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"Old" theories, "New" technologies: Understanding knowledge sharing and learning in Brazilian software development companies

André Menolli [a,b,*], Maria Alexandra Cunha [c], Sheila Reinehr [a], Andreia Malucelli [a]

[a] Post-graduate Program in Informatics (PPGIa), Polytechnic School, Pontifícia Universidade Católica do Paraná – PUCPR, Curitiba, Brazil
[b] Computer Science Department, Universidade Estadual do Norte do Paraná, Bandeirantes, Brazil
[c] Graduate Program in Business Administration, Business School, Getulio Vargas Foundation – EAESP/FGV, São Paulo, Brazil

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ABSTRACT

Context: New technologies such as social networks, wikis, blogs and other social software enable collaborative work and are important facilitators of the learning process. They provide a simple mechanism for people to communicate and collaborate and thus support the creation of knowledge. In software-development companies they are used to creating an environment in which communication and collaboration between workers take place more effectively.
Objective: This paper identifies the main tools and technologies used by software-development companies in Brazil to manage knowledge and attempts to determine how these tools and technologies relate to important knowledge-sharing and learning theories and how they support the concepts described by these theories.
Method: A survey was conducted in a group of Brazilian software development companies with high levels of process software maturity to see how they implement the Brazilian Software Processes Improvement model (MPS.Br) and use new tools and technologies. The survey used a qualitative analysis to identify which tools are used most and how frequently employees use them. The results of the analysis were compared with data from the literature on three knowledge-sharing and learning theories to understand how the use of these tools relates to the concepts proposed in these theories.
Results: The results show that some of the tools used by the companies do not apply the concepts described in the theories as they do not help promote organizational learning. Furthermore, although the companies have adopted the tools, these are not often used, mainly because they are felt not to organize information efficiently.
Conclusion: The use of certain tools can help promote several concepts described in the theories considered. Moreover, the use of these tools can help reduce the impact of, some common organizational problems. However, companies need to improve existing organizational policies that encourage employees to use these tools more regularly.

1. Introduction

Knowledge is an essential property for companies in contemporary economies, especially knowledge-intensive ones such as software-development companies. Such companies must not only explore current knowledge but also invest continuously in the search for new knowledge to provide strategic options for future decisions and develop a competitive edge [1]. Hence, it is extremely important that companies acquire, store and reuse knowledge systematically. To achieve this goal, new technologies such as social software can help promote the sharing and reuse of acquired knowledge. Social software is a term for software systems that support human communication, collaboration and interaction in large communities [2]. Normally, social software is associated with Internet communities but may also be used in learning contexts [3]. Many new technologies, which are also known as Web 2.0 technologies, constitute social software. They facilitate distributed collaboration, foster the free reuse of information and experience and help knowledge workers to deal with immense information overload by simplifying the organization, integration and reuse of information scattered across diverse content sources [4].

* Corresponding author at: Computer Science Department, Universidade Estadual do Norte do Paraná (UENP), Bandeirantes, Brazil.
E-mail addresses: and.menolli@gmail.com (A. Menolli), alexandra.cunha@pucpr.br (M.A. Cunha), sheila.reinehr@pucpr.br (S. Reinehr), malu@ppgia.pucpr.br (A. Malucelli).

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In recent years, many knowledge-intensive companies such as those involved with software-development have used these new technologies as substitutes for intranets, creating an environment in which communication and collaboration between workers take place more effectively and organizational learning (OL) is possible [5]. However, despite the growing number of companies using these new technologies as a way of promoting the codification, sharing and reuse of knowledge, in many cases the companies do not know how these technologies can aid the OL process. Therefore, it is important to map how each technology can facilitate the different steps of the OL process in order to maximize the use of these tools. This is particularly important for developing countries such as Brazil, which have a large domestic software market and aim to compete in international markets. In Brazil, efforts are being made by both the government and industry to improve software processes.

This study seeks to understand how knowledge-sharing and learning theories relate to new technologies. Three well-established knowledge-sharing and learning theories were used: the single- and double-loop learning theory of Argyris and Schön [6], Wenger's communities of practice theory [7] and Nonaka and Takeuchi's SECI knowledge-creation theory [8]. These were chosen because the models proposed in the theories describe processes at the individual and organizational levels and the concepts described are closely related to the concepts that these new tools implement. In addition, since each tool applies a concept described by a theory, it can be claimed that the use of the tool can help improve the OL process related to that concept.

