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VALIDATING KNOWLEDGE CREATION INDICATORS FOR THE SOFTWARE INDUSTRY: A FIELD RESEARCH THROUGH A STRUCTURED QUESTIONNAIRE

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ABSTRACT

Individual knowledge is the primary asset in the software industry and can lead its companies to achieve competitive advantage through Knowledge Management (KM) processes. One of the KM processes that stimulate innovation is the knowledge creation. However, this process needs monitoring to assess whether software industry companies are on the innovation way. An assessment is only possible through indicators which measure the KM processes performance. Based on a previous study of the review and discussion indicators for knowledge management and knowledge brokering in international development, we built a structured questionnaire to validate knowledge creation indicators. We applied it on twelve expert software project managers. By examining data from the structured questionnaire, we find twenty-six relevant indicators to monitoring the knowledge creation process for the software industry.

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INTRODUCTION

Knowledge has become a fundamental intangible asset of great value to organizations, especially in the search for competitive advantage. In this sense, knowledge added to work has had an important influence on business and management models in organizations. Due to it, many organizations need to adopt processes which aim for the creation, use, and spreading of knowledge in the organizational environment (Dalkir, 2011). Especially, in the software industry the companies are intense on knowledge, and even, characterized as being highly competitive and dynamic (Nawinna, 2011). In these companies, the individual knowledge is directly connected to the final product, which, in this case, is the software.

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Knowledge is an intangible asset and being in a highly complex environment, and hard to be measured. According to Sveiby (1996), companies have great difficulties in assessing performance and measuring their intangible assets, since there is not a formal and widely accepted standard. Besides, it is difficult to identify the intangible assets which add value to the production activity once they are not easily recognized in the organizational structure. Adopting performance indicators is an approach to assess organizational knowledge. Since knowledge is incorporated into organizational processes, indicators need to be addressed to the organizational and individual learning and productivity (Goldoni and Oliveira, 2010). In this context, among the processes related to KM, the one about knowledge creation is fundamental for project executions, development of new projects and technological innovations in the area helping organizations to keep being

innovative and sustainable in the competitive market (Desouza and Awazu, 2005). Mansfield and Grunewald (2013, p. 6) present 100 KM indicators resulted from a workshop whose objective was gain an overview of what indicators are used to measure KM in the international sector. The authors argue that "It is important to ensure that indicators are tailored to the particular context in which they will be used (…)". Thus, considering knowledge creation as technological innovations essence for the software industry (Desouza and Awazu, 2005). Therefore, this paper aims to validate forty-two of knowledge creation suggested by Mansfield and Grunewald (2013), determining which of them are relevant to be used forthe software industry. In the direction of this, we built and applied a structured questionnaire. The remainder of this paper is structured as follows. This section presented the introduction. Next section presents the theoretical reference followed by a description of the research method. After that, we present the results achieved and, lastly, the conclusions and guidance for future research.

KM FOR THE SOFTWARE INDUSTRY

By the end of the 20th century, the knowledge became the main organizational aspect, and responsible for structural and production changes. As a consequence, there was information accumulating in organizations which needed to establish methods to identify, manage, share, and keep the knowledge in the organizational environment (Stewart, 2007).In this context, knowledge started to be managed within organizations to secure them a prominent place in the market, improve their performance, maximize their business opportunities, and minimize their risk of opportunity loss (Schiuma *et al.,* 2012), ensuring their long-term well-being and viability (Wiig, 1997).

KM has become relevant in the organizational environment, promoting the development of a knowledge base alongside individual skills, thoughts, innovations, and ideas (Dalkir, 2011). Wiig (1997) highlights that the KM aims to introduce organizational actions to build an organization capable of transforming, organizing, implanting, and using knowledge resources.KM has drawn software industry attention since its companies have a peculiar characteristic which distinguishes them from others: they take place knowledge-intensive activities which results in high added value products (Bjornson and Dingsoyr, 2008).Thus, KM requires a set of practices addressed to developing, spreading, and use of knowledge within an organization (Kebede, 2010).The KM practices should consider explicit knowledge, which has already been or will be articulated in some media, and tacit knowledge, which is the one hidden in people's experiences and insights (Nonaka *et al.,* 2014). However, in the software industry companies, the primary challenge is using knowledge to deal with problems concerning management and other organizational matters. Furthermore, KM must work as an organizational learning facilitator to increase company's capacity to learn through its environment and also incorporate knowledge into its business process (Aurum *et al.,* 2008).

