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The knowledge products within software industry organizations: a new perspective on software artifacts

Os produtos de conhecimento dentro das organizações do setor de software: uma nova perspectiva sobre artefatos de software

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ABSTRACT

The Knowledge Management (KM) has become essential for organizations looking to store, encode, retrieve and disseminate knowledge in the environment in which they operate. In the software industry, KM presents itself as a form of management with relevant contribution

potential, since this industry produces information on a constant basis. In this way, this information can be consolidated into software artifacts. Such artifacts represent knowledge of a particular software project, as well as a knowledge product. That is because a knowledge product also represents some kind of codified and stored knowledge. Thus, this work aims to analyze software artifacts from the perspective of knowledge products. To this end, a questionnaire was conducted and interviews with ten experienced project managers from the software industry. As a result, it was observed that the software artifacts become knowledge products because they allow reuse and register intellectual capital creating new knowledge and encouraging innovation in the software industry organizations.

Keywords: Knowledge management; Software Artifacts; Information Technology.

RESUMO

A Gestão do Conhecimento (GC) tornou-se essencial para organizações que buscam armazenar, codificar, recuperar e disseminar o conhecimento no ambiente em que operam. Na indústria de software, a GC apresenta-se como uma forma de gestão com relevante potencial de contribuição, uma vez que esta indústria produz informação de forma constante. Dessa forma, essas informações podem ser consolidadas em artefatos de software. Esses artefatos representam o conhecimento de um projeto de software específico, bem como um produto de conhecimento. Isso porque um produto do conhecimento também representa algum tipo de conhecimento codificado e armazenado. Assim, este trabalho tem como objetivo analisar artefatos de software sob a perspectiva de produtos do conhecimento. Para este fim, um questionário foi conduzido e entrevistas com dez gerentes de projeto experientes da indústria de software. Como resultado, observou-se que os artefatos de software se tornam produtos do conhecimento, pois permitem reutilizar e registrar o capital intelectual, criando novos conhecimentos e incentivando a inovação nas organizações do setor de software.

Palavras-chave: Gestão do conhecimento; Artefatos de Software; Tecnologia da informação.

1 INTRODUCTION

Knowledge Management (KM) aims to help organizations achieve sustainable competitive advantages in the market in which they operate. Therefore, KM helps in the creation of new knowledge in order to disseminate them quickly in new products/services, technologies, and systems, perpetuating the change within the organization (Nonaka, 1994). Thus, KM, from its models, cycles, practices, and tools, allows organizations to store, encode, and share knowledge. In this way, it is possible to generate new knowledge (Dalkir, 2005). From this perspective, one of the ways of generating new knowledge is a knowledge product.

According to Mentzas, Apostolou, Young & Abecker (2001) a knowledge product is constituted by the process of transferring knowledge to documents or files. According to the authors, this process of knowledge transfer is based on making the knowledge explicit and registrable, since the knowledge product is available to the other members of the

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organization. In this scenario, the KM provides facilitating processes in which they seek to support organizational learning through these knowledge products. In this way, the organization's ability to learn from its environment and incorporate knowledge into its business processes is enhanced and is therefore essential for organizations in the software industry (Aurum, Daneshgar, & Ward, 2008).

The organizations belonging to the software industry are dynamic and complex, so the KM processes are indispensable (Pinto, Bortolozzi, Menegassi, Pugino, &Tenório Jr., 2016) since it stands out from the other areas of the market to have an end product in which it is knowledge intensive. This means that the final product (software) goes through several processes, in which it receives specific knowledge so that it can be consolidated (Bjørnson&Dingsøyr, 2008).

According to Santos, Lourenço, Gomes, Bortolozzi, &Tenório (2018) knowledge is the main organizational asset in organizations of the software industry. Therefore, according to the authors, knowledge becomes a source of profit when directly related to the development of the final product, *i.e.*, software. Thus, these organizations regularly produce, through technologies, knowledge products such as software artifacts (*e.g.*, user requirements, software modeling, database models), user manuals, multimedia material, among others, which are constantly used by the individuals of this industry (Lourenço, Sartori, Menegassi, Oliveira, &Tenório, 2018).

