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TOWARDS IMPROVED MANAGEMENT WITHIN THE COTTAGE INDUSTRY: PRODUCT LIFECYCLE MANAGEMENT CASE

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Abstract:
Product Lifecycle Management remains a strategy that aims to strengthen the capabilities and competitive advantages of the company. Its implementation and its adoption depend on the problems that are brought back to be solved by this tool as well as its acceptance by the companies that will implement it. Hence, we like to introduce this approach within the cottage industry to improve its competitiveness. For this, we are going to present this article as being the first step towards the introduction of this strategy within the craft sector. So, we aim to investigate the problems faced by the craft sector, the levers favoring the establishment of this kind of approach and to analyse the independence between the problems investigated, the nature of the companies interviewed and their sector of activity. Data was gathered from surveys of 132 craft industries the primary data analysis was performed using excel and SPSS techniques and chi square test. The results affirm that the management and communication problems, as well as problems related to the raw material waste, are the most dominant in the sector. Moreover, our study shows that the problems faced by the sector are independent towards the nature of the company and the sector of activity.

Key words: *Product Lifecycle Management, waste of raw materials, needs map, a survey, levers and benefits*

INTRODUCTION

The advent of new technologies interested in analysis and development of the product throughout its life cycle, chiefly computer-aided design (CAD) software, digital models have opened the doors to virtual introduction of all kinds of technology within a company, namely Product Lifecycle Management (PLM) [1, 2].

Digital technologies are encouraging manufacturing companies in their servitization process by accelerating the offer of integrated product and service to create new value and grow relationships with customers in the Industry 4.0 era [3].

Product lifecycle management (PLM) remains a strategic business approach that applies a consistent set of business solutions in support of collaborative creation, management, dissemination and use of product definition information across the extended enterprise from concept to end of life – integrating people, processes, business system, and information [4].

Moreover, it promotes innovation, hasten product development time, minimize costs, enhance quality, visualize product information, and alleviate the communication gap between the cooperating parties [5, 6].

In the present work, we will identify the cottage industry needs and levers pushing the sector to choose PLM approach as a solution. Hence, the need for introducing software, management and design techniques enabling valuable management of the artisanal product lifecycle. These issues led to the following research questions:

- What are the major problems faced by the cottage industry?
- What are the levers and benefits pushing the cottage industry to introduce a PLM approach in there process work?
- How about the relationship between the problems encountered by the companies, their nature, and the activity sector?

Besides, it was deemed necessary to conduct a survey to answer the research questions by expressing, specifying and framing the major problems where technological tools can intervene as well as levers related to PLM introduction. Furthermore, we complete our analysis by a chi-square test to identify the relationship between the problems faced by companies, their nature and their activity sector. The Organization of the present work is as follows: section 2 includes literature review about PLM and the

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major researches about it. Section 3 explains the methodology followed and the collection of data. Section 4 presents the results found, while Section 5 provides the conclusions based on the findings of the present study.

LITERATURE REVIEW

PLM can be broadly seen as a model focusing both on the product and on its lifecycle since the product data are shared between all collaborators of a project, the actors, the stakeholders and the organizations throughout the product lifecycle by aiming to achieve the traced goals and promoting the sustainability for the product and its services [7, 8, 9].

Besides, it can be seen as a strategic business approach that applies a consistent set of business solutions in order to create, manage, control and disseminate all information generated along the lifecycle of a product [10].

it extends the scope to include the stakeholders engaged throughout the lifecycle of the product taking into consideration all the stages chiefly research and development, production, delivery, maintenance and recycling. That's why, PLM remains an appropriate solution for enhancing the enterprise competitiveness [11].

The term 'life cycle' generally indicates the whole set of phases from 'its cradle to its grave' [12]. So, it was obvious that the product lifecycle includes three phases: the beginning of life (BOL), middle of life (MOF) and end of life (EOL) [13]. The first stage, consists on design and production, the second one contains the use of the product, its service and maintenance, the third stage focus on the timespan when the disassembly, recycling, reuse or disposal are carried out. PLM systems are based on a principal framework which assists persons engaged in such projects to select and implement the suitable PLM application to satisfy their needs like document management [14].