To identify the main tools and technologies used by companies and to understand what perception companies have of these tools and technologies, a survey was conducted in a group of Brazilian software-development companies. The revenue of the Brazilian software and services sector reached U.S. $27.1 billion in 2012 and has grown faster than the world average in recent years. The sector is now responsible for almost 50% of IT investments in Latin America. The present study, which focused on consolidated software development companies in Brazil with a medium to high maturity level, showed which tools these companies use to manage knowledge and how they view these tools. The data from the survey allowed us to identify which of the new technologies available are used to store knowledge generated during the software-development process.

This paper presents the results of a survey applied in thirteen out of twenty Brazilian software-development companies that implement the Brazilian Software Processes Improvement model (MPS.Br) at level A, B or C and use some type of new technology or social tool as a knowledge repository. The paper investigates the main new technologies used by these companies and compares the survey findings with data from the literature. It maps how the tools and technologies used relate to three knowledge-sharing and learning theories. More specifically, it aims to answer the following questions:

1. Which tools or technologies do the software-development companies studied here use as knowledge repositories?
2. Which theories of OL do the new technologies or tools cover?
3. To which new technologies or tools is each theory related?
4. Which new technologies or tools help promote OL in software-development companies more efficiently?
5. What organizational improvements do the tools or technologies make possible in the companies?

The remainder of the paper is organized into six more sections. Section 2 presents a brief overview of knowledge management (KM) and the three knowledge-sharing and learning theories. Section 3 describes the survey methodology, while Section 4 presents the survey results. Section 5 contains an analysis of the results and compares the survey data with the theories. Section 6 discusses the tools and theories presented. Final considerations are presented in Section 7.

2. Knowledge management

In recent years, organizations have placed increasing importance on their employees' experience and know-how, i.e., their knowledge [9]. This underlying knowledge is applied in many ways by companies, e.g., in routines, production practices and relationships. As a result, companies are faced with the challenges of creating and implanting processes that generate, store, organize, disseminate and apply knowledge produced and used in a company in a systematic, explicit and reliable way so that it is accessible to the community that makes up the organization.

The concept of KM can help organizations to minimize these challenges. KM is the process of creating, capturing and using knowledge so that it can be transferred significantly to another person [10], or, according to Landoli and Zollo [11], so that organizational performance can be improved. The primary objective of KM in a business context, according to Tiwana [12], is to facilitate the opportune application of fragmented knowledge by means of integration. KM refers to the practice and techniques used by an organization to identify, represent and distribute knowledge, know-how, expertise, intellectual capital and other forms of knowledge to leverage, reuse and share knowledge and learning throughout the organization [11].

KM is an especially relevant field for research into information systems (IS) as the functionalities of information technologies play a crucial role in organizational definition and in efforts to create, acquire, integrate, evaluate and use knowledge.

The focus of KM system implementation in companies has been the development of accessible document repositories to support the digital capture, storage, recovery and distribution of the explicit knowledge documents of a company. KM systems also encompass other technological initiatives, such as the training of database specialists, the development of support systems for decision-making and systems specialists and the development of networks to provide access to distributed resources [13].

KM systems thus help achieve the goals of OL by assisting the capture, storage, sharing and use of knowledge. According to Senge et al. [14] and Ali, Pascoe and Warner [15], OL can be defined as the continuous testing of experience and its transformation into knowledge that is accessible to the whole organization and relevant to its basic purposes. Another definition is given by Nevis, Di Bella and Gould [16], according to whom OL is the capacity or the processes within the organization that are designed to maintain or improve performance based on experience.

However, it is often difficult to identify OL and to differentiate it from KM, as they are intrinsically connected. Distinguishing between these two concepts is important because the subtle nature of the boundary between KM and OL means that some authors may see a conflict between the two areas.

