilities and business process approach throughout the lifecycle of a product (Menon et. al., 2019).

Defining Product Lifecycle Management or PLM

Geceveska, Stojanova, and Jovanovski, (2013) define "Product Lifecycle Management (PLM) bolsters the ability of novelty, design, creation, management, share, and usage of product data, information, and knowledge in virtual enterprise networks by coordinating people, processes, and technology" (Littell, 2016). Stark defines PLM as "The procedure or action to manage a company's products across their lifecycle in the most effective way" (Stark, 2016; 2020; 2022).

Components of the PLM Approach

PLM is a coordinated tool encompassing the trustworthy arrangement of techniques and instruments related to IT for overseeing information related to the product, its designing procedures, and applications along the distinctive periods falling in the lifecycle of a

product (McKendry, Whitfield & Duffy, 2022). PLM is a tremendous heap of complex IT apparatuses and applications that help advanced planning and assembling. This implies amid the joining stage where countless choices must be made to guarantee fruitful usage. After PLM execution, organizations are likely to get cost decrease, quality change, efficient, and better business choices (Paavel, Karjust & Majak, 2017). PLM support is not a simple process rather it is complex practice because it involves information transfer within a product as well as amongst all the stakeholders involved in the product management features of that specific product throughout its life span. Therefore, it is important to incorporate all the partners in the communication model from all facets linked with to product to achieve complete mental mode harmonization (Marchetta, Mayer & Forradellas, 2011)

PLM-Centric Information Attributes

Organizations and firms are investing hugely in PLM systems to get support for product development and product management across the complex product life cycle management and formulate a framework to incorporate the necessary attributes (Conlon, 2022). The focus of PLM information remained with the development of the product including different distributed locales. Although the focus is changing towards makers and providers as well because users give preferences and desires to makers for expected criticism (Sorli & Stokic, 2009). It is only possible during the use phase that the client can provide input about the product because the product is being used at that time and that is the perfect time to review the advancement of the product by analyzing the criticism on the product. Thus, PLM models can stretch over a complete lifecycle to manage products properly (Sorli & Stokic, 2011). PLM Information content can be divided into three attributes includes Product awareness, Product utilization/usability, and Product maintenance.

Product Awareness

This explains "What" about the product describing its composition, its characteristics, and its physiology. For information dealing with the "what" of the product, entailing its geometry and material composition. (Rachuri et al., 2008). Product Information is at the center of any shopping background. Product data is partitioned into offers and catalog information. This incorporates further enlightening information like properties, highlights, pictures, remarkable identifiers, and so forth. Late methodologies for Product Lifecycle Management (PLM) go for the effective usage of accessible product data. A purpose behind this is the

measure of data is developing, because of the expanding multifaceted nature of the product, and simultaneous, communication forms along the lifecycle. (Collins, 2007). Researchers have discussed about the significant relationship between product awareness and quality. (Chi, Yeh, & Yang, 2009; Thanh, 2012).

Product Utilization

This aspect explains the information explaining the "Why" of the product by unfolding the functional details leading to the expected behaviors of a specific product (Rachuri et al., 2008). ISO describes usability as "The maximum grade at which a product can be utilized by a resolute user to achieve designated goals with suitability, proficiency, and accomplishment in a predefined set of utilization. Usability is mostly related to the functionalities of a product. Usability measures a product's utility, capacity, subjectively pleasing for a user, and reliability (Jokela et. al., 2003). Seva et al. (2011) have discussed the significant and positive relationship between product usability and quality. (Seva et. al., 2011).