The role of knowledge creation on the software industry

In the software industry companies, knowledge creation practices perform an essential role to carry out software development tasks which often resulting in technological innovations (Desouza and Awazu, 2005). Popadiuk and Choo (2006) show that the knowledge creation process is continuous and involves interaction between individuals, groups, and organizations. Knowledge creation is a dynamic process which the objective is to convert tacit knowledge into explicit knowledge (NONAKA *et al.,* 2014). The authors argue that tacit and explicit knowledge are major entities which complement each other, and their interaction is the primary source of knowledge creation in organizations. Apart from that, new knowledge is inherent to individuals, converting itself into organizational knowledge afterward. The process of knowledge creation, carried out into practices, improving tacit knowledge contributing to creating new organizational knowledge that contributes to continuous innovation and competitive advantages (Nonaka *et al.,* 2003). The purpose of this newly created knowledge is related to the company's development of new skills and capacities, enabling the creation of new products and services and the improvement and perfecting of the organizational processes (Menolli *et al.,* 2015).

KM INDICATORS

As any organizational process, it is necessary to verify if the results expected from the KM are being achieved. The KM practices can be managed and measured through KM indicators (Goldoni and Oliveira, 2010). Furthermore, the authors affirm that since knowledge is incorporated into the organizational processes, the indicators must be focused on learning and organizational productivity. Nevertheless, managing and measuring KM practices is not an easy task because the knowledge is an intangible asset hard to be measured. The indicators focused on KM processes can be divided into two groups: quantitative and qualitative. The quantitative indicators are expressed in numbers (quantity and percentage) and tend to be more objective, parameterize able and comparable. On the other hand, the qualitative indicators are subjective because the quality is something inherent to the individual (Goldoni and Oliveira, 2010). Mansfield and Grunewald (2013) suggested that the best way to measure KM in companies is combining the quantitative and qualitative indicators. Also according to the authors, indicators gain strength when used as a structure that links multiple indicators together within a broader monitoring and evaluation framework. However, the KM indicators must be defined according to the context of each organization (Goldoni and Oliveira, 2010; Mansfield and Grunewald, 2013). Therefore, for the knowledge creation measurement to become possible in the software industry, it is necessary to combine a set of quantitative and quantitative indicators.

METHODS

This paper is an exploratory study based on a research field aiming to validate knowledge creation indicators and determines which of them are relevant for the software industry. Thus, we followed the stages presented in Figure 1. In the first stage, we performed pre-selection of the indicators. We analyzed all KM indicators suggested by Mansfield and Grunewald (2013), and we found out forty-two knowledge indicators grouped in the following subgroups: (i) indicators for an online community of practice; (ii) indicators for knowledge product, and; (iii) indicators for the organizational development of the KM capacity. In the second stage, we organized pre-selected indicators into a structured questionnaire, presented in Appendix (Questionnaire), containing the forty-two knowledge creation indicators suggested by Mansfield and Grunewald (2013). We choose five-point Likert scale to be used for each question, as

suggested by (Harpe, 2015). The scale value contains five possible answers: (1) strongly agree; (2) agree; (3) neither agree nor disagree; (4) disagree and; (5) strongly disagree. Alongside the structured questionnaire, we added questions regarding the relevance of the indicators supporting the participants daily work tasks. Furthermore, we also formulated questions regarding the influence of those indicators on their decision-making process.