We can notice the existence of a number of studies concentrating on different stages of PLM evolution; some of them are as follow:

The PDM (Product Data Management) prototype is dated from 1980 and was extracted from CAD (computer aided design)/CAM (computer aided manufacturing) domains and technical design [15]. In the first instance, the PLM aims to adjust the storage, recovery and recuperation problems related to an important number of files for CAD products drawings [16]. For example, to organize data in convenient and standardized form, Alemanni et al. [17] propose a new approach using methods related to the quality function deployment promoting the implementation of the model-based definition [17]. Its principal goal is to eliminate the redundant files and drawings, enhance data evenness, encourage product/process virtualization and support manufacturing and engineering fields by taking into consideration tasks related to computer aided technologies [18]. Maropoulos and Ceglarek [19], give an analysis, a classification and verification related to engineering design from the preliminary stage to the physical verification and validation of products and processes.

A qualitative evaluation was done about the PLM and its visualization solutions including security, user interaction, customization and performance. Monticolo et al. bring a deep study by developing a knowledge engineering system using a collaborative workstation approach [20]. To bear in mind that the multi agent system can be used to enhance ergonomics and collaborative solutions in industrial fields, Holtwert et al. create a secure and cloud based platform for PLM applications in plant [21].

Thomas et al., [22] present a metadata repository for semantic product lifecycle management that provides an information management layer while using a minimalist kernel-based computing architecture to display and access product data. a multitude of computer source systems. Sakao et al. aims at proposing an innovative and practical method to support manufacturers in the design of a product/service system (PSS) for resource efficiency and sustainability [23].

Tchoffa et al., [24] aim to illustrate define and demonstrate the evolutionary character required of the FIF (federated interoperability framework) since its genesis by describing the past, present and future evolutions in particular for the PLM standards testbed, virtual manufacturing and CPS (cyber physical systems).

Liu et al., [13] propose a blockchain-based industrial PLM framework to accelerate the exchanging of data and service distribution in the product lifecycle. First of all, they suggested the concept of industrial blockchain as the use of this technology in the industry with the integration of IOT, M2M and efficient consensus algorithms. The author proposed an open and secure information storage and exchange platform for different stakeholders to attain openness, interoperability and decentralization in the era of Industry 4.0.

Jiewu et al., [25] examine how blockchain can overcome potential barriers to achieving sustainability from two perspectives namely the manufacturing system perspective and the product lifecycle management one: the survey first examines the literature on these two perspectives, after that, the state of research on blockchain-based sustainable manufacturing is presented. The document ends with a discussion of the challenges and social barriers that blockchain technology will be able to find and that it will have to overcome in order to ensure its sustainability at the industrial and commercial level.

Mckendry et al., [26] introduce the first framework for implementing product lifecycle management in high value-added custom engineering programs. When implementing PLM, and in order to decide on the PLM approach to use, it is essential to carry out an organization which must include the strategic objectives and the basic processes to be employed. The research first highlights that scale, complexity, uncertainty, long lifespan, maturity management and inability to prototype engineering to order products (ETO) lead to significant challenges requiring a tailored approach for implementing PLM. In order to develop the framework leading to address these challenges a thematic

analysis of 27 semi-structured interviews of PLM practitioners in the context of ETO product development was carried out.

It should be noted that the authors [27], suggest an approach to choose the most appropriate system for SMEs. So, to choose the most effective PLM system, they propose a methodology based on a process of determining the needs, of specifying the requirements of management as well as the evaluation of a supplier to be able to establish this kind of system [27].

The authors Bertoni et al., [28] carried out a systematic literature review combined with a mapping study to understand how digital twins are applied today across the PSS lifecycle (beginning of life, middle of life and end of life), in terms of types, capabilities, research facets, and contribution facets.

Ebel et al., [29] support product-centric companies in customer-centric smart service innovation with a pattern-based service design approach, which addresses the challenge to assess the potential of digital technologies for creating new business opportunities, while transforming from transactional product sales towards relationship oriented solutions already in the design phase.

Woitsch et al., [30] propose a model-based approach, including digital twinning, showing how data can be integrated along the product & service lifecycle leading to closer integration of products and services.