Product Maintenance System

This explains the information related to "How" a product is formulated, and how it will operate and be disposed of after proper maintenance. Hence, this leads to maintenance-related information in the lifecycle of the product. Lifecycle information describing "how" the product is made operated and will continue to operate properly and disposed of. (Rachuri et al. 2008). Maintenance is a critical piece of the lifecycle of installed frameworks and must be considered from the design stage until the end of life. Maintenance covers two parts of frameworks that are operation and execution. Maintenance is mostly performed on suspicion of or in response to a disappointment. Maintenance is performed to guarantee or reestablish framework execution to determined levels. There can be predictive, preventive, corrective, or failure-finding maintenance (Supriyanto, Kurniati & Supriyanto, 2021). Researchers have claimed a significant and positive relationship between product usability and quality (Fakher, Nourelfath & Gendreau, 2018).

Product Quality

The literature identifies two types of quality including perceived and objective quality. Perceived quality is an outcome of a consumer's subjective judgment about the product whereas objective quality explains the designs of the product (Zeithaml, 1988; Dodds et al., 1991; Aaker, 1991). Garvin (1983) also proposed that perceived quality describes users'

recognition while objective quality defines manufacturing orientation. (Wang & Tsai, 2014). Thus, the difference between objective and perceived quality lies in that objective quality has a pre-designed standard for a product, but the perceived quality is influenced by internal and external product features, which is an assessment basis for consumers (Harju, 2022). In this study, we have taken quality as a unified phenomenon; however, we can say it is more of subjective quality being its consideration during the use phase.

Product Life Cycle Management Theory

The theory of the product life cycle was proposed by Raymond Vernon (1966) in his article titled, "International Investment and International Trade in the Product Cycle". He believed that product also has life like human life and divided the product life into different phases from idea until it is disposed of. These product stages are relevant to the development of a product strategy as well as a market strategy (Han, 2022) Life cycle theory provides a great range of indicators, parameters, and tools to evaluate the transformation of a product phase into another (Pan, Chen, Wang, & Wu, 2022). This study has used the product life cycle management theory as a base to evaluate the relationship of PLM-centric information attributes with product quality in the use phase.