Levitt and March [17] differentiate between OL and KM, arguing that the former is supplementary to the latter and that, at first glance, OL is seen as the codification of historical inferences in routines that guide behavior. Another differentiation is given by Easterby-Smith and Lyles [18], who consider that OL is centered on process, whereas KM is centered on the knowledge content that an organization acquires, creates, processes and occasionally uses. Yet another way of conceptualizing the intersection between both areas is to view OL as an objective of KM [19]. By motivating the creation, dissemination and application of knowledge, KM initiatives help organizations to achieve their objectives. OL can help organizations put knowledge to use.

OL is an adaptive change process influenced by past experience. It is centered on the development or modification of routines and supported by organizational memory. Knowledge is created by individuals from their abilities, beliefs and experiences and thus crystallized as part of organizational knowledge. The line between OL and KM is subtle: essentially, KM should somehow support the storing of knowledge created by individuals and also help to spread this through groups and the organization so that individual knowledge becomes organizational knowledge, consequently generating a learning organization. KM is important if OL is to be achieved because it supports the capture, organization, storage and sharing of knowledge, facilitating the implementation of techniques, methods and processes that help the organization to grow and develop.

However, if it is to be used in a systematic and reliable way, knowledge generated, which is often the property of a sole individual, must be spread. Various models describe different ways that this knowledge-sharing and learning process can occur at the organizational and individual level.

2.1. Theories of knowledge sharing and learning

Many theories and models of knowledge sharing and learning can be found in the literature, particularly that related to cognitive sciences and administration. The models describe processes at the individual and organizational level, and the main theories include [20] Kolb's model of experiential learning [21], the double-loop learning theory proposed by Argyris and Schön [6], Wenger's communities of practice theory [7] and Nonaka and Takeuchi's theory of knowledge creation [8]. After a detailed study of how these theories are applied to promote OL in software engineering [22], it was found that three theories (the single- and double-loop learning theory of Argyris and Schön, Nonaka and Takeuchi's theory of knowledge creation and Wenger's communities of practice theory) are used extensively in software-engineering studies. We therefore chose to use these theories, which are summarized here:

According to Argyris and Schön [6], there are two forms of learning (Fig. 1):

- Single-loop learning: this occurs after error detection, and the policies underlying the actions that generate errors are not questioned.
- Double-loop learning: this type of learning involves questioning of values, beliefs and, therefore, the resulting policies.

In single-loop learning the event and the effect are observed and if there is feedback from these observations, action is taken to change or improve the process on the basis of the observations. In double-loop learning, the effects of a process or chain of events are observed and the factors that influence the effects are also understood.

The model proposed by Nonaka and Konno [8], which is known as SECI, is a spiral model in which learning generates new knowledge within a company by means of the interaction between tacit and explicit knowledge. Nonaka and Konno [8] identified four forms of knowledge conversion: socialization, combination, internalization and externalization. These processes are described below, and Fig. 2 shows how they interact to create knowledge.

- Socialization: the conversion of part of a person's tacit knowledge to the tacit knowledge of another person. It occurs through the sharing of experiences between people. Socialization leads to the construction of so-called "shared knowledge".
- Externalization: the process of converting tacit knowledge into explicit knowledge by means of metaphors, analogies, concepts, hypotheses or models and by using spoken or written language. Externalization generates a type of knowledge called "conceptual knowledge".
- Internalization: the conversion of explicit knowledge into tacit knowledge. The process is closely related to learning by practice and generates a type of knowledge called "operational knowledge".
- Combination: the conversion of explicit knowledge generated by an individual to add it to the explicit knowledge of the organization, thereby generating a type of knowledge called "systemic knowledge".

The third theory used in this paper is the theory of communities of practice [7]. According to Wenger, a community develops its own learning practices, including routines, rituals, artifacts, symbols, conventions and stories. These are often different from what is found in work instructions, manuals and similar materials. Furthermore, Wenger distinguishes learning in communities from practice among individuals, communities and organizations. For individuals, learning occurs through continual practice and contributes to a community. For communities, learning is perfecting practice. For organizations, learning is supporting communities of interconnected practices.