The PLM approach is considered to be a reference framework that can be useful for the company according to its needs. It puts the company at the center of the observations under certain constraints relating to the quality of the product, the collaboration between the company and all the stakeholders as well as the know-how. Then, each company is able to understand and use the PLM approach according to its context, its existing and its priorities. In the next chapters, we will focus on the craft industry as a case study, we will try to delimit the problems faced by the sector and which can be solved by the introduction of a PLM approach. Similarly, we will focus on the acceptance of this kind of tools through the study of the levers favoring the establishment of this kind of approach within the sector. In addition, we will study the correlation between the problems faced by the surveyed companies, their nature and the sector of activity to find if the foundation of a technological approach based on PLM systems to solve a specific problem will be influenced by the companies nature and activities sector.

DATA AND METHODOLOGY

After carrying out a literature review about the PLM which is considered as a helpful strategy for the organizations to perform their activities, we choose to integrate this concept in the Moroccan social economy sector that's why and as a first step we limit the objectives of our study as follow:

- Identify the problems and needs faced by the cottage industry.
- Identify the levers and factors influencing the integration of PLM within the cottage industry.
- Write a report based on the results found.
- Identify the problem where technology can intervene.
- Proposal of solutions (will not be dealt with for the moment but our study may constitute a starting point for the achievement of this objective).

For this reason, we choose to follow the methodology proposed in Figure 1.

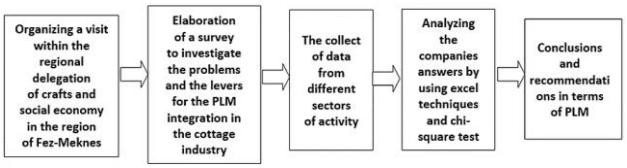


Fig. 1 The methodology conducted to satisfy the objectives of the study

A questionnaire realization

To carry out our study, we organized a visit within the regional delegation of crafts and social economy in the region of Fez Meknes, where we were able to find a certain number of managers and executives in the sector. In the same way, we tried to contact a multitude of craftsmen in order to be able to talk about their trades, the advantages and disadvantages of the trade as well as the difficulties and risks encountered.

The first observation made by the group of participants is that the craft sector faces a number of technical as well as organizational problems which leads us to identify and classify the failures encountered by the sector (Figure 2).

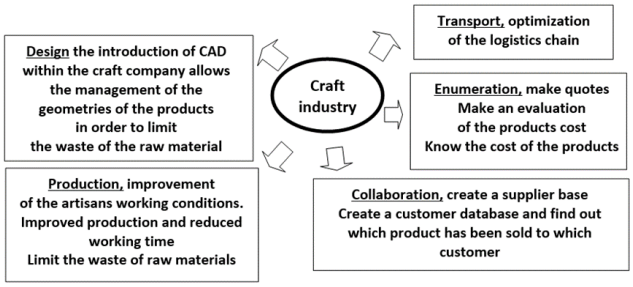


Fig. 2 Needs map for a craft company

To contribute to the integration of PLM in the artisanal industry in Morocco, we decided to conduct a survey to be able to explore all the needs and levers pushing the cottage industries to integrate PLM while based on what was presented in the last paragraph (the visit within the regional delegation of crafts and social economy in the region of Fez Meknes and the needs map). So, we try to realize a number of questions that can lead us to determine the problems, the needs and levers as well as the position of the companies towards technological tools.

Field survey

During our study we tried to communicate with a lot of companies. However, we just received responses from 132 companies. Equally, we tried to diversify the company's activity sectors so as to tackle the points studied in different sectors.

The companies surveyed are small and medium-sized companies with between 20 and 100 employees divided

into 3 categories, namely craftsmen, master craftsmen and apprentices located in Morocco, namely the regions of Fes Meknes, Rabat Sale Kenitra and Marrakach Tansifet. So, we tried to diversify our sample so that our results are credible.

The study targeted 9 activity sectors and 3 natures of enterprises. Notably, we try to interview 132 companies in the social economy sector, chiefly 63 cooperatives, 66 associations and 3 mutuals as presented in the Figure 3.