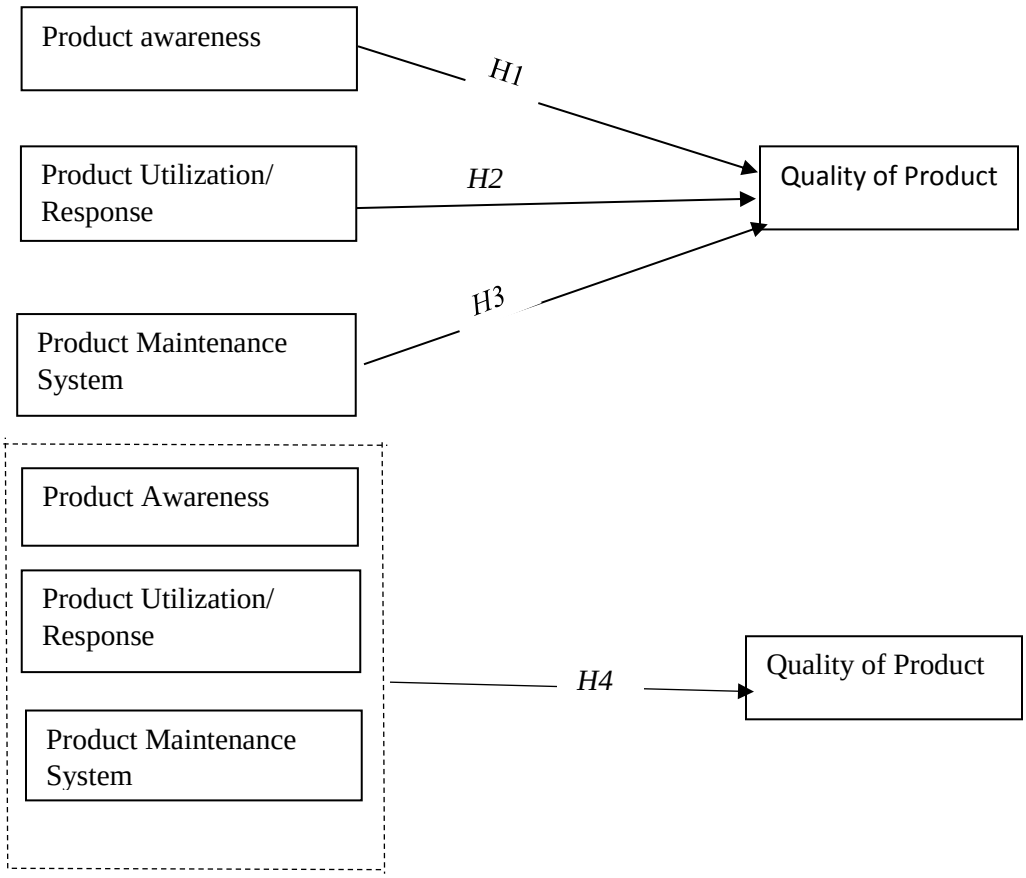
Conceptual Framework

Product Lifecycle Management (PLM) frameworks have driven item design and creation improvement for more than a quarter century yet the business place used extreme limits due to growing complexity in the business environment. The administration of PLM is pointed in driving all the particular zones that affect segments of life cycle stages like support, quality, data structures and costs, capacity, product administration etc, PLM-centric information has been revolving around the following variables.

- Product Awareness. This explains "what" about the product describing its composition, its characteristics, and its physiology.
- Product Response/ Usability. This aspect explains the information explaining the "Why" about the product by unfolding the functional details leading to the expected behavior of a specific product.
- Product Maintenance System. This explains the information related to "How" a product is formulated, and how it will operate and be disposed of after proper maintenance or completing life. Actually, it is the product's maintenance-related information during the life cycle of a product.

- Product Quality. The composition of highlights and qualities of a product which decides its desirability. Moreover, it can also be controlled by the maker to meet certain fundamental prerequisites

The figure below explains the conceptual framework of the study and explains that product quality (DV) is influenced by the PLM-centric information attributes.



Research Hypotheses

H1: Product awareness and product quality is significantly related.

H2: Product utilization/ usability and product quality is significantly related.

H3: Proper maintenance system (preventive/ corrective) and product quality is significantly related.

H4: PLM-centric information attributes (product awareness, product utilization/ usability, and product maintenance system) have a statistical impact on product quality.

Research Design

Population and Sample

Haseen Habib Company had been selected for research purposes being well-reputed and the largest national supplier of safety equipment. It is the oldest firefighting equipment company in Pakistan with vast customers from different sectors including energy, health care, industrial, technology, telecom, and banking. It provides safety equipment with product awareness specific to that product through pamphlets as well as in persons. It also enlightens the user about usability with the agreement of availing the maintenance/ service facility. The scope of service includes periodic inspection, maintenance, troubleshooting, and repair of fire detection and alarm system, Fire pump and hose reel system, and Fire extinguishers. In addition, the service also includes the following:

- Maintains an updated plan of fire-related equipment and systems in each facility.
- Timely information and advice on new regulations, standards, and procedures.

Haseen Habib Company has more than 1200 customers all over Pakistan. The sample size for research calculation was calculated by Yamane (1967) as follows:

$$\mathbf{S= N/1+N\ (e)^{2}}$$

$$S= 1200/1+1200(0.05)^2$$

$$S= 300$$

N= total population

E = error term/ confidence interval = 0.05/95% confidence interval

The research study is based on data obtained from the received questionnaire from the customers of the Haseen Habib Company. One variable is the dependent variable (Product Quality) and three are independent variables (includes Product Awareness, Product Usability/ Response, and Product maintenance system). Statistical package for

social science (SPSS) is used to analyze the data that is collected from annual reports and received questionnaires. Correlation and Regression techniques are used to get results.