In this context, this research aims to analyze software artifacts from the perspective of knowledge products. Therefore, this article is organized in five sections. In addition to this Introduction, the second section deals with Knowledge Management in the software industry, containing two subsections: one relates to knowledge products and the other brings explanations about software artifacts as knowledge products. The third section reports the methodological procedures used in the research, which clarifies how the data were obtained and analyzed, and the following section presents the results obtained. Finally, in the fifth section the conclusions of the research are followed, followed by the references used.

2 THE KNOWLEDGE MANAGEMENT IN THE SOFTWARE INDUSTRY

Managing knowledge is one of the most complex and arduous tasks of an organization. To that end, KM can become support, through its processes and practices. This is because KM can be described as a process in which it aims to continuously create new knowledge, disseminating it or incorporating it into new products and services, as well as technologies

and systems, favoring changes within the organization (Nonaka, 1994). Thus, an organization becomes an amplifier of knowledge, since it clearly allows the sharing of information for all its employees (Takeuchi & Nonaka, 2008).

According to Becerra-Fernandez and Sabherwal (2010), KM can be defined as doing what is necessary to get the most out of knowledge resources. In this sense, it can be highlighted that the KM is process-oriented conduct, in which it aims to identify, capture, store, disseminate and apply knowledge throughout the organization. Thus, it is possible that actions in the organization can be completed quickly, reducing the cost of production and rework (Mohapatra, Agrawal, &Satpathy, 2016). In this scenario, it is understood that the KM can be a support for the organizations inserted in the software industry.

Software industry organizations use knowledge intensively since they perform many complex tasks at the same time (Nawinna, 2011). In this sense, Tenório*et al*. (2017) add that in these organizations' individuals use personal technologies to communicate with each other. In this way, they produce more information, thus consolidating organizational knowledge.

However, this organizational knowledge must be structured in order to be beneficial to the organization (Wiig, 1993). In order to do so, the KM can become support, since it makes it possible to integrate knowledge into the organization (Zhang, Liu, Tan, Jiang, & Zhu, 2018). Thus, incorporating knowledge, this industry is guaranteed to achieve greater productivity and innovation due to the fact that individuals' knowledge is directly related to the final product (software) (Fenton &Bieman, 2014). This knowledge of individuals is called the intellectual capital of the organization.

The intellectual capital of the organization corresponds to the set of knowledge and information found in organizations that adds value to products and/or services through the application of intelligence rather than money capital (Stewart, 1998). That is, it is the sum of individuals' knowledge, together with know-how, know-why and experience, which form one of the most important assets of organizations (Klein, 1998).

However, integrating the KM into organizations within the software industry is relevant to support the structuring and integration of knowledge. In addition, through the support of the KM it is possible to use processes such as identification, capture, storage, dissemination, and application of knowledge in order to reinforce the actions in these organizations, making them more profitable and competitive in the market active.

2.1 KNOWLEDGE PRODUCTS

The definition of a knowledge product is not easily found in the literature. Nonetheless, these knowledge products are usually explicitly shared, expressed in words or numbers (Onte& Martial, 2013). In this way, a knowledge product makes knowledge explicit so that it becomes valuable and applicable in the organization (Woitsch, Hrgovcic, & Buchmann, 2012). So, a knowledge product is understood as the register of the supplier's expertise, experience, and skills of that knowledge that becomes accessible to groups of people, *e.g.* departments, sectors, communities of practice, or even the whole organization.

Thomas and Hettige (2012) reinforce that a knowledge product is one of the keys to disseminating knowledge within the organization, in which it can occur through the continuous publication of results, experiences, conference reports, transfer of knowledge to other organizations, among other forms. The dissemination of knowledge brings among its benefits the preservation of organizational information so that there is no waste of this resource.

According to Dalkir (2005) in generating and storing knowledge products, some processes must be adopted, such as the creation, use, and dissemination of organizational knowledge. The author points out that such processes make up the KM cycle so that it becomes adherent to the practices, which consist mainly of creating a knowledge product of greater value to the organization. For example, a basic database may represent an example of coded and stored knowledge.

Tenórioet al. (2017) state that codified knowledge can be structured and stored in systems that can, in turn, provide indexing in order to be distributed throughout the organization through a data network, thus enabling access to their products knowledge. Consequently, these products, when properly created and stored, enable reuse of best practices and reduction of project rework (Nonaka, 1994). In addition, knowledge products have several other applicability's, such as supporting decision-making in a particular strategic action in an organization (Antle, Jones, & Rosenzweig, 2017) and can also be used as a learning certain subject (Runesson& Gustafsson, 2012).

