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***Research paper***

# Innovation and quality processes in software development of Smes, in Baja California, Mexico

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**Abstract**

The objective of this article is to research the impact that innovation has in the development and quality of software production processes, and in turn, how innovation influences the profitability of small- and medium-sized enterprises (SMEs). This research was carried out with a sample of 52 enterprises in the software area in Baja California, Mexico. The collection of data was made from June to September 2016, with the support of a survey aimed to the enterprises' managers. For the analysis of the model and validation of structured relations, the factorial exploratory method of analysis was used, with support from Statistical package software for social sciences (SPSS), version 21. The results show that both innovation in the development and quality have a positive and significant influence over products innovation and in processes developed in SMEs. Furthermore, products' quality has a positive and significant influence in the enterprises' profitability.

***Keywords***: *Software Processes; Innovation; Software Engineering; Quality and SPEM.*

## 1. Introduction

For the enterprises dedicated to software development, seeking to implement improvements in software production processes, innovation has become a key factor to get competitive advantages. Enterprises must be capable of accepting new challenges in order to compete in a globalized world, where the role played by technologies and knowledge in enterprises is essential to achieve innovation in their production processes, as well as satisfy the client's needs by acquiring a product that reunites the highest quality standards. In this sense, the innovation economy studies tend to point out certain typical characteristics of production services that have an impact on the nature of innovation processes [7]. Innovation poses as one of the main cores of the new economy in modern society, through which the company's competitiveness can be increased, also increasing efficiency, reliability, and safety of their processes, as well as generating added value through the creation of a high quality product, which meets the highest quality standards [2]. There are processes in enterprises in which there are work roles assigned to professionals capable of carrying out the designated tasks, where to-be-innovated processes are analyzed through the application of development methodologies in software production processes, in which the assigning of roles has a high difficulty, since the abilities and knowledge required in many levels of development processes must be taken into account. In this sense, the technical and organizational competences in this process are key to the achievement of objectives. This causes a level of advantageous use of such competences that could be beneficial in some cases, but, from professionals' point of view, it constitutes an increase in their work load. The software production process is a complex activity that involves various highly creative phases, in which innovative activities are part of the production process. In this sense, SMEs creative actions will be the ones to prepare innovation in their processes as part of their business strategy in technical, organizational, and commercial terms. In addition, a better comprehension of innovation nature can generate significant contributions to the design of innovation measure instruments [18].

The development process starts with the analysis of a client's requirements, contemplating four development phases: specification, design, implementation, test and launch, and, as a result, a single software product, in which, regardless of work methodology, the assigning of roles to actors in development is difficult, considering that the knowledge and abilities they possess are different. Furthermore, there are different modeling methods, such as software product line engineering, which suggests a new form of developing the software product, which consists of developing software by product line and not one software for each product, being useful for analysts, designers, and programmers to develop software [3]. The Product Line Software Engineering revolves around the development of multiple informatics systems similar in a domain from a common code base [17]. The first application of a Software Product Line (SPL) arises in the Swedish company Celsius Tech System AB, using systems for ships control, contemplating delivery dates with clients, applying reutilization techniques for their development processes in many systems, along with a reorganization of the company, achieving the compliance to the dates of both systems and the development of new systems. After that moment, more software products with more requirements in less delivery time were created, improving design time and maintenance. According to [16], it is important to consider the costs that the product entails and the cost reduction in the development of similar products managed in parallel; this is one of the benefits of SPL. A SPL allows reconfiguration, in which components can be added or removed from the system, components' parameters and restrictions can be defined, and knowledge from this business processes can be included. This configuration can be made in two points of the development process:

in launch and development. The configuration during launch is the use in software packages that are designed for a particular task, for instance, if the organization already has an application, it is used as a starting point to generate another one, in more generic application architecture. A generic system is adapted and specified to satisfy functions' specific requirements [4]. In figure 1, the elements involved, such as role, activity, knowledge, as well as documents and tools are shown, which are key elements to identify the problems that may be affecting the knowledge flow through the process activities and its transfer between roles. In terms of variability of a product line, selecting the specific requirements during the derivation of products, the variability of the resulting applications from the software product is defined, starting from artifacts identified in the process, establishing configurations for the final product [13].