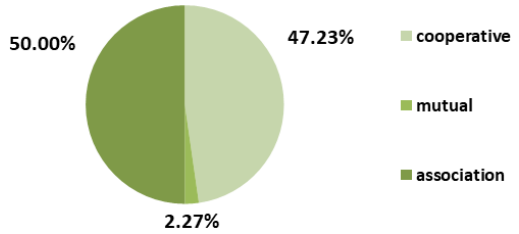


Fig. 3 Nature of the companies interviewed

Similarly, these surveyed companies come from a multitude of sectors as shown in the Figure 4.

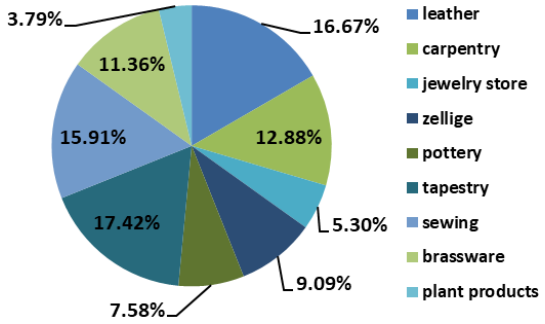


Fig. 4 Breakdown of companies by sector of activity

The companies questioned come from distinct sectors: 16.67% work in the leather sector, 12.88% in the wood and carpentry field, 5.3% produce in jewelry sector 9, 9% work in the zellige industry, 7.58% in the pottery field, 17.42% in the traditional fabrics and tapestry sector, 15.91% in the sewing and embroidery, 11.36% in the sector of brassware, metal and copper and 3.79% work in the plant products companies.

RESULTS AND DISCUSSION

In order to synthesize all the results found during our survey, we will start with a description of problems encountered by the companies interviewed as shown in Figure 5.

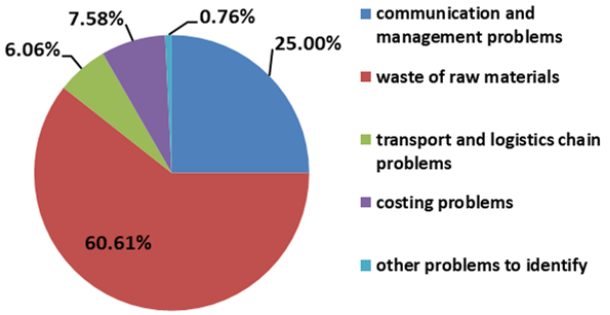


Fig. 5 Description of the problems encountered by the enterviewed companies

It should be noted that the companies questioned raised certain problems, namely: 25% of companies show that the major problems they face are management and communication problems, 60.61% think about the garbage generated by the raw material use, 6.06% find transport and logistics chain problems, 7.58% face costing problems and 0.76% find other problems they confirm a shortage of manpower.

After having studied the problems that can be encountered by the craft enterprises, we try to solve them through the use of technological tools. However, its use within the craft sector has a strong relationship with the benefits that these tools will be able to ensure. For this reason, it was considered necessary to analyze the levers and the benefits of the technology in the next paragraph. The study we carried out showed that the prospect of profits to be realized is the major incentive allowing the companies to integrate technology. For this reason, it was considered necessary to seek the opinion of the companies about the problems nature that can be solved by a technological approach (showed at Figure 6), the most influential external and internal factors (showed at Figure 7 and 8 respectively) as well as the benefits and the levers (showed at Figure 9) towards the integration of technology. The Figures 6, 7, 8 and 9 show the analysis of the results found.