Research Instruments

A questionnaire comprising ten questions for each variable was adapted and then circulated to all the customers/ clients through Haseen Habib Company's management. The questionnaire result was obtained through a 5-point Likert scale in which "1" represented Strongly Disagree, "2" represented Disagree, "3" represented Neutral, "4" represented Agree and "5" represented Strongly Agree. 350 x questionnaires were sent for the response but 178 x questionnaires were received back. 29 x questionnaires were excluded as they were not properly filled. Finally, the responses, we got, were 149 and the calculations have been worked out as per the response of the received questionnaire.

Quantitative Technique

In this study, descriptive and inferential statistics along with mean, standard deviation, normality, reliability, and factor analysis were used. In order to test the hypotheses correlation and multiple regression analysis have been used in SPSS.

Results

Table 1

Demographic Characteristics

Variable	Demographics	N	%age
Designation	Manager	94	63.1
	Non-Managerial	55	39.9
		149	100
Provinces	Punjab	43	28.9
	Sindh	38	25.5
	KPK	37	24.8
	Baluchistan	31	20.8
		149	100

Table-1 shows the demographic characteristics of the informants. There were 94 managerial staff who participated in this study these are 63.1% of the total sample size and the non-managerial staff 55 which was 36.9% of the total sample size. People from different provinces participated in this study. 43 x respondents belonged to Punjab, i.e. 28.9% of the sample size. 38 x respondents were from Sindh, i.e. 25.5% of the total sample size. 37 x respondents belonged to KPK, i.e. 24.8% of the sample size, and 31 people were from Baluchistan, i.e. 20.8% of the total sample size. The total sample size taken from the formula was 300 and out of 300 total of 149 complete questionnaires were returned and used in this study.

Normality Test

Normality test defines the distribution of data, as normal data distribution is an important and basic requirement to apply any parametric statistical test including t-test, ANOVA, or regression analysis. Tabachnick and Fidell (1996) have highlighted the importance of normal data distribution for most analyses. Tabachnick and Fidell (1996) have also explained two aspects of normality i.e. skewness and kurtosis. Both aspects are important to establish normality about any data. The criteria established for the normality test are ±2 for kurtosis and ±1 for skewness. Pallant (2010) has described that symmetry of distribution is depicted by skewness whereas peakedness of distribution is explained by kurtosis. A positive value of skewness specifies the data pile up on the left side whereas it is on the right side in the case of a negative skewness value. In the case of a positive kurtosis value, it is a pointed and dense-tailed distribution whereas in the case of a negative kurtosis value there is flat and light-tailed distribution (Field, 2009). The normality test for this study has been conducted via skewness and Kurtosis. Reliability for this study was tested through Cronbach's alpha. The accepted value of Cronbach's alpha is 0.70 to consider data as reliable. Table 2 explains that the data is reliable as all the Cronbach alpha values are greater than 0.70. The highest mean score is reported for product quality M=3.6642, S. D=0.72657, followed by product utilization M=3.5960, S. D=0.69540, then product maintenance M=3.5623, S. D=0.67874, the lowest score is reported for product awareness M=3.5114, S. D=0.64348 respectively.

Table 2

Normality and Reliability

	N	Mean	S. D	Skewness	Kurtosis	Alpha
PA	149	3.5114	0.64348	0.261	-0.344	0.766

PU	149	3.5960	0.69540	0.088	-0.305	0.823
PM	149	3.5623	0.67874	0.111	0.521	0.836
PQ	149	3.6642	0.72657	-0.489	0.340	0.853

Exploratory Factor Analysis

This study is exploratory; therefore, there is a requirement to identify the hidden variables in each domain to provide direction to other future researchers. Factor analysis aims at motivating the researcher in the identification of a variable set to determine whether latent variables are present which may be comparatively independent of each other. Factor analysis may also be used to reduce the variable number, identify any latent or underlying variable that may exist in the correlation measurement pattern (Hair et al., 2007).