Therefore, a knowledge product explicitly documents and records knowledge about a particular subject or skill. Hence, it is possible for such products to be used at appropriate times, such as in employee training. In this way, the dependence of individual knowledge is reduced, thus helping the organization to structure, code and store knowledge through such products.

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2.2 THE SOFTWARE ARTIFACTS AS KNOWLEDGE PRODUCTS

Understanding the requirements of a problem is one of the most difficult tasks encountered by those who model and develop a software system (Sommerville, 2011). In this sense, the Requirements Engineering provides a solid base, through techniques that guarantee the understanding of the domain of the problem to be developed, which allows the design and construction of the product (software) to meet the needs of the client.

In Requirements Engineering there are several techniques that can be used to extract data, generating so-called software artifacts. Pressman (2007) conceptualizes a software artifact as any artifice that assists in the understanding and development of the software. Therefore, a software artifact helps to describe the activities, structures, and design of the software being developed, generating detailed system documentation that can be used later. When combined, software artifacts result in system documentation, such as the requirements document, which is conceptualized as an agreed statement of needs that the system must meet, which are defined together with the user (Sommerville, 2011). In this way, a software artifact explicitly documents the product being built, *i.e.* software, as well as a knowledge product. That is because such knowledge products are also explicitly created and shared through written documents, templates, models or models, graphs or spreadsheets. This occurs because, in some way, knowledge is expressed and subsequently documented (Onte&Marcial, 2013).

From this perspective, Santos *et al.* (2018) emphasize that in organizations of the software industry knowledge is made explicit through knowledge products, better known in this industry as software artifacts.

Software artifacts are a form of captured knowledge that is not always easy to adapt to organizational changes. This adaptation must be carried out considering the software development process adopted by the project. Therefore, as software changes occur, the artifacts must be updated so that they do not become obsolete (Correia, 2010). One type of software artifact, for example, is the use case diagram, which represents a process of identifying the actors involved in an interaction, assigning a name to the type of action, allowing everyone involved a clear view of the software (Sommerville, 2011). In addition, software artifacts, such as test cases and database schemas, constantly change during evolution and maintenance of software systems.

Therefore, new requirements, functionalities or bugs may arise in the software development process (Li, 2016). In this way, a dynamic is created in which the organization

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creates and renews its knowledge, providing the basis for the innovation of its products and services (Nonaka &Hirotaka, 2008).

In view of this, software artifacts can be understood as a structured, stored and recorded explicit form of knowledge, as well as the knowledge products. This is because such knowledge products and artifacts correspond to the set of knowledge in a consolidated way, in which they will be necessary to support the tasks to be developed in the organizations of the software industry.

3 METHOD

The methodological strategy used in this research was the mixed sequential explanatory method. This method is used when the researcher investigates the observed phenomenon using a questionnaire (quantitative step) and then conducts interviews (qualitative step) to improve his understanding of the data collected in the previous step (Creswell, 2017).

Thus, the present research was carried out in three phases. The first one consisted of the search for publications related to the subject of this article, carried out in the Emerald Insight, Web of Science, Science Direct and Google Scholar databases. For this purpose, the following keywords were used (in Portuguese and English): Knowledge Products; Software industry; Knowledge management; Knowledge Products; Software Industry; Knowledge Management. In addition, the search was delimited to full articles published since 1994. This search resulted in 35 articles that contained in their summary or keywords the terms searched. From these results, a reading of all the documents was done, being considered adherent to this research 2 articles. The first one, that of Mansfield and Grunewald (2013), in which these researchers organized a workshop in which 30 practitioners from different sectors of the software industry participated to share indicators of KM practices, and the researchers validated 101 KM indicators. The second work was that of Scalabrini, Oliveira, Urbano, &Tenório (2017), in which the authors validated the Mansfield and Grunewald (2013) indicators with different experts from the software industry, *e.g.*, practitioners, project managers, and directors. Thus, the focus was on the indicators of knowledge products.

