



PLM in SME, What Are We Missing? An Alternative View on PLM Implementation for SME

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Abstract. Today, the concept of Product Lifecycle Management (PLM) is widely accepted as strategically important. It is used to manage the increasing complexity of products, processes and organizations. The need to adopt PLM is growing rapidly for Small to Medium-sized Enterprises (SME). PLM implementations are costly and require a lot of effort. The business impact and financial risks are high for SME. Also, SMEs seem to have relatively more difficulties to benefit from PLM. The study at hand addresses the question, based on literature research, why these difficulties exist and how they can be overcome. To answer that question, three sub questions are discussed in this paper. (1) A generic PLM implementation process structure. (2) A list of identified PLM implementation challenges, specific for SME. (3) A classification of PLM research for SME, related to the common PLM implementation process structure. A hypothesis for a PLM implementation failure mechanism in SMEs is formulated, based on the findings. Also, a potential research gap on operational implementation knowledge in SMEs is identified.

Keywords: PLM · SME · Implementation

1 Introduction

Product Lifecycle Management (PLM) is defined as a business activity or strategy. It manages products from their conception to their end-of-life disposal or recycling. This definition is used by industrial institutions like CimData [1] and Gartner Group [2], but also by academic authors like Stark [3, 4], Eigner [5] and Grieves [6, 7]. PLM should not be confused with *PLM software* that supports processes within PLM. Examples of PLM software are *Product Data Management* (PDM), *Computer Aided Design and Manufacturing* (CAD/CAM), *Project Management*, *Workflow Management* and *Production Planning*.

Nowadays, many *Small to Medium-sized Enterprises* (SME) start to adopt PLM. An SME, as defined by the European Commission [8], is a company with less than 250 employees with an annual turnover up to EUR 50 Million. For PLM implementations, SME specific challenges could also apply to larger companies.

The importance of PLM for companies grows with the increasing complexity of products, processes and organizations [5], also in SMEs. The introduction of the concept of *The Fourth Industrial Revolution* or *Industry 4.0* intensifies this increase in complexity [9]. Organizations have to work differently than before, if they want to make use of developments like *Internet of Things* (IoT), *Product Service Systems* (PSS) or *Mass Customization*.

Industry and academia have made efforts to improve the methods of PLM implementation. Nevertheless, industry surveys [10–13] show that companies are still struggling to implement PLM successfully. Some authors [4, 14, 15] claim that 50% of PLM implementations do not achieve their initial project goals. Unfortunately, no specific definition of project failure or project goals is giving in these references.

For this paper, we analyzed published research about PLM in SME. We searched for PLM challenges and for methods to overcome these challenges. To organize the results, we reviewed publications about PLM implementation and derived a suitable classification structure. The research method is explained in Sect. 2 and the result can be found in Sect. 3. In Sect. 4, we formulate a hypothesis for an SME specific failure mechanism, identify a potential research gap and propose future research.

2 Research Method

2.1 Research Questions

The key question in this paper is: “Why do SMEs struggle to implement PLM and what are the proposed solutions in academic literature?”. To answer this question we have defined three sub-questions:

1. Which implementation methods are described in literature?
2. What are the challenges in PLM implementation, specific for SMEs?
3. Which improvements are proposed in literature?

2.2 Literature Research for PLM Implementation Guidelines

A search was done for concepts *PLM* and *Implementation*, using Scopus, Web of Science, Google Scholar. We selected papers, specifically on the implementation process, holistically or partially. This selection was based on title, keywords and abstracts. Furthermore, we did a secondary search, using the references in the selected papers. This resulted in an additional number of books, articles, dissertations and industry reports. We derived a *generic PLM implementation process structure* from this literature to classify the results from the systematic literature review on PLM and SME.

2.3 Systematic Literature Review PLM and SME

We searched in Scopus, Web of Sciences and Google Scholar for both concepts (*PLM* and *SME*). Results were left out when SME or PLM had a different meaning than our purpose or when the terms were found only in the references section (Google). We were able to obtain full texts for approximately 50% of the resulting papers (Table 1).

