ISSN 2176-5480

22nd International Congress of Mechanical Engineering (COBEM 2013)
November 3-7, 2013, Ribeirão Preto, SP, Brazil

LEAN PRODUCT DEVELOPMENT: BENCHMARKING IN BRAZILIAN COMPANIES

Ana Julia Dal Forno
Santa Catarina Federal University – UFSC, Florianópolis/SC, Brazil
anajudalforno@hotmail.com

Fernando Antonio Forcellini
Santa Catarina Federal University – UFSC, Florianópolis/SC, Brazil
forcellini@gmail.com

Antonio Cezar Bornia
Santa Catarina Federal University – UFSC, Florianópolis/SC, Brazil
cezar@deps.ufsc.br

Abstract. *One of the ways of achieving learning is to have a structured benchmarking process to facilitate comparison of performance by simply the result or by product and management practices. This paper purpose is to diagnose what lean practices being applied in the product development process in Brazil large companies. The methodology used was a survey and was conducted with connection the theoretical level, construction of the questionnaire, sample definition, pilot implementation, data collection, data analysis and statistical validation of the survey instrument. Among the results, was diagnosed with the principles and practices of Lean Product Development are being used in companies evalued - Value Stream Mapping (VSM), Voice of Customer (VOC), Early Supplier Involvement (ESI), Standardization, Visual Management, Set-Based Concurrent Engineering (SBCE), Virtual Simulation, Project Library and Record lessons learned. The return rate of the survey was 37%, which does not allow generalizations, but it is possible to trace trends such as that Brazil has become a country of developer products, which encourages companies to organize themselves in a systemic to add value and become increasingly competitive business processes.*
Keywords: *Lean Product Development, Survey, Benchmarking, Big Companies.*

1. INTRODUCTION (TIMES NEW ROMAN, BOLD, SIZE 10)

The development and introduction of new products are essential to guaranteeing the sustainability of a business. The lean approach in manufacturing and its tools are broadly disseminated. Nevertheless, it is not very useful to have lean world class production if the product manufactured is not what the client wants. The product development process, in addition to being capable of capturing the dimensions of what clients consider to be of value, is guided by the operational and technological implications that, in a following moment, will be present in the manufacturing processes, in and outside the company (Ward, 2007; Dal Forno et al., 2008).

Among the countless advantages of using the lean approach and benchmarking, is that both are related to quality. In the lean approach, quality is the basic factor of stability (quality at the source) and benchmarking became well-known in the times of Total Quality, in the Quality Control Circles movements, based on Taylor`s principles of Scientific Administration, on Shewart`s Statistical Process Control, on Deming's PDCA and on Drucker's Administration by Objectives. In addition, both are processes for diagnostics and transformation. The Lean approach uses mappings as diagnostics and benchmarking generally uses quantitative questionnaires with standardized responses that allow comparing the same elements, factors and measures (or that is "apples with apples"). Thus, after a diagnosis, ,the steps of implementation, accompaniment, learning network and continuous improvement are also points it has in common with benchmarking and the lean approach (Dal Forno, 2012).

In Brazil, many companies and the academic environment were already strongly using the lean approach in manufacturing since the 1990s, although the tools were applied in an isolated manner and there was no standardization of the lean terminology. This article examines those lean practices that are being applied in the realm of product development by large companies in Brazil.

The paper is organized as follows. Section two provides definitions of the principles and practices of Lean Product Development such as Value Stream Mapping (VSM), Voice of Customer (VOC), Early Supplier Involvement (ESI), Standardization, Visual Management, Set-Based Concurrent Engineering (SBCE), Virtual Simulation, Project Library and Record lessons learned. Section 3 presents the methodology used to conduct the survey, including the definition of the sample, the classification of the questions and the research steps. Section 4 presents the survey results and graphs with the responses of the participating sectors. This is followed by the conclusion and the references used.

2. THEORETICAL PRINCIPLES OF LEAN PRODUCT DEVELOPMENT

ISSN 2176-5480

Synonyms found for lean PDP in the literature include Lean Design, Lean Engineering and Lean Development, in addition to the adaptation to Lean Development of Products and Processes.

This paper will use the term "practices" as a synonym for "best practices" and "good practices." According to the EFQM Benchmarking Manager apud Jarrar and Zairi (2000), "best practice" is defined as those practices that produce superior results, selected by a systematic process, judged to be exemplary, good examples or those that were successful. Thus, "good practices" are techniques, methodologies, procedures or processes that were implemented and improved the results of the business for an organization, satisfying the needs of clients and interested parties. Meanwhile, a "best practice" is that which was proven to be the best approach by many organizations, based on an analysis of performance data for the process (Jarrar and Zairi, 2000).

Thus, after filtering approximately 300 articles from the databases; Isi Web of Knowledge and Emerald Insight, the practices that appeared the most were: Value Stream Mapping, Voice of Customer, Early Supplier Involvement, Standardization, Visual Management, Set-Based Concurrent Engineering, Virtual Simulation, Project Library and Record lessons learned. These practices were the basis of the questionnaire used in the survey.

2.1 VSM

Value Stream Mapping (VSM), called a "Material and Information Flow Chart" at Toyota, was made popular by Rother and Shook (1999), and is designed to develop a map of the current state of a product on a sheet of paper, showing the flow of material and information, so that waste can be visualized and the total lead time for a product be calculated. The development of the future state map is linked to the proposition of an action plan, for implementing and accompanying the best proposals.

Morgan and Liker (2006) list some reasons for using the VSM in product development:

- Variability of task and stocks – as a function of the nature of work of the project it is possible to visualize and administer the waiting lists;
- The longer times than in manufacturing, generally involving weeks and months, make it more difficult to identify the waste;
- "Discernible standard of product evolution from one state to the other over time" – it is understood that the development process, from the concept to the release of the product, has many interactions with the client. Therefore, as much as attempts are made at standardization, for each product it is the clients, the times and the different information that influence the decisions;
- Capacity and questions related to programming – even if an indicator of hours per person or productivity is used, the PDP has large peaks and valleys in the work load. For this reason it is necessary to know how to deal with capacity restrictions;
- Making the transition from one functional activity to another – because the people and the team are involved in various parallel projects - creates a challenge.
- Pressure for reducing processing times – to be able to continuously reduce the time needed to place a product in the market is an objective at the level of the system;
- The tasks must be synchronized, the restrictions identified and administered and; the flow created.