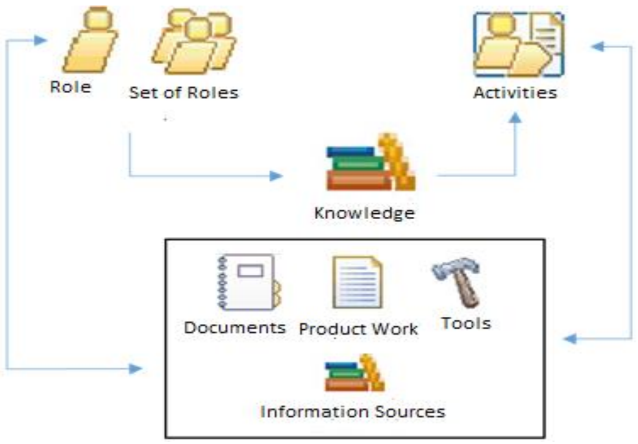


**Fig. 1:** Elements Involved with Adaptation to the Processes Model. Source: [21].

In this sense, the enterprises are increasingly interested in implementing development models that can facilitate the improvement of development processes; one of the best approaches of process improvement is the one that improves software processes (SPI), which evaluates practices and the form in which software products and services are developed, or SMART-SPI, which is a model that, according to [14], is a model for the analysis of SPI data, which provides a solution to identified problems in the company. The organizations involved in the software development process need to manage the development activity through the modeling of the software creation process, seeking to improve the products' development and quality, in other words, they must guarantee the construction of a software product inside the cost and time limits [5].

The Software Process Engineering (SPE) consists on modeling, designing, improving, and applying processes using process modeling languages (PML), considered as languages to model development processes of software products. In addition, one of the models is SPEM (Software Process Engineering Metamodel), which is an specification of OMG [19], which is a metamodel that allows the representation of components of various processes for which a set of process modeling elements are provided in order to describe any software development process, without the restrictions of a specific area or discipline [15]. SPEM bases its notation in three basic elements: work products, work definitions, and roles [21]. SPEM allows the software process modeling form different perspectives, with diverse abstraction levels and with a formally defined language; the adaptation made in Figure 2 defines the elements like roles, activities, and knowledge, involved in the process. According to [9], a process model is the structured collection of elements that describe effective processes characteristics, those which have proven to be effective. In this sense, ISO constituted standards for software processes, or adaptations of such in order for small and medium enterprises to apply it; such standards were published in year 2010 under the name ISO/IEC 29110 [20]. The basic profile of ISO/IEC 29110 regulation is divided in two processes: the proyects Process management (PM) and a process of Software implementation (SI). Each process is divided in activities, tasks, and the documents (work products or artifacts) produced [11].

Figure 2 shows an adaptation made to the software process engineering (IS) defined in the ISO/IEC 29110 regulation. According to [6], the Software Engineering is an intensive knowledge process that covers the collection of requirements, design, development, test, implementation, and maintenance. In this process, the Software Process Engineering Metamodel is shown under a symbology (SPEM) 2.0, where the flow of information in activities associated to the process is shown, including the most relevant work products and their relations [19]. The TI enterprises, according to [1], must improve quality in their products and services by getting certifications that help them improve processes, seeking to generate products that satisfy the clients' needs and requirements; likewise, it helps increase the competitiveness among enterprises of this area, developing a continous improvement in quality assurance, since this is a key factor in the software creation process. In this context, the appropriate selection of personnel that will make up the development teams is crucial and directly affects the process effectiveness [12].