Although these three theories are disparate, they all attempt to explain OL processes at the individual and organizational level. While Nonaka and Konno's [8] theory is the broadest, describing all kinds of knowledge conversion within a company, the authors do not show explicitly how each type of conversion can be achieved. On the other hand, the communities of practice theory [7] describes how OL can be improved in a community if the community develops its own learning practices. While the theory does not show what type of knowledge and conversion it applies to, we believe it can support two kinds of knowledge conversion:

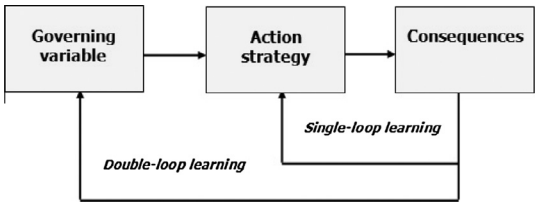

Fig. 1. Single- and double-loop organizational learning [6].

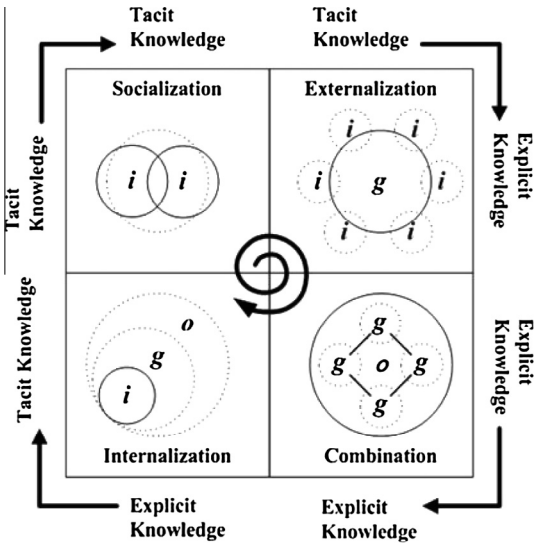

Fig. 2. Knowledge creation as a self-transcending process [8].

- Socialization: since the theory of communities of practice assumes that learning occurs through experience and involves the sharing of experiences between people, it can help socialization.
- Internalization: this is the process of converting explicit knowledge into tacit knowledge and is closely related to learning by practice, one of the premises of communities of practice.

Likewise, Argyris and Schön's theory [6] does not specify what type of knowledge and conversion it applies to. Nevertheless, analysis of the theory reveals that single-loop learning, and double-loop learning in particular, are closely related to the internalization process since the user needs to understand the previously existing information and adapt it.

2.2. Organizational learning and software engineering

Software projects are by nature knowledge-intensive [23]. Each member of a software project team is a specialist in his own domain. The success of a project depends on how well these specialists integrate their knowledge to achieve the goals of the project. To improve the software-development process, the underlying processes must be made practical, the knowledge base of the project team in relation to the software process must be strengthened and the knowledge base must be transferred to the organization as a whole [24].

Interaction between the organizational memory and software-development projects occurs by means of a series of feedbacks of different amplitudes and impacts in the organization, which make the process of KM cyclical and complex [24]. During project development, knowledge is developed when information is analyzed and interpreted. This type of learning occurs at the project level. Normally, learning is stimulated by the need to solve a problem in the organization [25]. Knowledge can also be developed at the end of the project, when the project performance and any problems are analyzed and compared with current or previous projects. This learning is concerned with the alteration of long-term memory and occurs at the organizational level.

When the learning and management approach is used, the knowledge created during software processes can be captured, stored, spread and reused [24]. Thus, better quality and productivity can be achieved. However, although the importance of OL in the software-engineering field has been described in previous studies, such as [26], which claims that learning during software projects is not an option but an imperative for organizational survival, OL is still a little-explored subject in software engineering because many companies ignore it completely, believing that efforts in this area are a waste of time and resources [27].

Although OL in software engineering is not a widely researched topic, KM in software engineering has been studied for a long time [28]. Early studies tried to solve problems such as how to maintain an appropriate level of knowledge in the organization, an example being the study by Basili et al. [29], which proposed an approach to this problem using an experience base. As it is a very broad area, software-engineering studies that seek to improve KM use a range of techniques, including artificial intelligence [30]. Early studies, such as [29,30], helped to promote research into KM in software engineering and to create and popularize new terms and concepts such as 'experience base' and 'experience management'. Over the years, new terms were defined and consolidated for managing experiences, such as 'experience factory' and 'lessons learned' (LL), which were subsequently extensively adopted in software-engineering KM studies.