In the second phase of this research, data collection was carried out through the conduction of a questionnaire with professionals in the software industry, with the objective of effectively identifying the importance of knowledge products and KM in the day to day of the organizations of this industry from the perspective of the participants. The questionnaire

was composed of twelve objective questions, and the Likert scale (1932) was adopted for the answers because it allows an analysis of different perceptions about a certain theme. The scale allowed responses in one of five different alternatives, being: (1) I fully agree, (2) Agree, (3) Neither agree nor disagree, (4) Disagree, and (5) Strongly disagree. Chart 1 presents the questions and their respective objectives for this research.

Chart 1 – Proposed Questionnaire

o	Description	Goal
	I understand the importance of knowledge products to my organization.	Verify that the respondent understands the importance of knowledge products within the software organization.
	A knowledge product generates ability to increase and maintain new skills in the organization.	Investigate the interviewee's point of view regarding the potential for new practices in the software industry.
	The management of knowledge products is important to my organization.	Identify whether the respondent considers the management of knowledge products meaningful.
	Monitoring the knowledge products within the software organization through measures and metrics corroborates to preserve their intellectual growth.	Detect if the interviewee believes that monitoring the knowledge products within the software organization, the preservation of intellectual capital is encouraged.
	A software tool would help organize knowledge products within my organization.	Investigate how much the interviewee deems important a software tool in the organization.
	Knowledge products are a way of storing knowledge in software organizations.	To characterize the extent to which the interviewee believes that knowledge products preserve knowledge in software organizations.
	Knowledge products promote the flow of knowledge in the organization.	Determine how much the interviewee understands about the flow of knowledge in the organization as to

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		the knowledge products.
	The knowledge products are closely related to the intellectual capital of the organization.	Specify whether the respondent understands that intellectual capital is closely linked to the intellectual capital of the organization.
	I often use knowledge to do my job.	Check how often the knowledge stored in the organization is used.
0	Check one or more knowledge products that you consider important to your organization: i) videos; (ii) handouts; iii) manuals; vi) tutorials.	Naming software artifacts as knowledge products that the participant believes are important to an organization in the software industry.
1	I constantly down, I use, I download knowledge products into the organization.	Check if the interviewee makes use and / or download of knowledge products stored in the organization.
2	The monitoring of knowledge products requires the quality of information.	To investigate how the quality of information influences the knowledge products.

Source: The authors (2019).

Ten professionals working in software development organizations were invited to participate in the research. All participants are professionals with proven experience of more than five years in project management in organizations of the software industry. All the organizations are located in Paraná, two of them in the city of Maringá and one in the city of Marialva.

It should be noted that before conducting the questionnaire, which occurred in the period from October 9 to 13, 2017, the researcher explained the concept of knowledge products, providing examples of such as, *e.g.*, videos, audios, system documents and artifacts produced during product design. Thus, through this questionnaire, it was possible to verify the perception of each participant about the knowledge products.

The third phase of this research was the conduction of interviews based on a pre-established script, which occurred soon after the participant answered the questionnaire of the second phase. The interview script, with twelve open questions, was designed to

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investigate the details about participants' understanding of KM and knowledge products. The questions that compose the interview script are presented in Chart 2.

Chart 2 – Interview script

o	Question
	From your understanding, do you believe you know what a knowledge product is?
	Do you think it is important to manage knowledge products within an organization?
	The knowledge product is important in order to stimulate and enhance the intellectual capital of the organization. Based on this statement, describe your opinion.
	How much do you believe a software tool would help store your knowledge products within your organization?
	By monitoring the knowledge products within the organization, how much do you believe would be easier to migrate, if necessary, to another business process?
	How much do you believe you have lost from knowledge products within your organization due to the lack of tools for storing information?
	How much do you believe an indicator of a knowledge product within your organization would be important?
	Assuming that you already have the knowledge products in your organization, what characteristics do you think it is possible to improve in your organization?
	How do you believe you can consolidate a knowledge product?
0	What tools do you currently use to share your knowledge products within your organization?
1	What are the long-term benefits, in your opinion, the knowledge management with your knowledge products can provide for your organization?
2	Name the knowledge products that you consider most important to your organization.

Source: The authors (2019).

Although the researchers followed the script of interviews, the participants were granted space for a demonstration if they wanted to make other observations about the subject investigated, as predicted by the semi structured interview technique.