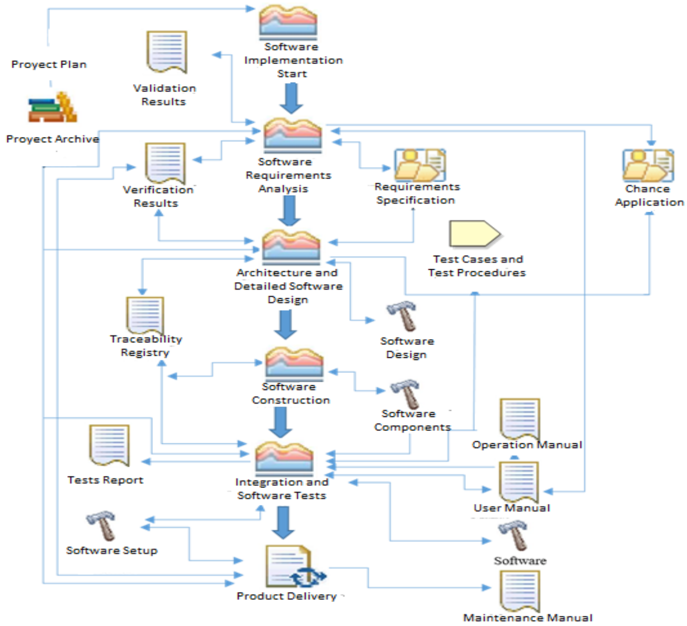


**Fig. 2:** Information Flow for Software Implementation. Adaptation and Translation of the Activities in the Software Implementation Process. Source: [11].

## 2. Methodology

The current research is correlational and its design was selected in order to look into an organizational phenomenon parting from the statistical analysis through the correlation between variables. The TI area was selected, small and medium enterprises dedicated to software development specifically and the number of the SMEs was obtained from the information provided in the Economic Census made by the National Institute of Statistics and Geography [10]. The structure of the sample has been formulated and based in the sample principles stratified for finite populations. The population is formed from SMEs established in the state of Baja California, specifically in the cities of Mexicali, Ensenada, and Tijuana. The size of the sample was determined considering and error margin lower than 0.03 points with a trust level of 95%. The technique for correlation of data was through an instrument (survey) sent through E-mail and, in some cases, the SME manager was personally interviewed from June to September in 2016. Lastly, a sample of 52 enterprises dedicated to software development was obtained. This area of the industry was selected due to its high growth potential as an area in development for the state of Baja California.

### 2.1. Hypothesis of the research

The hypothesis of the research are as follows:
$H_1$: Software development is positively related to innovation for development.
$H_2$: Software quality is positively related to innovation for development.
$H_3$: Clients' satisfaction is positively related to innovation for development.
A survey for data collection was designed, which is composed of 31 items for the research variables; the survey design and the collection of data were carried out according to the stipulations from [8]. Next, the analysis of this research' variables is detailed.
Measurement 1: Software development was analyzed based in the grade in which the enterprises' managers implement improvements in the requirements analysis, as well as the design of strategies and indicators that allow continuous development through the management and process integration, establishing work routines that adapt to a changing environment, in addition to using process improvement models that can help the company keep competing.
Measurement 2: Software quality was developed considering the extent to which the company's manager promotes quality, considering the commitment and importance that the highest ranks in the company give to the implementation of process continuous improvement, through the allocation of resources in order to apply international certifications or standards that facilitate quality assurance in the software product.
Measurement 3: Clients' satisfaction was analyzed by aligning strategies implemented by the company's manager through the continuous improvement of development processes with the level in which activities impact in strategic priorities of the company, considering the participation level of clients when establishing improvement objectives, through the use of process indicators in order to measure monitoring and feedback of the continuous improvement process.
Measurement 4: The innovation for development was analyzed based on the technical and organizational competences in this process, as well as the peculiarities of the work organization and its influence in the development of capabilities and innovation results, considering the economic impact in the company, as well as the roles that technical competences play in the innovation process.