In product development, the resources compete for the same tasks, there is great variability and little reuse of knowledge, in addition to the difficulty of perceiving waste in the information flow (Morgan and Liker, 2006; Locher, 2008).

2.2 VOC

The Voice of the Consumer (VOC) is a practice for identifying clients' needs, and generally uses the tools QFD, focus group and marketing research (Car, 2007; Gonzalez et al.,2008; Mccoy, Thabet and Badinelli, 2009). According to Jeong and Hong (2007), to involve the client improves the definition of requirements, the product design and the time-to-market.

2.3 ESI

The intention of the ESI is to maintain a reduced number of suppliers and to involve them from the beginning of the development process and thus establish a partnership relationship (long term). The benefits are decreased risk, reduced cost and lead time, in addition to joint development and the establishment of joint goals (Gurumurthy and Kodali, 2009; Mcadam, Hazlett and Anderson-Gillespie, 2008; Sarshar and Pitt, 2009; Park et al., 2010).

To work closely with the supplier, developing joint strategies helps lower costs, and allows the company to be sustainable and increase competitiveness (Mcadam, Hazlett and Anderson-Gillespie; 2008).

According to Aláez-Aller and Longás-García (2010), dynamic management in conjunction with the supplier involves reducing the cost of joint development, reducing the number of suppliers and increasing the level of technology. Co-innovation with suppliers reduces time to market by up to 60% (Brookfield, Liu and Macduffie, 2008).

2.4 Standardization

ISSN 2176-5480

Standardization is the basis for reducing variability through the verifications list and as a mechanism for capturing knowledge. The standardization of the project involves the product, its components, raw materials and its architecture. The standardization of the processes involves the common tasks and their sequence and duration. The standardization of technical abilities is related to the ability of the people involved in the development team (Muenstermann et al., 2010; Marksberry et al., 2010; Wee and Wu, 2009; Gurumurthy and Kodali, 2009; Grant and Banomyong, 2010; Aláez-Aller and Longás-García, 2010; Nunes and Bennett, 2010).

2.5 Visual management

This includes the devices for detecting errors at the source and not allowing them to advance. Examples are parametric systems in CAD, checklists and detailed and standardized plans. A visual chart with the schedule of dates and phases of the projects underway assists visualizing compliance with the deadlines and thus taking preventive measures in time, according to the frequency of checking the project performance (Locher, 2008; Childerhouse, Thomas, Phillips and Towill, 2010; Singh, Garg and Sharma, 2009; Arnheiter and Greenland, 2008).

According to Fouquet (2007), visualization tools show the opportunities for improvements in the PDP and allow companies to make their processes flow better, delivering value to the client and developing high quality products from the beginning of the project. Smadi (2009) complements that making the problems visible is the first step in kaizen, because it is the only way to improve and minimize similar problems in the future.

2.6 Set-Based Concurrent Engineering

In Set-Based Concurrent Engineering (SBCE) the entire development staff communicates a set of parallel and independent alternatives until, during the PDP phases, the alternatives are eliminated and the best alternative remains that was generated from a combination of systems, subsystems and components (Schäfer and Sorensen, 2010; Madhavaram and Appan, 2010; Salah, Rahim and Carretero, 2010; Doll, Hong and Nahm, 2010; Mols, 2010; Joh and Mayfield, 2009; Chin, Yang, Guo and Lam, 2010; Cooper and Edgett, 2009).

In the initial phase of the project there is a list of viable alternatives that were identified through an analysis of client requirements. The options are consolidated in the later phases (Haponava and Al-Jibouri, 2009).

Spiral development is among the seven practices for increasing the productivity of PDP, given that of the 105 companies evaluated in Canada, 26% of those that have average performance use this practice. Among the companies with high productivity, 45% use this practice (Cooper and Edgett, 2009).

2.7 Project library

This practice refers to learning and the habit of recording the lessons learned to facilitate the reuse of knowledge. The key elements of project management are composed of methodologies and tools. The challenge is how to quantitatively measure the knowledge and synchronize the development with the project management system (Eve, 2007).

Some metrics of knowledge management are the existence of initiatives for improving processes, formal benchmarking process compared to other companies, documentation of performance of past initiatives and hours invested in training per employee (Bilalis, Alvizos, Tsironis and Wassenhove, 2007).

2.8 Virtual Simulation

Conducting virtual simulation through digital models (CAD/CAM and other modeling software) is important for preventing errors and interacting with the process, thus reducing the cost of physical prototypes and time (Bargelis, Kuosmanen and Stasiškis, 2009; Saliba, Zarg and Borg, 2010; Muglestone, Maher, Manson e Baxter, 2008; Grant and Banomyong, 2010; Catalano et al., 2009; Durmusogiu, 2009). According to Shamsuzzoha, Kyllönen and Helo (2009), virtual simulation can occur to integrate supplier and manufacturer, increase the value perceived by the client and find the right solution for customized development.

3. RESEARCH METHODS

According to Forza (2002) and Miguel (2010) the survey in this study is considered exploratory-descriptive because it takes place in the initial phases of research to acquire a macro vision of a phenomenon and after a refinement is realized. Because it is aimed at understanding a certain phenomenon and providing support for a theory, it is considered to be descriptive.

The realization of the survey was based on prior theoretical research, the construction of the questionnaire, the definition of the sample, the application of the pilot questionnaire, data collection, data analysis and statistical handling for validation of the research tool.

The application of the Survey served to characterize the profile of Brazilian companies in relation to their management of product development and to the trends that refer to the introduction of the lean approach in this process.

The basic research tool was the questionnaire, with the sample defined based on the universe of the largest companies in sales (billing) in 2009 located in Brazil. Thus, of the 330 companies of the sectors that develop products, it was sent to 175 and the rate of return was 37%. Figure 1 depicts the research steps.