The first rule of thumb explains measurement issues by using an interval scale (Field, 2009). The second rule of thumb stresses on rationale required to support the possibility of factors' existence before performing factor analysis (Hair et al., 2007). The third rule of thumb describes the value of BTS (sig < 0.5) present amongst items. The fourth rule of thumb is the KMO test or Kaiser Meyer Olkin measure of sampling adequacy (Field, 2009).

The KMO values vary between 0-1 in the Kaiser Meyer Olkin measure of sampling adequacy test. The KMO value of 0.7 is good but it's problematic if the KMO value is less than 0.5. In this regard, Hutcheson and Suffornіou (1999) have suggested that if the KMO value lies between 0.5 to 0.7 it is acceptable and considered as the medium range. In case it lies between 0.7 to 0.8 it is good but in case it lies between 0.8 to 0.9 it must be taken as very good and the KMO value above 0.9 is superb. Measurement of internal reliability is the last criterion and that is already discussed in reliability analysis.

Apart from the requirement, the researcher also needs to decide which type of factor analysis to be used. As there are two types i-e principal component analysis (PCA) and principal axis factoring (PAF) based on the procedure to find commonality present (Bryman and Cramer, 2004). PCA highlights which linear component exists within data and how it can contribute to the component (Field, 2009) whereas underlying factors are estimated by PAF only (Dunteman, 1989). Factor analysis tells

us about the commonality of each item i.e. variance explained by the proportion of factors and factor loading that explains the item's contribution in that particular item.

Factor analysis provides the initial solutions about the different factors that are part of set of items. This is done by the allotment of eigenvalues of each item that accounts for total variance by that factor. In this study, PCA has been employed to identify the underlying latent constructs to measure variables instead of data reduction.

In the second step, we decide about the retention of the number of factors. There are two criteria for this purpose i.e. Kaiser Criterion and the graphical scree plot test. Kaiser criterion describes the selection and retention of the factors having eigenvalues greater than 1(Wisner, Blaike, Cannon & Davis, 2003). When the number of items is less than 30 and the commonality is greater than 0.70, or when the sample size is more than 250 and the mean commonality is greater or equal to 0.6 then Kaiser Criterion is the best choice (Stevens, 1996). According to Bryman and Cramer (2001), we use a graphical scree plot test to draw a graph and is suitable when the sample size is more than 200. In this study, we have used both methods.

Factor rotation is the third decision, which is to enhance the factor loading of the items and their interpretability. In this regard, oblique rotation and orthogonal rotations are two methods. The first method allows the factors to be correlated while the other method produces factors, which are independent of each other (Bryman and Cramer, 2001). Oblique rotation is used in this study.

The last step is factor loading which is the degree of correlation between the factors. According to Hair et. al., (2006) factor loading greater than $\pm$ 0.30 is considered minimum level, $\pm$0.40 factor loading is important but it is significant at greater than $\pm$ 0.50. From table-3 it is evident that the sample is adequate for EFA. Moreover, according to table-4, four factors with initial eigenvalues greater than 1 have been retained. Furthermore, one item highlighted in bold black in table-5 has been cross-loaded. So future studies may exclude this item from their analysis.

Table 3

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.	.848
Bartlett's Test of Sphericity Approx. Chi-Square	3721.644

Df	780
Sig.	.000

Table 4

Initial Eigen Values

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	12.888	32.221	32.221	12.888	32.221	32.221
2	3.716	9.289	41.510	3.716	9.289	41.510
3	2.338	5.846	47.356	2.338	5.846	47.356
4	2.056	5.141	52.497	2.056	5.141	52.497

Table 5

Pattern Matrix[a]

	Component			
	1	2	3	4
PRODUCTRESPONSE	.819			
PRODUCT QUALITY	.798			
PRODUCTMAINT	.783			
PRODUCTMAINT	.753			
PRODUCTMAINT	.729			
PRODUCTRESPONSE	.716			
PRODUCTQUALITY	.676			
PRODUCTMAINT	.649			
PRODUCTQUALITY	.630			
PRODUCTMAINT	**.589**	**.457**		
PRODUCTQUALITY	.551			
PRODUCTMAINT	.471			
PRODUCTQUALITY				
PRODUCTMAINT		.936		
PRODUCTMAINT		.753		
PRODUCTQUALITY		.738		
PRODUCTMAINT		.727		