Basili et al. defined the experience-factory approach [31], which helps to promote OL and acknowledges the need for a separate support organization that works with the project organization to manage and learn from its own experience [31]. Another concept used in several software-engineering research projects is LL. An example of this can be found in the work by Reifer et al. [32], which presents empirical results gathered from data as LL rather than as results or hypotheses. This concept has been well explored in OL applied to software engineering, and many researchers are still using it. Andrade et al. [33] explored KM in companies through LL, specifically for software testing. They proposed an architectural model for software testing based on LL as a component of OL to improve and promote the dissemination and reuse of individual experience gained from technical and managerial software-testing activities. They identified significant weaknesses in existing systems addressing software-testing experience management. Most important among these are (i) unstructured and unformalized LL systems (LLS), (ii) uncontextualized LLS and (iii) failure to integrate LL management processes with software-testing activities. To overcome these weaknesses they proposed a new architectural model whose main features included definition of a representation scheme that allowed a structured formalization of the LL repository and integration of LL procurement management, verification, storage, dissemination and reuse processes with software-testing activities.

An area of software engineering that has been explored in recent years is agile development. Livari and Livari [34] analyzed the relationship between organizational culture and the post-adoption deployment of agile methods. They found that a hierarchical culture orientation increased the deployment of these methods in the case of IS developers and a rational culture decreased the perception of agile methods by IT managers. As an outcome they suggested a number of propositions and hypotheses to explain their findings. They introduced thirteen new hypotheses inspired by agile methods and associated these with the theoretical model. Recognizing that the competing values model represents just one view of organizational culture, the paper introduces a number of alternative conceptions and identifies several interesting paths for future research into the relationship between organizational culture and agile methods deployment.

Another work that explores agile software development is [35], in which the authors try to understand the challenges of shared decision-making in agile software-development teams. They used a multiple case study consisting of four projects in two software product companies that recently adopted Scrum and collected data in semi-structured interviews, from observation of participants and process artifacts. Their data showed that the decision-making processes differed in each project. They found that introducing shared leadership and shared decision-making does not mean that everyone needs to be involved in all decisions, but that all important decisions must be communicated to the whole team and that the team needs to identify which decisions need to be taken together. Agile software development requires alignment of decisions at the strategic, tactical and operational levels to overcome these challenges as well as a transition from specialized skills to redundancy of functions and from rational to naturalistic decision-making.

In [36] a survey was conducted among software developers at a software-development organization to investigate and empirically assess the impact of physical environment on different constituents of communication, coordination and collaboration. The study sought to provide guidelines for prospective agile software developers. It describes which kind of physical environment can contribute to communication among team members and notes, for example, that an open working environment with only half-height glass barriers and communal space plays a major role in this type of communication.

However, agile development has not been alone in receiving attention in recent years, and various other areas have been stud-

ied in an attempt to improve OL. For example, Faegri et al. [37] explored the benefits and challenges associated with improving knowledge redundancy among developers participating in job rotation, which gives individuals direct experience of working with different knowledge domains and therefore contributes to knowledge redundancy [38]. By legitimizing the movement of people between existing groups in an organization, job rotation can help overcome barriers put up by departments, projects or product groups. The study by Faegri et al. [37] sought to improve understanding of knowledge redundancy in software development and put forward two practical proposals: firstly, the establishment of a more formalized support service that would provide developers with some shielding from support enquiries, and, secondly, improved flexibility in project staffing by allowing developers to gain overlapping product experience. Action research was used to experiment with job rotation in practice. The authors cite as the main benefits of knowledge redundancy the innovation stemming from integration of different knowledge domains and the greater appreciation of organizational concerns such as those related to coordination. In addition, job rotation can help expose established values and rationalities.

Companies have always used technologies to improve OL, as evidenced in earlier studies such as [30] and more recent works such as [33], which proposes and implements a model based on LL, an enshrined theory. The proposed tools were created specifically to improve KM and are normally grounded in OL theories. However, in recent years, software companies have used tools and technologies for KM that were not designed for this specific purpose, such as social technologies and web-based tools. In light of all these new tools and technologies available, we sought to find out which are most widely used by software-development companies and to understand what companies' perceptions of these tools and technologies are, as well as how these tools can help OL in software development companies.