ISSN 2176-5480

a) **Preparation of the questionnaire** – the questionnaire was based on five lean principles (Womack and Jones, 1996), from among the 13 Lean Product Development principles at Toyota presented by Morgan and Liker (2006), beyond the practices identified in the literature and presented in item 2 of this article
b) **Selection of the sample** – The criteria for the selection of the companies was inclusion among the "Largest Companies in Sales in 2009" (Exame, 2011). In Brazil, companies with annual revenue of more than US$150 million are classified as large (BNDES, 2011). The sectors that participated were automotive, capital goods, consumer goods, several sectors, electronics, paper and pulp, steel and metallurgy and textiles because they were considered product developers.
c) **Registration of the Companies** – each company was registered with its name, sector, city, name of contact person, the contact's position, company website, email of the person responsible for completing the questionnaire, telephones and status of the questionnaire.
d) **Calling the companies** - Initially, after filtering by economic sector, 330 companies remained. Of these, 31 appeared more than once because they had productive units in various states or had undergone mergers. If a company was not able to be reached after five attempts it was not considered. Thus, the initial valid sample included 233 companies. Nevertheless, after telephone contact, 58 problems were found. Most of the problems (40%) were related to the fact that the company believed that it "does not apply" because they do not use a lean approach, their products were developed outside of Brazil, or because of the type of product. Thus, the sample considered included 175 companies, from which were received 64 valid questionnaires.
e) **Pilot lot and re-sending** - The study was initially evaluated by specialists in Product Development (2 professors of Production Engineering and 2 professionals from companies). After the adjustments, the first lot sent to a random sample of companies also served to test the questionnaire. For each lot of 15 companies contacted, the questionnaire was sent individually by email and a confirmation that it was read was requested. The deadline stipulated for responding was up to 15 days. The first lot was considered as a pilot to validate the questions. In this first lot companies from the various participating sectors were selected randomly.
f) **Data entry** – The data were tabulated in an electronic spreadsheet with filters for later generating graphs and analyses. Table 1 shows the segmentation of each sector that participated in the survey, the number of questionnaires, those that were responded to, the rate of return of each sector and the representativeness of the sample.

Table 1. Classification of the sample according to the economic sectors.

SECTOR	Sent	Responded	Rate of Return by Sector	Representativeness
Automotive	48	22	46%	34%
Capital Good	17	9	53%	14%
Consumer Goods	46	13	28%	20%
Several Sectors	5	2	40%	3%
Electronics	13	5	38%	8%
Paper & Pulp	12	2	17%	3%
Steel and Metallurgy	17	4	24%	6%
Textiles	17	7	41%	11%
	175	**64**	**37%**	**100%**

g) **Studies of other Surveys** – in parallel to the practical application, a study was conducted in the databases. The criteria were use of the survey methodology, the sector applied, the geographic location and the rate of return obtained. Within this scope and considering that the sample was quite varied (various sectors, various Brazilian states) the rate of return of this study could be considered valid (38%). Due to the extensive number of studies (73), they will not be described in detail here, but can be seen in the thesis of Dal Forno (2012).
h) **Results** – the practical results will be detailed in item 4 of this article.
i) **Report** – at the end of the study each participating company received the report with the global results and also segmented by sector.
j) **Statistical analyses** – Cronbach's Alpha was used to evaluate the internal coherence of the research tool. This study considered the values suggested by Malhotra (2005), which are those between 0.6 and 1. The software used to calculate Cronbach's Alpha was Statistica 10.0 and SPSS and the value was 0.99; considered to be excellent by Hill and Hill (2008). For the statistical analysis and correlation between the questions, Pearson's Coefficient of Correlation (ρ) was used, also known as the "product-moment coefficient of correlation," which measures the

ISSN 2176-5480

degree of correlation (positive or negative) between two variables of metric scale. Examples of positive correlations tested, or that is "ρ = 1," were for the questions between VSM and Lean; Training and Kaizen, SBCE and Virtual Simulation, Project Library and the Registering of lessons learned.

The following hypotheses were verified:

- The development practices define the degree of implementation of the lean approach to the Product Development Process;
- Companies that begin applying lean techniques in manufacturing tend to expand them to other fields of the business (product development, logistics, administrative processes);
- Companies do not always identify themselves as "Lean." Many already use some practices, but there is no denomination of the lean term from a systemic perspective.
- No companies are completely "zero Lean" and none are "totally lean";
- Large companies tend to formally define the Product Development Process more than the small companies;
- Brazil came to be seen as a country apt for the development of products that previously came ready-made from the multinational headquarters.

4. FINDINGS

Confirming the proposal that Brazil came to be a country where product development is conducted, when asked if the products are developed in Brazil, 91% of the responses were "yes" and 9% no. Figure 2 shows the types of projects that responded affirmatively and only 12% are of the follow-source type in which the project comes from headquarters but undergoes regional adaptations, which were also considered to be incremental projects (38%). Figure 1 shows the types of projects developed by the companies that answered the survey.

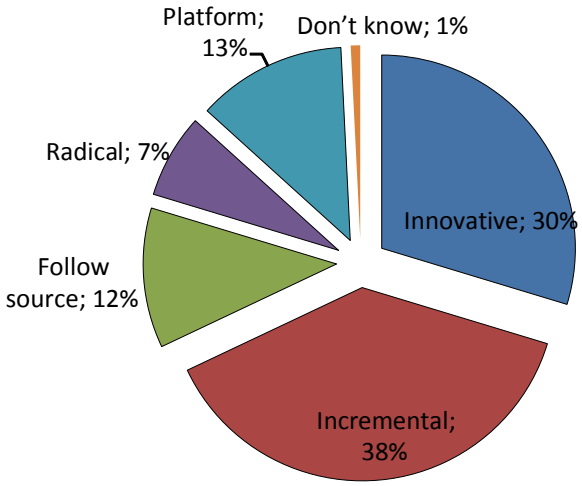

Figure 1. Types of projects developed at the companies that participated in the Survey (Dal Forno, 2012)

The questionnaire asked directly if the company uses the lean approach and 64% answered yes. This answer would be verified later through the other survey questions, to identify if the use of the lean approach is occurring systematically or only with some practices implemented in an isolated manner.