PRODUCTRESPONSE	.686			
PRODUCTQUALITY	.566			
PRODUCTQUALITY	.523			
PRODUCTMAINT	.515			
PRODUCTQUALITY	.467			
PRODUCTAW		.892		
PRODUCTAW		.800		
PRODUCTAW		.681		
PRODUCTRESPONSE		.568		
PRODUCTAW		.563		
PRODUCTAW		.469		
PRODUCTRESPONSE		.463		
PRODUCTRESPONSE		.454		
PRODUCTAW				.908
PRODUCTRESPONSE				.865
PRODUCTAW				.631
PRODUCTRESPONSE				.561
PRODUCTAW				.550
PRODUCTRESPONSE				.465
PRODUCTAW				.464
PRODUCTRESPONSE				.438
PRODUCTAW				.425
PRODUCTQUALITY				

Extraction Method: Principal Component Analysis.
Rotation Method: Promax with Kaiser Normalization.
a. Rotation converged in 6 iterations.

Product Awareness: PA, Product utilization/ response: PU, Product Maintenance: PM, Product Quality: PQ

Table-6

Correlation

	PA	PU	PM	PQ
PA	1			
PU	0.759**	1		
PM	0.565**	0.724**	1	
PQ	0.638**	0.806**	0.770**	1

Product Awareness: PA, Product utilization/ response: PU, Product Maintenance: PM, Product Quality: PQ

Table-6 shows the Pearson correlation movement between Product Awareness and Product Response/ Utilization as positive and highly significant i.e. r = 0.759, p= 0.000. It means that increase in one variable will increase in other variables. The correlation between Product Awareness and Product Maintenance is positive and is highly significant i.e. r = 0.565, p= 0. 000. Correlations between Product Awareness and Product Quality are positive and significant i.e. r = 0.638, p= 0.000. Correlations between Product Maintenance and Product Utilization is positive and significant i.e. r = 0.724, p= 0.000. Correlations between Product Maintenance and Product Quality are also positive and significant i.e. r = 0.770, p= 0.000. Correlations between Product Quality and Product response are positive and significant. i.e. r = 0.806, p= 0.000. These are the correlations between variables of the PLM-centric Information Questionnaire; in this study, we have found these values after this analysis of correlation at level 0.01 (2-tailed).

Table-7

Regression Analysis

D.V	I.V	R	R^2	F	B	p	Support
PQ	Constant	0.638	0.407	101.087		0.000	H_1 Yes
	PA				0.638	0.000	
PQ	Constant	0.806	0.649	271.968		0.000	H_2 Yes
	PU/R				0.806	0.000	
PQ	Constant	0.770	0.593	214.273		0.000	H_3 Yes
	PM				0.770	0.000	

Product Awareness: PA, Product utilization/ response: PU, Product Maintenance: PM, Product Quality: PQ

The results in the above Table-7 explain the number of things. First, it explains how much of the variance in Product Quality is by the predictive power of PLM-centric information components i-e (Product Awareness, Product utilization/ response and product maintenance). The product awareness (PA) is denoted by the "R^2" which is 0.407. Here the results explain that 40.7% variance in Product Quality is due to product awareness. The goodness of fit F=101.087, $p<0.05$ and $\beta=0.638$, $p<0.05$

thus H_1 is substantiated. We can deduce that product awareness do impact product quality. Secondly, the variance of product utilization/ response is explained by the PR which has a significant beta score (R^2= 0.649, 64.9% variance, β=0.806 with significant p-value<0.05, F=271.968, p<0.5). Thus H_2 is also accepted. Finally, the product maintenance shows R^2 = 0.593 i.e. 59.3% variance upon the quality of a product. F= 214.273, β=0.770, p<0.05 H_3 also accepted.