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Ten of the software industry professionals were invited to be part of the research, with six invited by e-mail and four invited by mobile messages. The data were collected in the period of October 9 and 13, 2017. The interviewees belong to three different software development organizations, all of them with more than five years of experience in their functions. To obtain the results of this research, we first selected participants that act at the management level in organizations of the software industry, because it is understood that only these professionals have the managerial information necessary for this research. The choice of this profile was determined based on the importance of the role in the decision making of the organizations since a manager is one of those responsible for the conversion and use of knowledge within the organization, thus they become knowledge engineers (Takeuchi & Nonaka, 2008). Therefore, this is the profile that is considered adequate for this research.

Regarding the tabulation of the obtained data, all the answers of the questionnaires were transcribed to a spreadsheet of the program Microsoft Excel. At first, the objective questions were analyzed, which come from the Likert scale. Thus, a quantitative analysis was performed based on the percentages of the 120 responses obtained through the ten participants with twelve responses each. The calculated percentages presented the level of importance that the managers gave to the elements present in the affirmative of the questionnaire.

In a second moment, the interviews were analyzed through content analysis with the use of the tool *Atlas TI*, and it is possible to codify the interviews to be later analyzed in light of the objective of this research.

4 RESULTS AND DISCUSSION

Given the respondents' answers, it is observable that the participants understand that software artifacts are knowledge products. Among the types of software artifacts identified by the participants were videos, diagrams, user and system manuals, and handouts. In this scenario, participants were unanimous in stating that KM and software artifacts as knowledge products are important to the organization. Thus, 60% of the respondents said they fully agree and 40% said they agree that these knowledge products explain organizational knowledge. In addition, the interview results reiterate the percentages about the importance of the knowledge products to the software organization, since one of the interviewees, when asked about the importance of knowledge products within the

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organization, revealed that "the management of knowledge products within the organization is of eminent importance." (Project Manager, 09/10/2017).

In this same sense, another project manager stated that "[...] the reuse of knowledge reduces work by the diffusion of knowledge, by standardizing practices and products." (Project Manager,13/10/2017).

There is also unanimity about the importance of the management of these knowledge products, proving the data obtained in the questionnaire. However, respondents reveal that there is no effective use of specific practices for the management of knowledge products. Such practices refer to the forms of reuse of knowledge in the organization and for that to happen, it is necessary to structure it. One of the ways the knowledge product becomes ready for use and reuse is to structure it into yellow pages. According to Dalkir (2011), the yellow pages, or knowledge localization systems, present a map that shows where and how this knowledge can be found. In addition, the yellow pages indicate the source of knowledge, *i.e.*, who possesses this knowledge. Therefore, this documentation that stores knowledge can be retrieved in the form of explicit knowledge, thus becoming robust of knowledge. The research results, obtained both through the questionnaire and the interviews, also revealed that software artifacts as knowledge products are seen as the intellectual capital of software development organizations.Klein (1998) emphasizes that the intellectual capital of organizations is formed by their knowledge, experience, expertise and related social assets. In this way, their competitive positions in the market in which they operate are determined more and more. Thus, 80% of respondents say they fully agree with the importance of intellectual capital for the organization and 20% say they agree. During the interviews, this importance was not only reinforced but also understood as essential for the organization of the software industry. This is observed when one of the project managers interviewed comments on the importance of theknowledge products to be valued to stimulate and improve the intellectual capital of the organization.

Intellectual capital creates knowledge products in an evolutionary cycle where a synergy shapes a new knowledge product [...]. This recursion should be at the heart of the evolution of organizational knowledge products and so organizing them is so important to organizations especially when we refer to software that live in rapid and constant evolution (Project Manager,13/10/2017).

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In this sense, another project manager commented that"Knowledge Management and the knowledge product are important for the intellectual capital of the organization, as this means managing, disseminating organizational knowledge among employees" (Project Manager,11/10/2017).