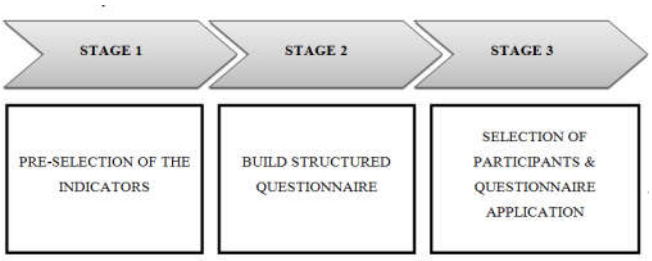

Figure 1. Stages of the validation of the indicators for the organizational knowledge measurement in software industry

The third and last stage was taking place during September of 2016 when we visited four different medium-sized software development companies to encourage volunteers in participating in this research. Our desired profile was experts in software project management with graduation diploma in related fields. Thus, we selected twelve participants over than five years of experience conducting software development projects and with graduation in Management, Information System, Computer Science, and System Analysis. Furthermore, four participants were Master in Computer Science. We managed the questionnaire face to face and individually during October of 2016. Before starts questionnaire fill-up, we explained each question to the participants.

For data analysis, we defined parameters, shown in Table 1, for acceptance or dismissal the KM indicators. The values considered as ideal were based on: i) questions which show mode (MODE) and median (MED) between 1 and 2, indicating that the participants "strongly agree" or "agree" about relevant indicators to knowledge creation for the software industry; ii) the interquartile range (IQR) between 0 and 1, indicating that 50% of the data is centralized in this interval and hardly vary; iii) full range between 1 and 4, including all the values of the data set because, since it is a measure which is very sensitive to tiny or huge values, the full range could lead us to wrong conclusions. Thus, the adopted full range to does not distort the result. After that, we organized data in MS-Excel spreadsheets. Finally, we analyzed and interpreted data through descriptive statistics, as suggested by Harpe (2015).

Table 1. Parameters for the selection of relevant indicators for the software industry

FILTERS	PARAMETERS
Mode	|1 and 2|
Median	|1 and 2|
Interquartile	|0 and 1|
Full range	|1 and 4|

RESULTS

We found out three following creation indicators subgroup: Online Community of Practices (CoP) Knowledge Sharing Forum, Knowledge Products, Organizational Development of KM Capacity each of them detailed below.

Subgroup online community of practice (CoP)or knowledge sharing forum

The subgroup online community of practice or knowledge sharing forum contained sixteen indicators. After the validation, the participants considered six of them relevant for the software industry. The validation results are presented in Figure 2.The indicators #5 (number of answers by discussion) and #7 (number of members who engage discussions) were considered relevant by participants to measure the knowledge creation process. The participants also considered relevant the indicators #8 (number of contributions from moderators), #10 (number of discussions which broke down into other topics), #11 (participation of the target public on the CoP settings procedures), and #12 (non-participation of the public target by the discontinuation or lack of settings of the CoP). Conversely, they were not considered relevant for the software industry the indicators #1 (number of members of the CoP), #2 (number of contributions by content), and #15 (interaction between people who met at the CoP). The participants were not certain about the relevance of the indicators #9 and #14 (related to CoP members interactions), #3 (number of views of different content), #6 (number of days before the first answer on a discussion), and #13 (number of chats which has resulted in the portal). Lastly, the participants "strongly disagreed" or "disagreed" about indicators #4 (related to the participation of members of the CoP) and #16 (what the community allows to be done).

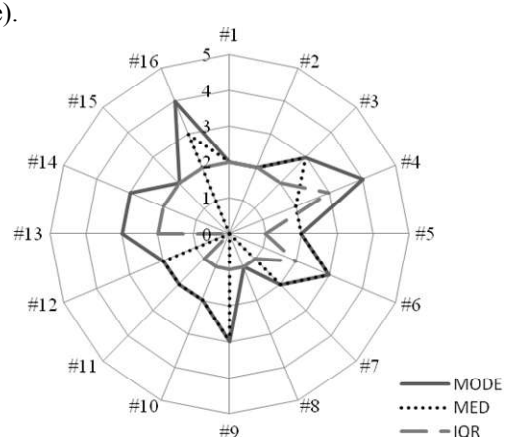

Figure 2. Indicators submitted to validation considering online community or knowledge sharing forum