## 3. Results

A Kolmogorov-Smirnov test was carried out in order to verify the normality of the data. A $p>0.05$ value was obtained, for which the Ho isn't rejected; the data comes from a normal distribution [8]. In order to analyze the relation between research variables, a correlation analysis of Pearson Bivariate was carried out between software development, software quality, clients' satisfaction, and innovation for development variables. In this sense, the calculation for each dimension analyzed was carried out; the result can be observed in Table 1, where the Cronbach alpha was obtained with an average of 0.840; the result of the Cronbach reliability analysis can be observed through SPSS software version 21. Based on these results, we can conclude that the instrument is reliable.

**Table 1:** Reliability Analysis Abstract (Cronbach Alpha) for Each Measurement

| Variable | Cronbach Alpha |
|---|---|
| Software development | 0.875 |
| Software Quality | 0.858 |
| Clients' satisfaction | 0.812 |
| Innovation for development | 0.834 |

**Table 2:** Results of the Correlation Analysis

| | | | Software development | Software Quality | Clients' satisfaction | Innovation for development |
|---|---|---|---|---|---|---|
| Pearson | Software development | Significant correlation coefficient | 1.000 | .359** | 0.468** | 0.572** |
| | | (bilateral) | | 0.000 | 0.000 | 0.000 |
| | Software quality | Significant correlation coefficient | .286** | 1.000 | 0.387** | 0.563** |
| | | (bilateral) | 0.000 | | 0.000 | 0.000 |
| | Clients' satisfaction | Significant correlation coefficient | 0.491 | .445** | 1.000 | .532** |
| | | (bilateral) | 0.000 | 0.000 | | 0.000 |
| | Innovation for development | Significant correlation coefficient | 0.532** | 0.511** | 0.525** | 1.000 |
| | | (bilateral) | 0.000 | 0.000 | 0.000 | |

** The correlation is non-significant at level P<0.01 (bilateral). In table 2, the correlation matrix between the research variables is shown. The correlational analysis was carried out through SPSS version 21. The correlation coefficients between software development, software quality, and clients' satisfaction with innovation for development were of 0.572, 0.563, and 0.532 respectively. Therefore, hypothesis $H_1$, $H_2$ and $H_3$ are accepted.

The results are shown in Table 2. As it can be observed, all correlation coefficients are significant for presenting a $p<0.01$, therefore, the correlation between variables is significant. There is statistical evidence for accepting the research hypothesis. Also, in Table 2, it is observed that the variable 'software development' has a moderate correlation with the innovation for development level, pointing out the highest correlation of 0.572. Therefore, there is statistical evidence to indicate that software development is positively related with the level of innovation for development. The variable 'clients' satisfaction' also has a moderate correlation with the level of innovation for development (see Table 2), therefore, clients' satisfaction, composed by those clients to which the enterprises sell the software product, is also positively associated with the level of innovation for development. The results of this research contribute to the state of the art when demonstrating that the adoption of certain organizational practices aimed to innovation help the company keep generating competitive advantages and the improvement of quality indicators, which is of high utility form a competitive perspective, since, in this way, it is possible to measure if there is a relation between implementing new organizational practices.

## 4. Conclusions

The research results contribute to the importance that innovation has in SMEs dedicated to software development, which is very limited right now, where there is statistical evidence to establish that the level of innovation in enterprises is positively related to three variables: software development, software quality, and clients' satisfaction. According to the correlation analysis, the level of innovation for software development associated to software quality shows the commitment from the enterprises' owners in order to promote an improvement in such process; software development is also associated, where the establishment of measures or indicators that facilitate the knowledge of the current state in processes, implementing an organizational structure that supports software development in an efficient way, seeking to be more competitive. Lastly, for administrative personnel of the software development area, we show statistical data as evidence that the variables 'development', 'quality', and 'clients satisfaction' are positively associated to the level of innovation for development, for which the results of this research can help make an introspection regarding their organizational practices in order to comprehend their current state and allowing them to keep innovating with the purpose of increasing their organizational competitiveness in the strategic and operative parts, achieving the quality of the software product offered

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