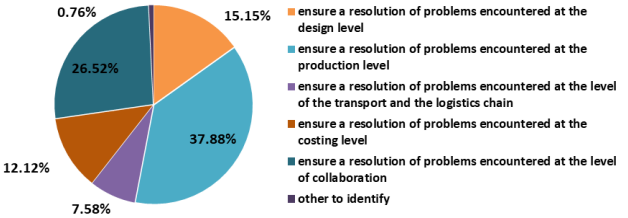


Fig. 6 The nature of the problems that can be solved by a product life cycle management approach

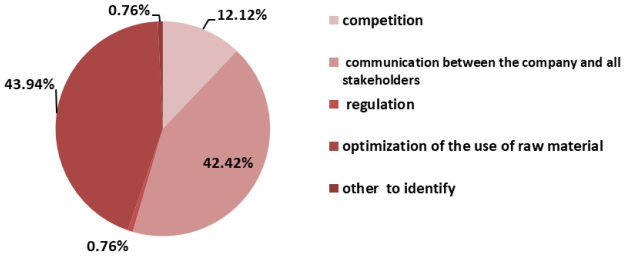


Fig. 7 External levers influencing the integration of Product lifecycle management approach within a company

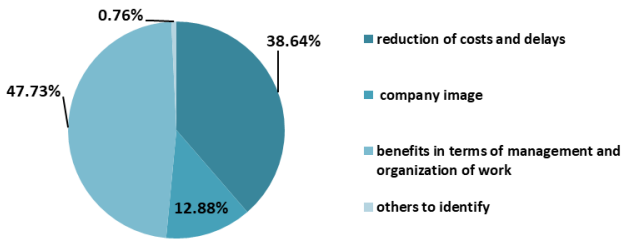


Fig. 8 Internal levers influencing the integration of Product lifecycle management approach within a company

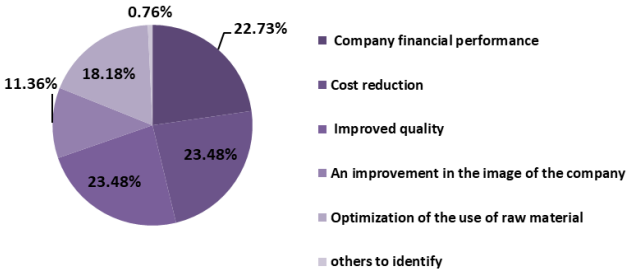


Fig. 9 Benefits related to the integration of a of Product lifecycle management approach within a company

So, 15.15% of the companies interviewed think that a technological methods such as product lifecycle management can find an answer to problems at the design level, 37.88% consider that the technology can intervene to solve production problems, 7.58% see that technological tools can opt for problem solving at the supply chain level, 12.12% provide problem solving at the costing level, 26.52% at the collaboration level and 0.76% at the level of solving problems related to the shortage of manpower.

It should be noted that 12.12% of the surveyed industries see that competition is the major incentive that can lead to PLM integration into the company, 42.42% select the communication between the company and the all its collaborators, 0.76% have opted for regulation, 43.94% have a preference for the factor relating to the optimization of the waste of raw material and 0.76% think about the optimization of energy consumption.

As far as the internal factor is concerned we find that 38.64% would prefer the reduction of costs and delays, 12.88% think that technological tools like PLM can intervene to enhance the image of their company, 47.73% have opted for the factor relating to the benefits at the level of management and organization of work and 0.76% think about benefits in term of environment.

Regarding the benefits pushing to the integration of a technological tool (PLM), we find that 22.73% of the companies interviewed select the financial performance of their companies, 23.48 % satisfied on the factor relating to cost reduction and 23.48% have chosen the factor related to the enhancement of the quality, 11.36% prefer the improvement of their company's image and 18.18% choose the optimization of the garbage generated by the use of raw material and 0.76% think about the fact of receiving as many orders as possible.

The introduction of a technological constraint is the result of the existence of a multitude of problems within the company and it could resist to the absence of internal or external levers to the company [31, 32]. Then, as we have already presented, the craft industry undergoes a number of problems, chiefly problems of waste of the raw material, collaboration and communication, and costing problems. But, before putting in place a technological tool within this kind of industries we have to know whether the problems mentioned above depend on the company's nature and the sector of activity and this is what we are going to develop in the following paragraph through the chi-square test.

The chi-square test

Intending to integrate a technological solution within the cottage industry, it is essential to analyze and study the independence between the problems that we want to solve by this technological tool, the companies nature as well as the activities sector. For this, it was deemed necessary to realize a chi-square test based on the production of contingency tables: the first table crosses the company's nature and the problems encountered by the craft sector and the second one crosses the companies activity sector and the problems found.

Then the test achieved obeys the following steps [33].