The Value Stream Mapping is an initial tool for the implementation of the lean approach that allows diagnosing the current state and proposing improvements for the future state. In survey were revealed that 44% of the companies use this practice and 36% do not, the others responses were blank or "don't know".

"Questions 6 and 7" focused on the consumer, with the goal of verifying in what development phase the strategic supplier is involved and in relation to the quantity of suppliers. Figure 2 reveals that 87% of the companies involve the supplier from the beginning of development. Figure 3 shows that most companies increased or maintained the same number of suppliers in the past five years. Only 23% follow the lean trend that strives to reduce the number of suppliers.

ISSN 2176-5480

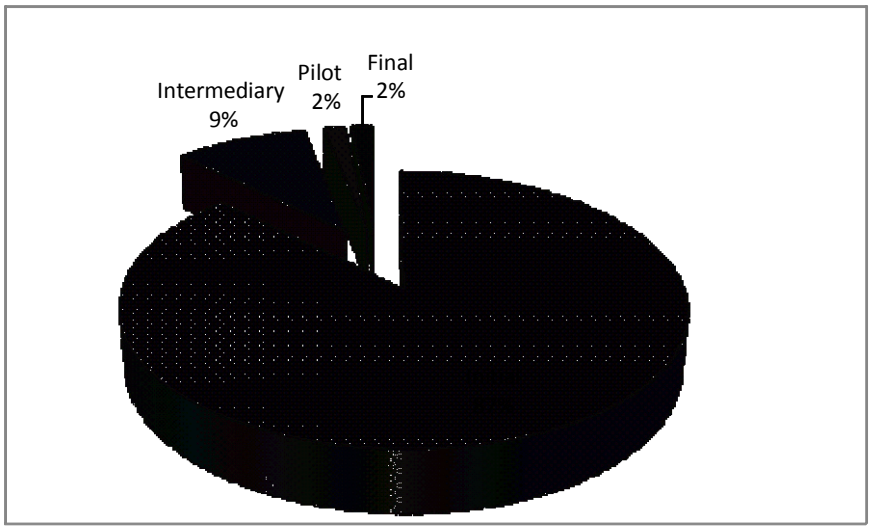

Figure 2. Phase of the PDP in which the supplier is involved (Dal Forno, 2012)

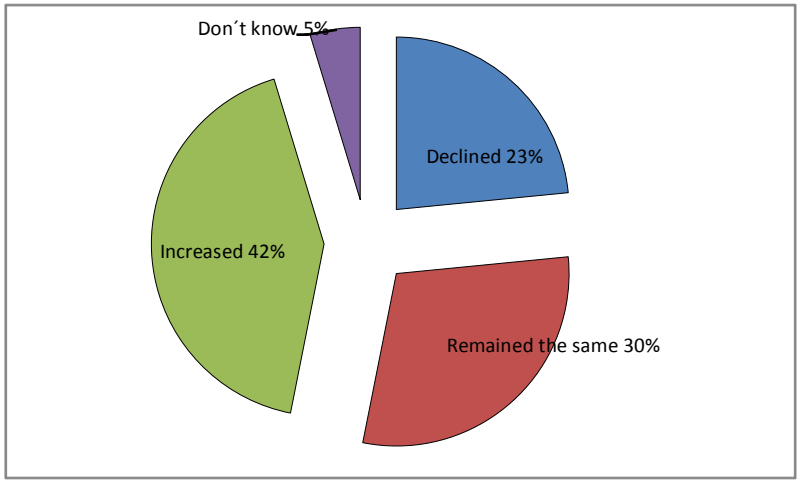

Figure 3. Trend in number of suppliers (Dal Forno, 2012)

One direct question sought to verify if the development process is standardized, that is, if there is a reference model that is formalized and followed by the team. Figure 4 highlights that 91% said the PDP is standardized.

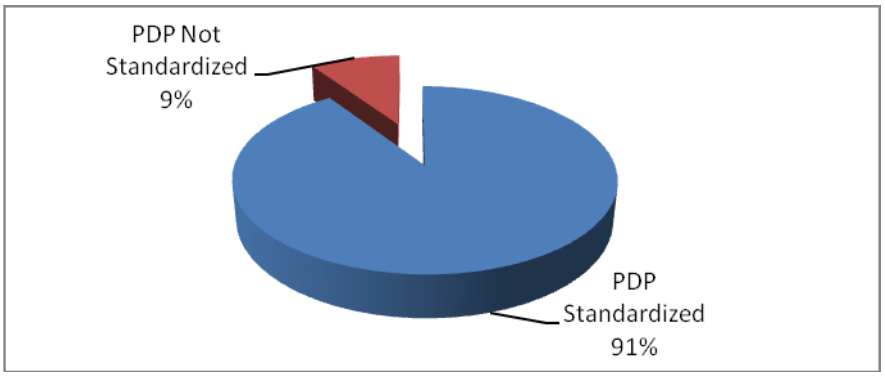

Figure 4. Standardization of the PDP (Dal Forno, 2012)

The purpose of "Question 10" was to identify if techniques are used to capture the Voice of the Consumer. The majority, (61%) responded yes. Figure 5 shows how the question was answered.

ISSN 2176-5480

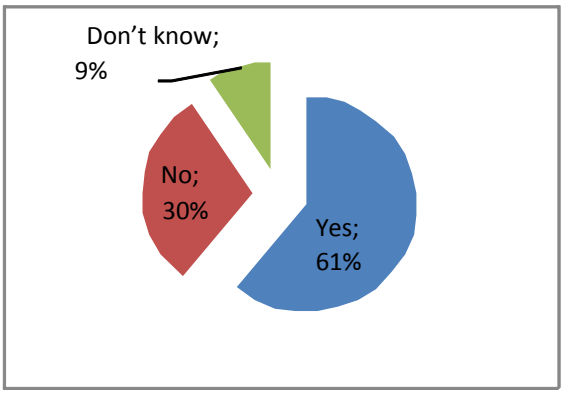

Figure 5. Use of techniques to capture the Voice of the Consumer (Dal Forno, 2012)

One question asked about the areas involved from the beginning of the development to evaluate the practical integration. Most (48% of the responses) involved five or more areas and 39% involved four or five areas, showing that the PDP is taking place in a multidisciplinary manner. Figure 6 illustrates this result. An insignificant portion totaling 13% involved at most three areas, usually engineering and manufacturing and or logistics/purchases.