3. Survey methodology

This section describes the survey methodology used to collect the data. The survey was conducted by e-mail and with an online questionnaire which the companies were invited by email to complete. This approach was chosen because although online questionnaire surveys usually have the lowest overall response rate [39,40], they are easy to complete and allow the responses to be analyzed quickly [39]. Furthermore, Brazil is a country of continental dimensions and web surveys are easy to carry out. The questionnaire was planned to be objective and simple in order to increase the response rate. The survey demographics and questionnaire structure are described in the following subsections.

3.1. Survey demographics

The survey was carried out with Brazilian software companies. In 2012, the Brazilian market for software and services was the seventh largest in the world and the largest in Latin America, accounting for 3% of total global revenue. While the average growth of the IT sector worldwide in 2012 was 5.9%, in Brazil it was 10.8% [41]. Revenue for the Brazilian market for software and services reached U.S. $27.1 billion in 2012, of which the software segment accounted for $9.67 billion. Revenue in this sector grew from U.S. $1.93 billion in 2004 to U.S. $9.67 billion in 2012, corresponding to an annual growth rate of over 20% [41]. There are over 2500 software development companies in Brazil, of which 5.3% are medium-sized (100–500 employees) and 1.3% are large (500 or more employees) [41].

For this survey, Brazilian software companies that implement the Brazilian Software Processes Improvement (MPS.Br) model [42] and use new technologies were chosen. The MPS.Br is both a movement to improve Brazilian software and a model of quality processes for use in Brazil. The program is coordinated by the Association for the Promotion of Brazilian Software (SOFTEX) and began in 2003 as a way of helping Brazilian companies to achieve quality in software development. MPS.Br is based on ISO/IEC 12207 and ISO/IEC 15504 [42]. The scales in the MPS.Br model vary from G to A and correspond to the following maturity level descriptions: G – Partly Managed, F – Managed, E – Partly Defined, D – Broadly Defined, C – Defined, B – Quantitatively Managed, A – In Optimization. MPS.Br is equivalent to CMMI [43], as shown in Fig. 3, but is more affordable.

As this survey was carried out in Brazilian companies in Brazil, only those companies that implement the MPS.Br model were chosen. The study focused on companies with MPS.Br levels C, B or A, since companies at these levels can be expected to use some kind of tool to manage their knowledge. Twenty companies in this situation were identified. As the initial population was small, relationships were developed by a network of researchers to ensure an adequate number of responses. Because the software sector in Brazil is the object of numerous academic studies there is some resistance to collaboration. This is reflected in the fact that only thirteen of the twenty companies responded, equivalent to approximately 65% of the initial population. On average, the companies have been active in software development for more than eighteen years. Table 1 shows the main types of software developed, and Table 2 shows the continents to which it is exported.

3.2. Survey structure and background

This paper aims to investigate the main new technologies used by software development companies and to map how these technologies relate to three knowledge-sharing and learning theories. The questionnaire was therefore designed with the following two main goals to allow the five questions in Section 1 to be answered:

- To investigate which new technologies are used by software-development companies and what their perceptions of these technologies are.
- To identify how these tools and technologies relate to important theories of knowledge sharing and learning and how they support the concepts described by the theories.

To ensure that the questionnaire would achieve these two goals, it was developed in steps and refined until the final version was reached. The first step was to identify which OL theories and concepts are being applied in the software-engineering area. A broad systematic review was therefore undertaken to identify which software-engineering areas OL studies are concentrated in and how OL concepts have been applied in software engineering in recent years [22].

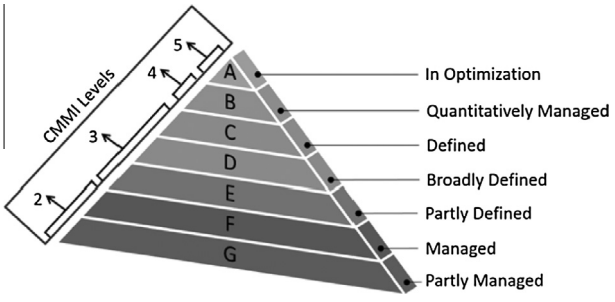

Fig. 3. Comparison of MPS.Br and CMMI.

Table 1
Type of software developed by the companies surveyed.