Table 1. Literature research results by database.

Database	Hits	Viewed	Relevant	Full text
Web of science	23	23	16	10
Scopus	66	66	48	23
Google scholar	5970	250	120	71
Total (overlapping)			148	75

We analyzed the retrieved papers in two ways. Firstly, we identified SME-specific challenges that influence the implementation and adoption of PLM.

Secondly, we related the main research topic (contribution) of each paper to one or more steps in the aforementioned generic PLM implementation process structure.

3 Results

3.1 Implementation Guidelines

We selected the following publications that contain a holistic description of a PLM implementation process: Stark [3, 4], Eigner et al. [5], Grieves [6, 7], Feldhusen et al. [16, 17], Schuh et al. [18], Bitzer [19] and Arnold et al. [20]. There is a clear structure of preparation, analysis, design and implementation that can be found in all of these publications. We derived a simplified 4-phase structure from these publications, as shown in Table 3 in Sect. 3.3.

3.2 SME Challenges

We identified SME specific challenges in the full-text papers and organized them in 12 categories. The results are listed in Table 2, ranked by occurrence.

Table 2. SME specific PLM challenges, found in literature.

SME Challenge	Sources	References
High cost of implementation	16	[21–36]
Lack of skilled resources	11	[22, 25, 27–31, 33, 37–39]
Network dependency	10	[26, 29, 33, 38, 40–45]
Limited understanding of PLM	9	[18, 22, 31, 40, 43, 46–49]
Informal processes	9	[33–35, 40, 44, 50–53]
Informal organizations	8	[27, 33, 50, 52–55]
Lack of suitable PLM solutions	7	[29, 33, 35, 36, 38, 47, 48]
Unstructured information (flow)	6	[23, 52, 55–58]
Business risk	5	[33, 42, 44, 50, 59]
PLM complexity	5	[23, 31, 33, 36, 46]
Unstructured knowledge management	4	[21, 40, 50, 60]
Lack of strategic business planning	1	[43]

3.3 Proposed Solutions in Literature

After reviewing the papers, we related the research to subphases in our generic PLM implementation process structure. Classification is based on our interpretation of the main contribution of the papers. This interpretation is intrinsically subjective, also because of variations in structure of the reviewed papers (e.g. case studies, theories, reviews, etc.)

Table 3. Research on PLM in SME, categorized by implementation phase.

Phase/sub phase	Sources	References
1. Prepare and define		
1.1. PLM Awareness	5	[42, 47, 48, 61, 62]
1.2. PLM Vision	2	[18, 63]
1.3. Maturity level	4	[31, 49, 61, 64]
1.4. Goals	2	[18, 49]
1.5. Strategy	3	[30, 63, 65]
2. Analyze and measure		
2.1. Product structure	2	[37, 54]
2.2. Processes	7	[22, 38, 47, 50, 52, 54, 66]
2.3. Organization	4	[52, 67]
2.4. Infrastructure and ICT	0	
2.5. Requirements documentation	3	[38, 47, 54]
3. Design		
3.1. Data model	17	[23, 25, 26, 28, 30, 36–38, 41, 45, 46, 60, 68–72]
3.2. Processes	18	[21, 26, 30, 36–38, 40, 46, 53, 54, 58, 67, 69–74]
3.3. Organization	3	[41, 46, 53]
3.4. Infrastructure and ICT	7	[24, 25, 27, 37, 39, 57, 59]
3.5. Specification documentation	2	[54, 65]
4. Implement and maintain		
4.1. Project management	2	[54, 75]
4.2. Vendor selection	4	[25, 32, 76, 77]
4.3. Realization	2	[37, 69]
4.4. Customization	8	[26, 35, 38, 54, 62, 69, 72, 74]
4.5. Verification	1	[27]
4.6. Deployment	0	
4.7. Training	0	
4.8. Evaluation	3	[33, 56, 62]

3.4 Interpretation of the Results

Prepare Phase. Solutions and challenges are clearly related in the papers related to this phase. Awareness creation aims to overcome the challenge of limited understanding of PLM. With insight into the potential of PLM, organizations can build a vision for the future.