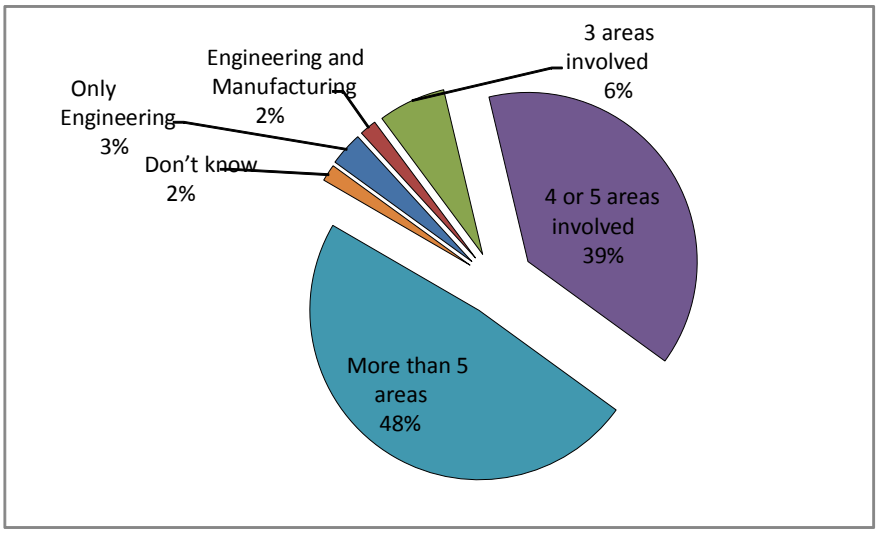

Figure 6. Number of areas involved from the beginning of development (Dal Forno, 2012)

The central idea of SBCE is to explore various alternatives until the end, so that when an option is tested it is correct and follows the lean principles of "do it right the first time." Thus, through Figure 7 it is possible to perceive this trend when 55% of the answers tested various options (funnel), although 40% still test each option in an isolated manner (trial and error).

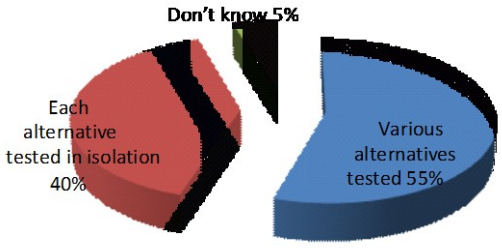

Figure 7. Responses to reveal the SBCE (Dal Forno, 2012)

"Questions 16 and 17" were related to knowledge management and the use of lessons learned from previous projects and registering these lessons (project library), whether physically or virtually. Figure 8 shows that most of the companies that responded (72%) have the habit of recording the lessons learned. Nevertheless, it is not enough to only record the lessons, for this reason, Figure 9 shows that 95% of the companies use the experiences of the previous projects in the practice.

ISSN 2176-5480

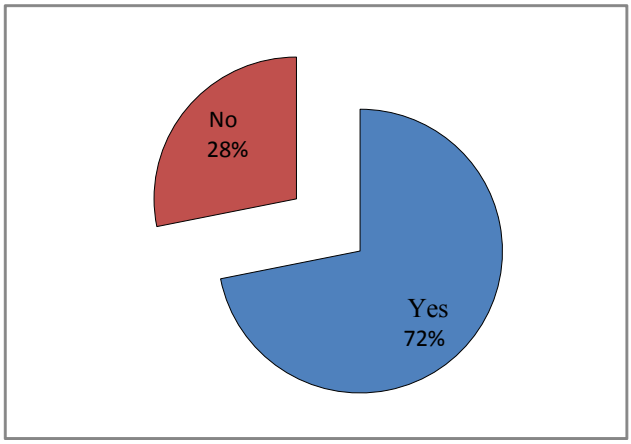

Figure 8. – Percent of companies that use the practice of recording lessons learned (Dal Forno, 2012)

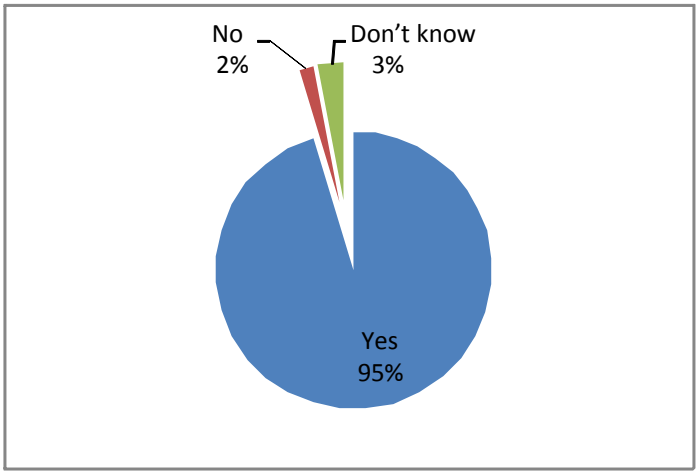

Figure 9. Percentage of companies that use in practice experiences of previous projects (Dal Forno, 2012)

Regular accompaniment of the project allows making needed reactions and changes in time. In this sense, the Japanese culture has the habit of conducting fast daily meetings to establish goals and update the schedule. These meetings, called Kentou, are held standing up and last around 15 minutes. In Brazil, it can be seen that 46% hold weekly meetings to check project performance (see Figure 10).