Discussion

PLM is a strategic process that is used and practiced by companies to manage their products effectively. Many companies have tried to improve their processes by incorporating PLM drills and procedures (Mousavi, Mohammad Zadeh & Zare, 2022).

The primary achievement of the study is to find out the impact of PLM-centric Information on Product Quality. The result concludes that all the independent variables (i-e product awareness, product response/ utilization, and product response) have a substantial and convincing effect on Product Quality.

The conducted study remained focused on mentioned objectives and hypotheses. Initially, the hypotheses had to check the variable relationships. It was deduced from the study that all the independent variables i.e. Product Awareness, Product Response/ Utilization, and Product Maintenance system were positively and significantly correlated with Product Quality, which leads to establishing that variables are correlated hence all the hypotheses of the relationship are accepted. Correlation results supplemented the Regression results. Subsequently, the regression model appeared fit, the value of r square contributed significantly to Product Quality. The results proved that there was no multicollinearity and overall data was normal.

After finding the correlation and regression of independent variables on Product Quality, a composite impact of independent variables was found on Product Quality, which showed that in the composite framework, though the component of PLM centric Information i-e Product Utilization / Response and Product Maintenance System remained significant yet Product Awareness remained insignificant.

The study results show that product lifecycle-centric information attributes have a significant impact on product quality and we can manage product quality with proper management of PLM-centric information attributes. If the customer is given proper awareness about the product, the product is being utilized properly with all its functions and product maintenance is being managed properly then the quality of the product will

remain good. Hence, product quality management is dependent on PLM-centric information attributes.

The study results are in line with the correlation and regression results of the Sierra, Iglesias, Markovic, and Bus Ethics. They have found a significant relationship between product awareness and product quality. (Sierra, Iglesias, Markovic & Singh, 2017). The obtained results are also aligned with the findings of Mc Call's quality model (Al-Qutaish, 2010 & Trichkova, 2015). They all found a significant relationship between product usability and product maintenance with product quality like Mc Call's quality model and ISO 9126 Quality Model. (Trichkova, 2015; Lestantri & Rosini, 2018).

Limitation

Limitations are part of any conducted study as ideal environments are very difficult to achieve. Similarly, this study had a few limitations. The first limitation was the sample size and analysis period for the study, as safety equipment can only be religiously practiced and reviewed in real-time scenarios. Secondly, the study is based on the primary data, which is prepared by the customer's feedback on their safety equipment handling, in this way the complete study is dependent on the customer's feedback. Thirdly, this study used one-time data collection to complete the study in the prescribed time.

Implications of Study/ Future Research Dimension

As the present-day industry is developing and PLM is an important aspect of our industry, so it can be a great addition to business development. Thus, this study can have inferences the PLM practitioners, future researchers, and academicians. PLM is a highly focused and eye-catching issue in the industry. This study has contributed to the existing literature as an endeavor has been made to bridge the gap between PLM-centric information attributes and product quality. This study can yield dividends if applied successfully with the aim to enhance product quality by raising PLM-centric information attributes throughout the product's life in general and during the use phase in particular. Future researchers may extend this research model by adding more dimensions including PLM-centric information attributes, moderators or mediators attributable to the business scenarios of the country. Moreover, instead of using one-time data, the future researcher may conduct their study on longitudinal data.

Conclusion

Product lifecycle management (PLM) is a business methodology that maintains a product's lifecycle. This study has provided evidence that PLM-centric information will have a significant impact on product quality. In this way, if industrialists/ PLM expert enhances their emphasis on PLM-centric information attributes (i-e Product awareness, Product Utilization/ Response, and Product Maintenance) then Product quality will get enhanced and will provide a very positive economic effect to the business.

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