- Define the hypothesis we like to test: In our case, we are going to test the following hypothesis: "the two variables which are the company's nature and the problems found are independent".
- Elaborate the Pivot or contingency table where we are going to present the combinations of values of the two variables.
- Calculate the chi-square test criterion.
- Determine the degree of significance and interpret the results found.

So, as a first step we try to cross the nature of the company and the problems encountered by the surveyed companies we find the Table 1.

Table 1
Crossing the problems encountered in a craft business and the nature of the enterprises questioned

	costing problems	management and communication problems	transport and logistics chain problems	problems related to the waste of raw materials	other problems	total
association	6	18	4	38	0	66
cooperative	4	12	4	42	1	63
mutual	0	3	0	0	0	3
total	10	33	8	80	1	132

According to the results presented in Table 1 we conclude that associations and cooperatives encounter problems of waste generated by the raw material use with a total of 38 and 42 respectively out of 132 observations followed by management and communication problems with a number of 18 associations and 12 cooperatives out of 132 observations.

After carrying out the contingency table, we try to calculate the criterion of the chi-square test by applying the formula 1 that makes it possible to estimate the difference between the theoretical and the observed numbers [29].

$$\chi^2 = \sum_{j=1}^{L} \sum_{i=1}^{K} \frac{(nij - Tii)^2}{Tij} \quad (1)$$

where:

K: the companies natures = 3 (in our case, we have cooperatives, associations and mutuals),
L: the problems encountered by the surveyed companies = 4,
Tij: the theoretical numbers that we would have if the two variables i.e. (the companies' natures as well as the problems encountered by the companies) were independent i.e. if the rows and columns of the table were proportional,
nij: the observed numbers calculated in Table 1.
For the estimation of theoretical numbers *Tij* we find:
Tij = total of row (i) · total of row (j)/total number of observations (132).
For the calculation of the first value we find:
T11 = 66 · 10/132 = 5
All calculation done we find the Table 2.

Table 2
The calculation of theoretical numbers Tij

	costing problems	management and communication problems	transport and logistics chain problems	problems related to the waste of raw materials	other problems	total
association	5	16.5	4	40	0.5	66
cooperative	4.772727273	15.75	3.818181818	38.18181818	0.477272727	63
mutual	0.227272727	0.75	0.181818182	1.818181818	0.022727273	3
total	10	33	8	80	1	132

Next, we can apply the formula mentioned above we find a statistic:

$$\chi^2 = \sum_{j=1}^{L}\sum_{i=1}^{K}\frac{(nij-Tii)^2}{Tij} = 11.917 \qquad (2)$$

Likewise, the SPSS software can be used to perform this statistical test; we find the Table 3.

Table 3
The chi square Test

	Value	Degree of freedom	Asymptotic significance
Chi-square	11.917	8	.155
Number of observations	132		

According to Table 3, we notice that when the natures of companies and the problems encountered are independent, the probability of observing a difference between the effectives really observed and the theoretical effectives (in the case of independence) of 11.917 in one sample is equal to 0.155.
Since the probability is higher than 0.05 we conclude that the relationship is not statistically significant. So, we deduce from the responses reported by the companies questioned that the problems encountered do not depend on the company nature. Thus, we can solve a problem by implementing a technological tool within a craft company without taking its nature into consideration. For example, we can study the management and communication problems and it will not depend on the nature of the company (whether it is a cooperative, a mutual or an association it will be the same).
Equally, we can test if the problems confirmed by the companies depend on the activities sectors. That's why; we can use the chi-square test while crossing these two modalities. Regarding the contingency table, the results found are presented in Table 4.