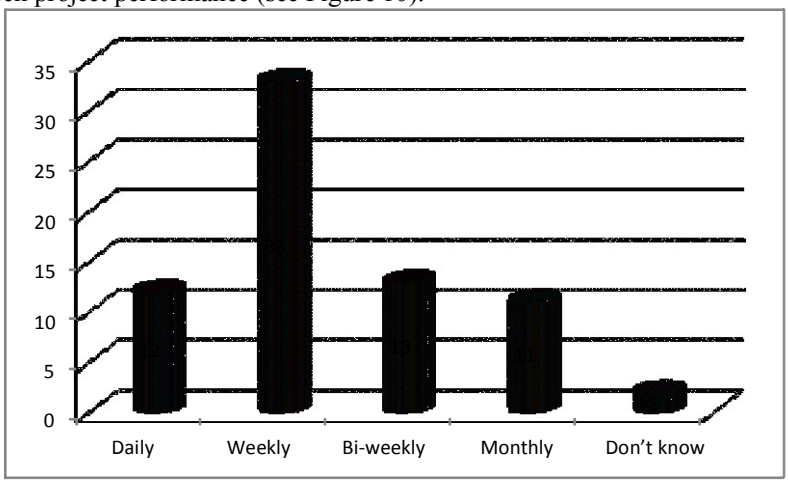

Figure 10. Frequency of accompanying the project (Dal Forno, 2012)

The use of virtual simulation allows simulating various product alternatives and testing some requirements of the product without additional costs of the physical prototype, in addition to reducing the time-to-market. Figure 11 shows that 66% of the respondents use this practice during development.

ISSN 2176-5480

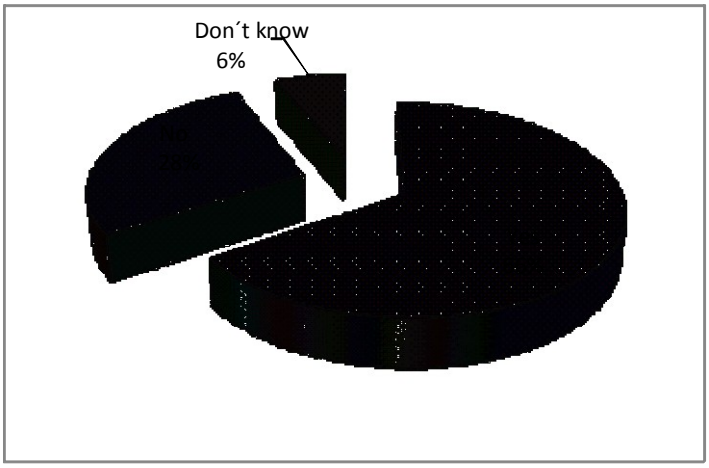

Figure 11. Use of virtual simulation in the project (Dal Forno, 2012)

Kaizen signifies the constant search for improvement. This practice is important to verify if there is a concern for improving the process continuously, which was confirmed by 97% positive answers and 3% that did not use techniques to improve the process continuously.

Investment in employees also encourages improvements. Most of the trainings seek to update and improve the technical abilities of employees. Figure 12 shows that 89% of the companies that responded made investments in employee training. A more detailed analysis can determine if the investments are needed due to a lack of training because of the general level of education in the country or if it is due to the complexities of the projects and the maturity of the company so that it is ready to develop a multidisciplinary team.

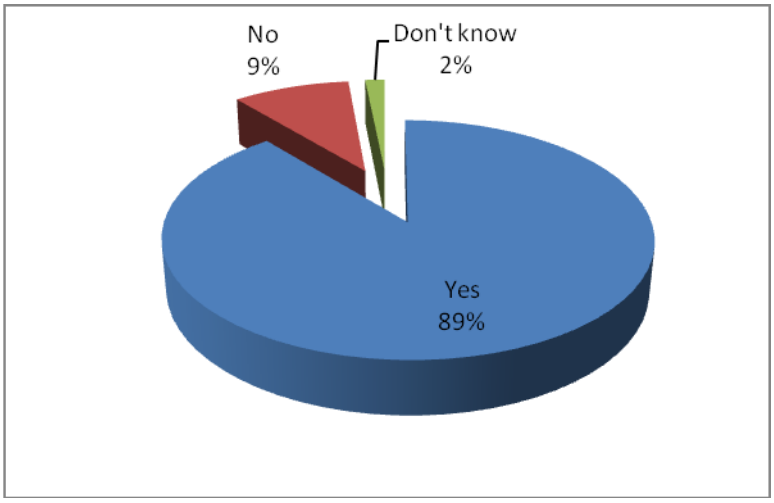

Figure 12 – Verification of the investment in employees (Dal Forno, 2012).

Other practices /questions verified are related to (Dal Forno, 2012):

- The realization of overtime during the project,
- Waste found in the PDP (over-production, waiting, stock, transportation, movement, defects, process, reinvention, lack of discipline and integration of Information Technology.);
- Value of the internal client;
- What indicators are used and with what frequency;
- In what phases is the project accompanied;
- Software used to manage the product;
- Existence of techniques for rationalization of the product such as modularity and DFx;
- Types of organizational arrangements (departmental structure, by project, weak headquarters, strong or balanced);
- Techniques and tools for capturing Voice of the Consumer;
- Processes that have the lean approach (Office, logistics, manufacturing, engineering);
- Year that the companies began implementation of the lean approach.

5. CONCLUSIONS

ISSN 2176-5480

The purpose of this Survey was to diagnose the lean practices used in the Product Development Process at large companies in Brazil.

When considering all the sectors, only two constructs were not verified – to what degree the physical arrangement is of the departmental type and in relation to the increase in the number of suppliers. The first is related to the type of project, and, that upon finding that most of the companies undertake incremental projects, having a departmental structure is not a problem. The most common practices, with adopted by 90% of respondents were: standardization of the PDP, use of indicators, project library and continuous search for improving the process. Other practices found to be common were Initial Involvement of the Supplier, VOC, use of software, value of the internal client, registration of lessons learned, virtual simulation and investment in training. Although 64% of the companies directly considered themselves to be "Lean," when a VSM practice was verified, only 44% of these use this key tool for diagnosing the current state and planning the future state.

The Survey had a 37% response rate, which does not allow making generalizations about large Brazilian companies, but does allow the initial diagnosis that large Brazilian companies are implementing lean PDP practices. A deeper analysis will use more detailed questions and classify them in dimensions to verify if the implementation is occurring in a systemic and planned manner.

To simplify the visualization of the sectors that have implemented more lean practices in PDP, each sector was scored (see Figure 13), considering only the questions answered. The score for each question varied from 10 (least lean) up to 50 (most lean). This means that questions answered as "don't know" were not considered in order to not interfere with the result. The sector "several sectors." had the best score, followed by electronics, automotive and capital goods. Nevertheless, it is necessary to verify the representativeness of each sector in the sample to evaluate the internal variability of each sector, as is the case of the automotive sector which is the most representative.