In order for the dissemination of organizational knowledge to take place, it is necessary to have a culture of valorization of intellectual capital. In this sense, Nonaka and Takeuchi (2008) emphasize that valuing intellectual capital is a way of making explicit knowledge so that it is available for use and reuse. Such reuse can be done by means of words, numbers, sounds, shared in the form of data and consolidated in products or documents, since explicit knowledge can be quickly transmitted to individuals, formally and systematically. In this way, it is possible to observe that both project managers agree on the influence of intellectual capital and also on the knowledge products generated in the organization stimulate intellectual capital and the dissemination (or sharing) of knowledge. Such sharing fosters a supportive culture in the organization, resulting in a cyclical and renewable movement of knowledge within organizations (Thomas &Hettige, 2012).

Innovation was one of the points also revealed by both the questionnaire and interviews. Nonaka and Takeuchi (2008) argue that in addition to applying the basic KM processes, the organization must establish means to boost and amplify knowledge through continuous, dynamic and simultaneous interaction, *i.e.,* knowledge must be stored in a way that allows its use, or reuse, to create new knowledge. In this sense, 66.66% of the respondents fully agree and 33.33% of them agree that knowledge products can generate the capacity to foster and maintain new skills in the organization.During interviews, when asked about the long-term benefits of the knowledge products generated and available in the organization, a project manager reported that "[...]especially in organizations that seek to continuously improve their processes and products, the knowledge product must be up-to-date in order to generate innovation [for the organization]." (Project Manager,13/10/2017).

Nonaka and Takeuchi (2008) define innovation as a process of recreating certain knowledge from a new ideal. In this way, it is possible to have the development of knowledge, this means that when it is renewed periodically in the organization, through constant updating, it is possible to obtain innovation. Therefore, the interviewees reinforce the importance of innovation, since it is understood that the organization that uses the knowledge renewal process is able to innovate and remain competitive in the market.

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Therefore, keeping the knowledge up to date and available can become a path to the organization's innovation.

In the realized interviews it is observed that the project managers recognize the relevance of the KM and the knowledge products for an organization within the software industry. Conversely, this was not identified in the questionnaires, since there is no identification of practices related to KM, and particularly to the management of knowledge products. In this sense, Becerra-Fernandez and Rajiv (2010) affirm that organizations must, increasingly, share knowledge among individuals. The sharing of ideas enables the emergence of new ideas, renewing solutions for both products and services, and this is given by the organizational knowledge presented in the knowledge products. Therefore, maintaining knowledge products enables software industry organizations to promote innovation, structure intellectual capital, and provide reuse, as shown in Figure 1.

Figure 1 – Knowledge products and their possibilities for the organization
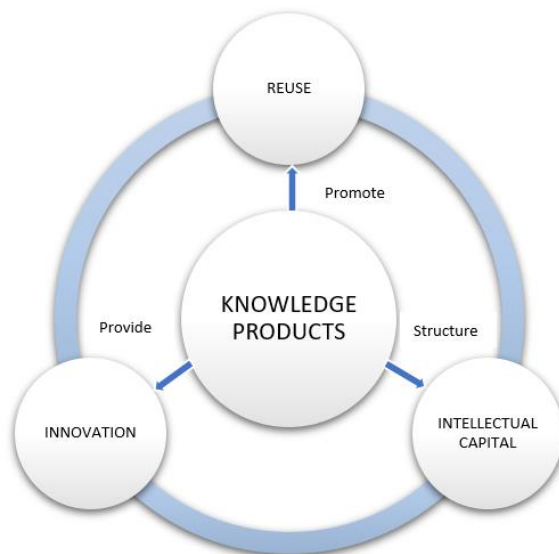
Source: The authors (2019)

5 CONCLUSIONS

This article aimed to analyze software artifacts from the perspective of knowledge products. To verify the importance of knowledge products, a questionnaire and a semi structured interview with the same research subjects were applied.

It was observed that in the view of the participants of this research, aknowledge product is conceived as the consolidation of the intellectual capital stored in a structured way, preserving, thus, the knowledge. In this sense, creating, storing and sharing the

knowledge products enables agility in organizational processes, while creating a knowledge base that is used throughout the organization.

From the results of the research, it was also possible to observe the importance of the reuse of consolidated intellectual capital, that is, of the reuse of the knowledge products. The practice of reuse must be structured, for example, in yellow pages, which become maps for the search of a certain subject in the organization. Another situation observed in this research was the relevance of innovation in organizations of the software industry. Innovation must be constant, through existing practices in the organization. As future work, further research on the questionnaire and interview responses is suggested in order to suggest processes for organizations in the software industry.

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