Subgroup Knowledge Products

In this subgroup, we submitted twelve indicators to validation, and the participants considered eleven of them relevant to the software industry, as presented in Figure 3.Among the validated indicators in this subgroup, only #24 (the number of channels where a knowledge product - KP) was not considered relevant for the software industry. However, most of the indicators were validated as "strongly agree" by participants. It is the case of the indicators #18 (percentage of users who classify the knowledge products as good, excellent, or useful), #19 (number of mentions), #21(number of people who read the

knowledge products), and #22(percentage of readers who accessed a particular knowledge product).Furthermore, matching this perspective are the indicators #23 (number of people who acquire knowledge related to their work through reading), #25 (if there was knowledge acquisition through discussions about the product), and #27 (if the usefulness of the knowledge product is noticed by the target public). The participants also agreed that the indicators #17 (number of KP created), #20 (number of KP downloads), #26 (number of KP recommendations), and#28 (number of examples where work has been mentioned) are relevant to the measurement of the knowledge creation process in the software industry.

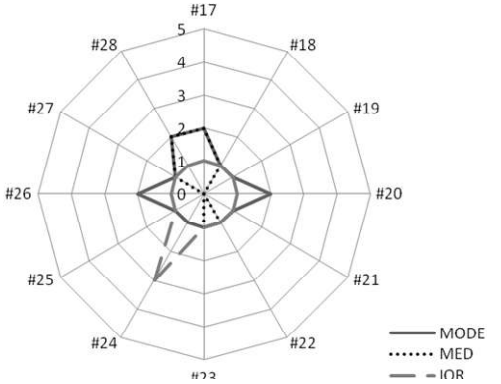

Figure 3. Indicators submitted to validation considering knowledge products

Subgroup organizational development of the KM capacity

Figure4 shows fourteen indicators validated in this subgroup and nine of them considered as relevant for the software industry by participants. The indicators #29 (who feel encouraged to share knowledge with their co-workers), #32 (people who believe knowledge is an essential organizational resource), and #33 (people who agree they are encouraged, by the organization, to seek knowledge from co-workers) were considered relevant by participants that “strongly agree” or “agree” with those. The participants also “strongly agree” or “agree” about the indicators #34 (percentage of people who agree that if the need for some specific knowledge comes up, the organization will offer an expert to help), #35 (percentage of people who know who knows what in the organization), #36 (people able to find the piece of knowledge they need quickly and easily), and #38 (people who agree that CoP improve and make it easy to share knowledge among the members of a team). The participants analyzed also two “Yes/No” indicators, #41 (the structures for teamwork help people present experiences and insights from other settings to shape their work) and #42 (encouraging people from many perspectives and different points of view to emerge in the organization). They considered those indicators also relevant for the software industry. The indicators #30, #31, #37, #39, and #40, presented in Appendix, were validated as "neither agree” or “disagree". Thus, according to our established parameters, they were not considered relevant by participants for the software industry.

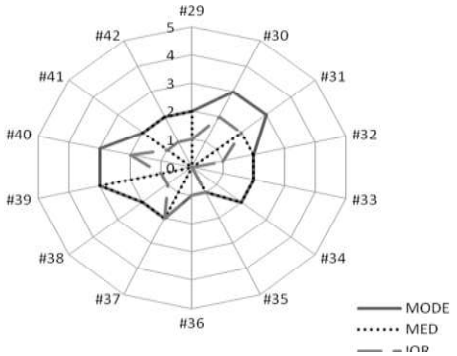

Figure 4. Indicators submitted to validation considering organizational development of KM capacity

VALIDATED KNOWLEDGE CREATION INDICATORS

Considering the parameters presented in Table 1, we show in Table 2 the indicators deemed relevant for the software industry, according to the participants.