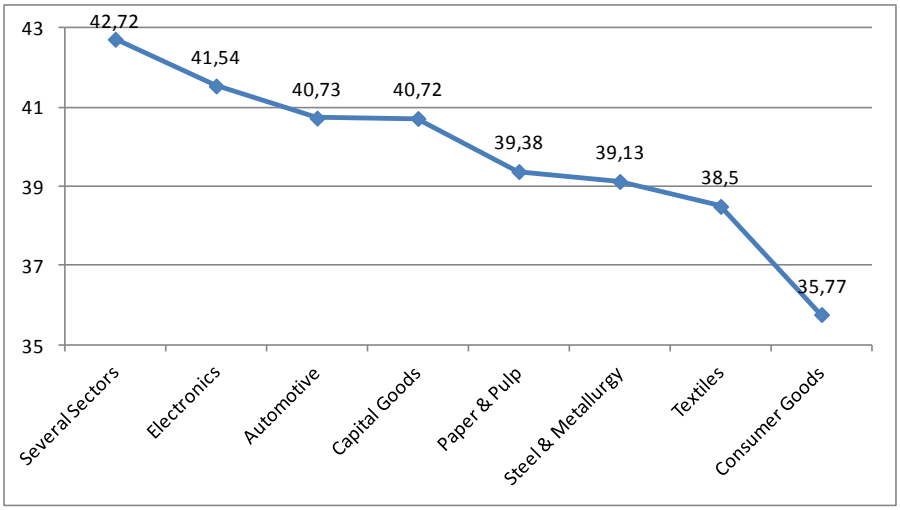

Figure 13. Ranking by sector of the companies that participated in the Survey (Dal Forno, 2012)

6. ACKNOWLEDGEMENTS

The authors express their thanks for the financial support received from CAPES – Coordenação de Aperfeiçoamento de Pessoal de Nível Superior.

7. REFERENCES

Aláez-aller, R.; Longás-garcía, J.C. (2010) "Dynamic supplier management in the automotive industry". *International Journal of Operations & Production Management*, v.30, n.3, pp. 312-335.

Arnheiter, E.D.; Greenland, J.E. (2008) "Looking for root cause - a comparative analysis". *The TQM Journal*, v. 20, n.1, pp. 18-30.

Bargelis, A.; Kuosmanen, P.; Stasiskis, A. (2009) "Inteligent Interface Module of Process Capability among Product and Process Development Systems in Virtual Enviroment". *Journal of Mechanical Engineering*, v.55, pp.1-9.

Bilalis, N.; Alvizos, E.; Tsironis, L.; Wassenhove, L. (2007) "Benchmarking the competitiveness of industrial sectors - application in textiles". *International Journal of Productivity and Performance Management*, v. 56, n.7., pp. 603-622.

Bndes – Banco Nacional do Desenvolvimento. Porte de Empresa. Available [http://www.bndes.gov.br/SiteBNDES/bndes/bndes_pt/Navegacao_Suplementar/Perfil/porte.html], accessed 09/nov/11.

ISSN 2176-5480

Brookfield, J.; Liu, R.; Macduffie, J.P. (2008) "Taiwan's bicycle industry: A-Team battles Chinese competition with innovation and cooperation". *Strategy & Leadership*, v.36, n.1, pp. 14-19.

Car – Center for Automotive Industry. (2007) "How automakers plan their product". *Business Planing*, Available [www.cargroup.org], accessed 07/sept/2010.

Catalano, C.E.; Camossi, E.; Ferrandes, R.; Cheutet, V.; Sevilmis, N. (2009) "A Product Design Ontology for Enhancing shape processing in design workflows". *Journal of Intelligent Manufacturing*, v. 20, pp. 553-567.

Childerhouse, P.; Thomas, A.; Phillips, G.; Towill, D.R. (2010) "Auditing improvements in a product delivery process (AIPDP)". *Business Process Management Journal*, v.16, n.4, pp. 598-618.

Chin. K.; Yang, J.; Guo, M.; Lam, J.P. (2009) "An Evidencial-Reasoning-Interval-Based Method for New Product Design Assessment". *IEEE Transactions on Engineering Management*, v. 56, n.1, pp. 142-156.

Cooper, R.G.; Edgett, S. J. (2008) "Maximizing Productivity in Product Innovation". *Research Technology Management*, v.51, n.2, pp. 1-20.

Dal Forno, A.J. (2012) "Método de Avaliação via benchmarking do Processo do Desenvolvimento Enxuto de Produtos". *Thesis*. Doutorado em Engenharia de Produção. Florianópolis/SC: Universidade Federal de Santa Catarina/Brazil.

Dal Forno, A. J., Barquet, A. P. B.; Buson, M. A., Forcellini, F. A., Gitirana, M. (2008) "Gestão de Desenvolvimento De Produtos: Integrando a abordagem *Lean* na fase do projeto conceitual". *GEPROS – Gestão da Produção, Operação e Sistemas*. Ano 3, nº 4, pp. 45-58. Available [http://revista.feb.unesp.br/index.php/gepros/article/view/503/198].

Doll, W.J.; Hong, P.; Nahm,A. (2010) "Antecedents and outcomes of manufacturability in integrated product development". *International Journal of Operations e Production Management*, v.30, n.8, pp.821-852.

Durmusogiu, S.S. (2009) "The role of top management team's information technology (IT) infrastructure view on new product development - Conceptualizing IT infrastructure capability as a mediator". E*uropean Journal of Innovation Management,* v.12, n. 3,pp. 364-385.

Eve, A. (2007) "Development of project management systems". *Industrial and Commercial Trainning*, v.39, n.2, pp. 85-90.

Exame (2011) "Maiores Empresas por Vendas em 2009". Available [http://exame.abril.com.br/negocios/melhores-e-maiores/empresas/maiores/1/2009/vendas/-/-/-/-?], accessed 25/oct/2011.

Forza, C. (2002) "Survey Research in Operations Management: a Process-based perspective". *International Journal of Operations & Production Management*, v. 22, n. 2, pp. 152-194.