Table 4
Crossing the problems encountered in a craft business and the activity sector

	costing problems	management and communication problems	Transport and logistics chain problems	problems related to the waste of raw materials	other problems	total
jewelry store	0	3	0	3	1	7
sewing	1	6	1	13	0	21
leather	1	6	2	13	0	22
brassware	3	4	1	7	0	15
carpentry	2	4	1	10	0	17
pottery	0	3	0	7	0	10
plant products	0	1	0	4	0	5
tapestry	2	5	3	13	0	23
zellige	1	1	0	10	0	12
total	10	33	8	80	1	132

We can notice that the number of companies which confirmed having problems related to raw material and energy remains the highest, i.e. 80 companies among 132 and the sectors which have a high total towards this problem are the sectors of leather, zellige, carpentry and sewing. Hence, we can admit that the sectors of activity, which their daily work requires cutting the raw material, find waste problems of the latter.
Equally, we find that the companies which encountered management and communication problems are in second position with a total of 33 out of 132 and this problem is identified in all the artisanal sectors. Thus, the craft indus-

try will have to move out of its routine, cloistered and resistance to change, towards a communicative, collaborative and open framework.

To exploit the contingency table presented above (Table 4) we choose to realize a chi square test through SPSS software between the two modalities namely the problems faced by the industries and the activity sector. The results are presented in Table 5.

Table 5

The Chi square test

	Value	Degree of freedom	Asymptotic significance
Chi-square	32.888	32	.423
Number of observations	132		

According to Table 5, we admit that when the activities sectors and the problems encountered are independent, the probability of observing a difference between the observed and the theoretical numbers (in the case of independence) of 32.888 in a sample is equal to 0.423.

Since the probability is higher than 0.05 we deduce that the relationship is not statistically significant. So, according to the responses communicated by the companies surveyed, the problems encountered do not depend on the sector of activity. Thus, we can solve a problem by implementing a technological tool within a craft company without taking the sector of activity into consideration.

We should bear in mind that our study reveals the presence of a number of problems within the craft sector and more precisely problems related to the garbage generated by the raw material use and problems relating to management and organization of the sector. Thus, the interference of a strategic, organizational and technical approach (PLM) becomes a prerequisite.

- Strategic: the generation of added value within the cottage industry depends on the product which is going to be considered the main source of income.
- Organizational: through the establishment of a collaborative approach within the craft sector that is going to include all the stakeholders in the same project.
- Technical: through the establishment of an IT approach by the implementation of a multitude of software and platforms that will facilitate the craftsmen tasks.

To sum up, the chi-square test allowed us to study the dependence between the nature of the companies, their sectors of activity and the problems encountered by the surveyed companies and to conclude that these three variables are independent. So, implementing a technological solution to solve a specific problem within the cottage industry can be done without focusing on the companies' nature and the activities sector. Hence, implementing the PLM either in a cooperative or an association under the sector either sewing, ceramic or carpentry will lead to the same results since these will not have an effect on the problems studied.

CONCLUSION

The objective of our research is the integration of PLM within small structures and more precisely within craft companies. This is why a survey was conducted within the craft sector in order to limit a number of problems faced, chiefly management and communication problems and the waste of raw materials. Also, we were able to identify the levers and benefits pushing the company to integrate a technological approach into its work process to end with an analysis of the results found which confirmed that the companies questioned have an interest in introducing technology in order to be able to resolve all the problems found but they should take care about the obstacles that can be generated while introducing technological approaches within their work.

So, it should be noted that our study showed that approximately 61% and 25% of the companies questioned respectively find problems of the raw material waste and problems of management and communication as well as the study which we carried out, in Overall (based on statements from companies interviewed), noted that the prospect of future profits is the major incentive for companies to integrate technology. The problem then lies in the ability to identify these opportunities. Beyond this evidence on the prospect of direct benefits, all of the companies interviewed agree that the two most influential external levers for the introduction of technology are communication between the company and the stakeholders and the optimization of the use of raw material for internal levers we found that the reduction of costs and deadlines and the benefits related to the organization of work remain the most important factors for the technology integration.

PLM is a recent approach that requires monitoring when it is introduced into a company. The transition to integrating PLM into the production process requires an organizational and strategic change at the company level which can give a new impetus allowing the company to market its products differently in order to better widen its profit margin.

Moreover, PLM remains a medium that contributes to collaborative innovation while bringing together a set of tools to collect ideas, manage data and disseminate the necessary information in different environments.

Also, the cottage industry remains an area that requires several measures for its improvement. Hence, the need to introduce PLM to be able to optimize the use of raw materials and this is what we will try to see in our future researches concerning the zellige sector in the cottage industry.

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