Table 2. Knowledge creation indicators selected for the software industry

Subgroup	Indicators selected
Online community of practice or Knowledge sharing forum	#5. Number of answers by discussion
	#7. Number of members who engage discussions
	#8. Number of contributions from moderators
	#10. Number of discussions which broke down into other topics
	#11. Presence of target public who participated in the CoP setting procedures
	#12. Non-participation of the target public due to discontinuation or lack of setting of the CoP
Knowledge product (KP)	#17. Number of KP created
	#18. Percentage of users who classify KP as good, excellent, or useful
	#19. Number of KP mentions
	#20. Number of KP downloads
	#21. Number of people who read a KP
	#22. Percentage of readers who accessed a particular KP
	#23. Number of people who acquire knowledge about their work and/or product policy through reading
	#25. If there was knowledge acquired through discussions about the product
	#26. Number of KP recommendations
	#27. Useful for the knowledge product noticed by the target public
	#28. Number of examples where work has been mentioned
Organizational development of the KM capacity	#29. Percentage of people who feel encouraged to share knowledge with their co-workers
	#32. Percentage of people who believe knowledge is an essential organizational resource
	#33. Percentage of people who agree they are encouraged, by the organization, to seek knowledge from co-workers
	#34. Percentage of people who agree that if the need comes up for a specific piece of knowledge, the organization will offer an expert to help
	#35. Percentage of people who agree that they know exactly "who" in the organization has the specific knowledge to help them in their job
	#36. Percentage of people who agree that they can find the knowledge they need quickly and easily
	#38. Percentage of people who agree that organization's CoP improve and facilitate knowledge sharing
	#41. Structures for teamwork and project which encourage people to present experiences and insights from other settings to shape their work
	#42. Encourage people from many perspectives and different points of view to emerge in the company

Source: The authors

The first subgroup indicators are focused on CoP participation. It shows the participants' careful in achieving the CoP objectives in which is promote discussion regarding a specific theme. The second subgroup of indicators presents the need to create knowledge products that can be used by different organizational individuals. The participants have also shown concern with the quality what is being produced. The third and last subgroup emphasize that knowledge sharing is required to knowledge creation. In this direction, the participants highlighted the importance of the communication among the team members to share ideas and experiences, and find solutions to problems. Those indicators could be used to monitor and measure the knowledge creation process for the software industry.

At the end of the questionnaire, we asked some questions regarding participants' perspectives about the use of the selected indicators in the decision-making process as well as their general opinion about KM importance in their daily work tasks (Appendix - Questions). Considering their indicators perspective, the participants (80%) agreed that the indicators validated could help them in the decision-making process. They also agreed (89%) that KM is important to the organization where they work and for the project in which they are involved. Finally, the participants reported us that establish knowledge creation indicators is a way to recognize the relevance of the artifacts in the software development such as the use of a standard code, the elaboration of a checklist, the exploitation of flow of the processes, and the creation of innovative products.

Conclusion

This paper aimed to validate a set of indicators to determine which are relevant to monitoring knowledge creation within the software industry. Thus, we designed a structured questionnaire was managed by twelve software project managers experts. The results pointed out twenty-six relevant KM knowledge creation indicators toward to the software industry. Among the subgroups evaluated, the set of indicators related to CoP showed a low relevance level for the spread of knowledge in the software industry. On the other hand, the subgroup knowledge products indicators presented great relevance to the participants, showing, this way, the importance of the knowledge products and the relation between the subgroup with the knowledge creation. Finally, the subgroup organizational development of the KM capacity indicators was considered relevant for the software industry, reinforcing the importance of the organizational practice in the knowledge creation process. However, this research presents the following limitations: i) the number of participants, which was limited to twelve); ii) the participants have the same job position (software project managers), which represents a single viewpoint of the knowledge creation indicators; and iii) only four software development companies contributed to this research. In spite of that, the questionnaire here presented has a significant scientific contribution because it works as a guide to aid the software companies in selecting knowledge creation indicators, and to monitor and track innovation in their products and services. For further research, we intend to apply the questionnaire to different job positions, such as team leaders, developers, and directors to refine the indicators. Finally, we plan to perform a pilot using those twenty-six indicators, here presented, in a real software development environment aiming to adjust those indicators and increase accuracy our analysis.