Maturity assessment enables organizations to describe the gap that needs to be bridged. Furthermore, better strategic planning and reduction of business risk is possible when the gap is known to the organization. Priorities can be set rationally.

Some papers emphasize the importance of vision, strategy and goals. Nevertheless, little has been written about how an SME can define them practically.

Analysis Phase. Analyzing the current state processes and organization of an SME is difficult. This is related to the SME challenge of informal processes and organization.

Generally, SMEs are rigid on a macro level and flexible on an operational level [67]. To overcome this, several new approaches have been proposed to assess these ad-hoc processes, for example by focusing on information flow and collaboration methods.

Design Phase. The largest number of papers has been published on the design of process models, data models or on both (ontology). With these process and data models, researchers aim to solve the issue of lacking availability of suitable solutions. They propose industry specific alternatives to the existing models.

Case studies have been done with new PLM models for specific situations. No evidence for a successful universal SME-approach has been presented in the reviewed papers.

Implementation Phase. Customization gets most attention in this phase for two reasons. Some papers propose to lower the cost of software by developing a new platform for SME. It is questionable if this is a valid approach, since only 20% of implementation costs is software cost [16, 20, 26] and software development is also a cost.

Others see a need for adoption of commercial software to overcome functional deficits for SMEs. This has been studied in specific cases.

In contrast to the high interest in customization, there is less interest in operational aspects of implementation (realization, verification, deployment, training), which has also been observed in a research by Bokinge et al. [78].

4 Conclusions and Future Research

In this paper we discuss answers to the sub-questions in Sect. 2.1 and we formulate a hypothesis for an answer to the main research question.

4.1 Sub Questions

Sub Question 1, Implementation Methods. We found a common structure for a generic PLM implementation process in various publications. This process can be very elaborate if all steps are followed consistently, even for large enterprises.

This method also implies that SMEs need to formalize their processes and organization drastically, sacrificing flexibility. Flexibility is a valuable asset of SMEs.

Sub Question 2, Challenges. We have identified 12 SME specific challenges in PLM implementation. This comprehensive list of challenges helps to understand reasons for

possible PLM implementation failure in SMEs. Organizations can take these challenges into account in future PLM implementations and manage project risks better.

Sub Question 3, Solutions in Literature. We have seen a variety of approaches to PLM for SME in the papers we reviewed. Our classification in the PLM implementation process structure uncovered *hotspots* and *white spaces* in published research. The largest hot spot is *data and process modeling*, the largest white space, or research gap, is *operational implementation knowledge*.

4.2 Main Research Question

Commercial PLM systems seem to be developed for reference process models, derived from large enterprises. These reference models often do not fit SMEs (Lack of suitable PLM solutions). Also implementation partners do not have clear answers on how to implement PLM for SME [33].

Every SME specific PLM challenge could cause failure, if it is not taken into account during an implementation. Most challenges can be overcome by good project management, following generic PLM implementation guidelines.

The exception is the dilemma between flexibility and formalization. We conclude from our literature research that this challenge needs an alternative approach, compared to large enterprises.

Our hypothesis is that if organizations (companies and implementation partners) are not conscious enough about the aforementioned dilemma between formalization and flexibility, they are at risk. They will start PLM implementations in the “large enterprise style” in expectation that good project management will ensure success. At some point the organization will run into problems with flexibility, leading to increased overhead costs (application management, new administrative work, waiting times, etc.), extensive customization to overcome functional deficits and/or massive rejection by users.

4.3 Future Research

As a next step, we plan to analyze implementation projects from the past. This qualitative empirical research should give more insight into the influence of the identified PLM implementation challenges in the implementation process in practice. This research can also provide more quantitative data on failure rates of PLM projects, under the condition that a neutral definition of failure can be defined.

Also more research is needed on operational PLM implementation knowledge.

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