Fouquet, J. (2007) "Design for Six Sigma and Lean Product Development - differences, similarities and links". *The Asian Journal on Quality*, v.8, n.3, pp. 23-34.

HERSTATT, C. *et al* (org). pp. 235-248.

Gonzalez, M.E.; Quesada, G.; Gourdin, K.; Hartley, M. (2008) "Designing a supply chain management academic curriculum using QFD and benchmarking". *Quality Assurance in Education*, v.16, n.1, pp. 36-60.

Grant, D.B.; Banomyong, R. (2010) "Design of closed-loop supply chain and product recovery management for fast-moving consumer goods". *Asia Pacific Journal of Marketing and Logistics*, v.22, n.2, pp. 232-246.

Gurumurthy, A.; Kodali, R. (2009) "Application of benchmarking for assessing the lean manufacturing implementation". *Benchmarking: an International Journal*, v. 16, n.2, pp. 274-308.

HAPONAVA, T.; AL-JIBOURI, S. "Establishing influence of design process performance on end-project goals in construction using process-based model". *Benchmarking: an International Journal*, v.17, n.5, 2010, pp. 657-676.

Jarrar, Y.F.; Zairi, M. (2000) "Internal transfer of best practice for performance excellence: a global survey". *Benchmarking: an International Journal*, v.7, n.4, pp. 239-246.

Jeong, J. S.; Hong, P. (2007) "Customer orientation and performance outcomes in supply chain management". *Journal of Enterprise Information Management*, v.20, n.5, pp. 578-594.

Joh, J.M.; Mayfield, M. (2009) "The discipline of product discovery - identifying breakthrough business opportunities". *Journal of Business Strategy*, v.30, n.2/3, pp. 70-77.

Locher, D. A. *Value Stream Mapping for Lean Development – a how-to guide for streamlining time to market*. CRC Press: United States.

Madhavaran, S.; Appan, R. (2010) "Developing complex business-to-business products: issues and implications". *Management Search Review*, v.33, n.7, pp. 715-733.

Malhotra, N. K. (2005) *Introdução à pesquisa de marketing*. Bookman: Porto Alegre.

Marksberry, P.; Badurdeen, F.; Gregory, B.; Kreafle, K. (2010) "Management directed kaizen: Toyota's Jishuken process for management development". *Journal of Manufacturing Technology Management*, v. 21, n. 6, pp. 670-686.

Mcadam, R.; Hazlett, S.; Anderson-gillespie, K. (2008) "Developing a conceptual model of lead performance measurement and benchmarking: a multiple case analysis". *International Journal of Operations & Production Management*, v.28, n.12, pp. 1153-1185.

Mccoy, A.; Thabet, W.; Badinelli, R. (2009) "Understanding the role of developers/builders in the concurrent commercialization of product innovation". *European Journal of Innovation Management*, V.12, n.1, pp. 102-128.

ISSN 2176-5480

Miguel, P.A.C. (org) (2010). *Metodologia de Pesquisa em Engenharia de Produção e Gestão de Operações.* Campus: São Paulo.

Mols, N. P. (2010) "How does concurrent sourcing affect performance?". *Journal of Business e Industrial Marketing*, v.25, n.7, pp. 525-534.

Morgan, J.; Liker, J. K. (2006) *The Toyota Product Development Process: Integrating People, Process and Technology*. Productivity Press: New York.

Muenstermann, B.; Stetten, A.; Laumer, S.; Eckhardt, A. (2010) "The performance impact of business process standardization: HR case study insights". *Management Research Review*, v.33, n.9, pp. 924-939.

Muglestone, M.; Maher, L.; Manson, N.; Baxter, H. (2008) "Accelerating the improvement process". *Clinical Governance: an International Journal*, v.13, n.1, pp.19-25.

Nunes, B.; Bennett, D. (2010) "Green operations initiatives in the automotive industry". *Benchmarking: an International Journal,* v.17, n.3, pp. 396-420.

Park, J.; Shin, K.; Chang, T.; Park, J. (2010) "An integrative framework for supplier relationship management". *Industrial Management & Data Systems*, v.110, n.4, pp. 495-515.

Reinsertsen, D. (2007) "Rethinking lean NPD - A distorted view of lean product development". *Strategic Direction*, v.23, n.10, pp. 32-34.

Rother, M.; Shook, J. (1999) *Learning to see – Value Stream Mapping to add value and eliminate MUDA.* Lean Enterprise Institute: United States, 102 p.

Salah, S.; Rahim, A.; Carretero, J.A. (2010) "The integration of Six Sigma and lean management". *International Journal of Lean Six Sigma*, v.1, n.3, pp. 249-274.

Saliba, M.A.; Zarg, A.V.; Borg, J.C. (2010) "A modular, reconfigurable end effector for the plastics industry". *Assembly Automation*, v.30, n.2, pp. 147-154.

Sarshar, M.; Pitt, M. (2009) "Adding value to clients - learning from four case-studies". *Facilities*, v.27, n.9/10, pp. 399-412.

Schäfer, H.; Sorensen, D. J. (2010) "Creating options while designing prototypes: value management in the automobile industry". *Journal of Manufacturing Technology Management*, v.21, n.6, pp. 721-742.

Singh, B.; Garg, S.K.; Sharma, S.K. (2010) "Development of index for measuring leanness - study of an Indian auto component industry". *Measuring Business Excellence*, v.14, n.2, pp. 46-53.

Smadi, S.A. (2009) "Kaizen strategy and the drive for competitiveness - challenges and opportunities". *Competitiveness Review: an International Business Journal*, v.19, n.3, pp. 203-211.

Ward, A. (2007) *Lean Product and Process Development*. Lean Institute: United States, 2007.

Wee, H.M.; Wu, S. (2009) "Lean supply chain and its effect on product cost and quality: a case study on Ford Motor Company". *Supply Chain Management: an International Journal*, v. 14, n.5, pp. 335-341.

Womack, J.P; Jones, D.T. (1996). *Lean Thinking*. Free Press: New York.

8. RESPONSIBILITY NOTICE

The authors are the only responsible for the printed material included in this paper.