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APPENDIX

QUESTIONNAIRE (1) Strongly agree; (2) Agree; (3) Neither agree nor disagree; (4) Disagree; (5) Strongly disagree.	
Online community of practice (CoP) or knowledge sharing forum	
Indicator	Scale
1. Number of members of CoP	(1) (2) (3) (4) (5)
2. Number of contributions by type of content	(1) (2) (3) (4) (5)
3. Number of views of different types of contents	(1) (2) (3) (4) (5)
4. Distribution of members' participation (comment, don't comment and listeners)	(1) (2) (3) (4) (5)
5. Number of answers by discussion	(1) (2) (3) (4) (5)
6. Number of days before the first answer on a discussion	(1) (2) (3) (4) (5)
7. Number of members who engage discussions	(1) (2) (3) (4) (5)
8. Number of contributions from moderators	(1) (2) (3) (4) (5)
9. Number of (mutual) connections of access, exit, moderators and members of the CoP in the corporate social network	(1) (2) (3) (4) (5)
10. Number of discussions which broke down into other topics	(1) (2) (3) (4) (5)
11. Presence of target public who participated in the CoP setting procedures	(1) (2) (3) (4) (5)
12. Non-participation of the target public due to discontinuation or lack of setting of the CoP	(1) (2) (3) (4) (5)
13. Number of chats which had resulted in the portal	(1) (2) (3) (4) (5)
14. If a person has talked to someone who they had never talked before and who they probably would not have talked to if it were not for the community	(1) (2) (3) (4) (5)
15. Someone who has already worked out of the CoP with someone who met on the CoP	(1) (2) (3) (4) (5)
16. The person can give an example of what the community allows you to do	(1) (2) (3) (4) (5)
Knowledge product (KP)	
17. Number of KP created	(1) (2) (3) (4) (5)
18. Percentage of users who classify KP as good, excellent, or useful	(1) (2) (3) (4) (5)
19. Number of KP mentions	(1) (2) (3) (4) (5)
20. Number of KP downloads	(1) (2) (3) (4) (5)
21. Number of people who read a KP	(1) (2) (3) (4) (5)
22. Percentage of readers who accessed a particular KP	(1) (2) (3) (4) (5)
23. Number of people who acquire knowledge about their work and/or product policy through reading	(1) (2) (3) (4) (5)
24. Number of channels where a KP is available	(1) (2) (3) (4) (5)
25. If there was knowledge acquired through discussions about the product	(1) (2) (3) (4) (5)
26. Number of KP reccommendations	(1) (2) (3) (4) (5)
27. Useful for the knowledge product noticed by the target public	(1) (2) (3) (4) (5)
28. Number of examples where work has been mentioned	(1) (2) (3) (4) (5)
Organizational development of the KM capacity	
29. Percentage of people who feel encouraged to share knowledge with their co-workers	(1) (2) (3) (4) (5)
30. Percentage of people who believe they have time to transmit and receive knowledge "from" or "to" other people	(1) (2) (3) (4) (5)
31. Percentage of people who share knowledge with a co-worker from outside their team at least once a week	(1) (2) (3) (4) (5)
32. Percentage of people who believe knowledge is an essential organizational resource	(1) (2) (3) (4) (5)
33. Percentage of people who agree they are encouraged, by the organization, to seek knowledge from co-workers	(1) (2) (3) (4) (5)
34. Percentage of people who agree that if the need comes up for a specific piece of knowledge, the organization will offer an expert to help	(1) (2) (3) (4) (5)
35. Percentage of people who agree that they know exactly "who" in the organization has the specific knowledge to help them in their job	(1) (2) (3) (4) (5)
36. Percentage of people who agree that they can find the knowledge they need quickly and easily	(1) (2) (3) (4) (5)
37. Percentage of people who agree that organizational knowledge is useful and meets their needs when sought for in an organizational repository	(1) (2) (3) (4) (5)
38. Percentage of people who agree that organization's CoP improve and facilitate knowledge sharing	(1) (2) (3) (4) (5)
39. Percentage of people who agree that it is not so easy to share knowledge with co-workers from other teams as it is with the ones from their team	(1) (2) (3) (4) (5)
40. Percentage of people who are confident that all their knowledge created with potential value for future projects will be known, traceable and used after they have left the organization	(1) (2) (3) (4) (5)
41. Structures for teamwork and project which encourage people to present experiences and insights from other settings to shape their work	(1) (2) (3) (4) (5)
42. Encourage people from many perspectives and different points of view to emerge in the company	(1) (2) (3) (4) (5)
Participants' perspectives about the research	
1. This set of indicators will help me with decision-making on my daily life?	
2. Do you think that KM is important to your organization?	
3. Do you think that KM is important to the project you are involved with?	
4. What is your understanding level regarding KM?	
5. Do you have any suggestion about those indicators? (*e.g.* add/replace/take out an indicator; comments; etc.)	

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