Type of software developed	Number of companies (percentage)
Software for own use	46.15
Software packages	38.46
Customized or partially modified software	84.62
Custom software	69.23
Embedded software	7.69

Table 2
Continents to which software developed by the companies surveyed is exported.

Location of clients	Percentage of companies with clients in this country/region
Brazil	100.00
South America (countries other than Brazil)	30.77
North America	23.08
Africa	7.69

It was observed from the systematic review [22] that three theories were used in studies of software engineering: the single- and double-loop learning theory of Argyris and Schön [6], Wenger's communities of practice theory [7] and Nonaka and Takeuchi's SECI knowledge creation theory [8]. The phases of OL emphasized in software-engineering studies were also identified.

The review also revealed that few studies deal explicitly with OL in the software-engineering area, but that authors often use OL concepts in their studies, sometimes implicitly. We therefore decided to expand the research and identify which concepts of the three theories are implicitly applied in the corporate environment and which tools and technologies help this process.

After the theories had been defined, tools and technologies were investigated by means of a literature review. From works such as [4], which describes the major web technologies that can be used by learning software organizations, the tools and technologies used in the study were defined: tags, discourse systems, social networks, blogs, property tools, other collaborative writing tools, repositories of shared documents and wikis.

Once the theories and technologies were defined, the questionnaire was created. This consisted of two main parts:

- Identification and Characterization of the Organization: the data collected with this part of the questionnaire was used to write Section 3.1, Survey Demographics.
- OL and KM: this part of the questionnaire was used to identify the main tools and technologies used by the companies surveyed, to identify what their perceptions of these tools and technologies were and to help map the technologies against the theories.

OL and KM involves technological and conceptual questions. To design the conceptual questions, an in-depth study of the three theories chosen was performed. This enabled us to identify and design questions involving all the main concepts in the theories so that we could understand how companies apply them. All the questions were based on theoretical concepts, using the literature. For example, Table 3 shows two questions, as well as the concept involved in the design of each question and the references used. The first question can be used to determine whether the company promotes internalization and if a particular concept, such as LL, is used to promote it. The second provides an analysis of how the company applies the community of practices.

However, the questions were not analyzed separately. Instead, using a set of questions, we inferred whether the concept is supported by the tools and which technology allows the concept to be applied more efficiently.

For a better understanding of the results, we show next how the OL and KM part of the questionnaire was organized and what the main questions were. This part was divided into two sections: codification and knowledge organization; and knowledge sharing and mapping. The organization of each of these sections is described below.

The codification and knowledge-organization section aimed to identify which tools and technologies the companies use to codify the knowledge generated by employees and to understand how the employees use these tools. The questions in this section were therefore planned with the aid of [4], which identifies the main new technologies for learning software organizations. This section sought to answer the following questions:

- On which technologies are the tools that the organization uses to store knowledge generated based?
- What are the greatest difficulties when entering information in the tools?
- How often do employees enter content in the tools?
- Who can enter content in the tools?
- How is the correctness of the content entered in the tools checked?
- How are the contents organized and classified after they have been entered in the tools?

The last part of the questionnaire focused on questions that allowed us to understand whether new technologies facilitate the sharing and mapping of knowledge.

Many concepts involved in the theories of communities of practice [7], single- and double-loop learning [6] and SECI [8] relate to how knowledge is shared among company members. The questions in this section were therefore:

- Are there any restrictions on accessing the contents of the knowledge repository?
- What types of technologies allow better sharing and reuse of knowledge?
- What types of technologies are used in the organization for sharing and reusing knowledge?
- At which stage of a project can employees access the contents of the knowledge repository?
- In which situations do employees consult the knowledge base?
- How often do employees consult the knowledge base?
- What are the major difficulties in using the knowledge repository?
- Do employees analyze and adapt the content to solve a problem?
- Are there organizational improvements resulting from the positive impact of the tools or technologies on the company?

4. Results

The results were divided into two parts. The first is an overview of the tools and is intended to help understand which tools are used most and enable better knowledge sharing; it also provides information on how often the tools are used by the companies surveyed. The purpose of the second part was to understand the impact that the use of the tools can have on the companies and their employees and how these tools are used. This part shows how the content is classified, what restrictions there are on access to it, in which situations the knowledge base is consulted and in which cases it is analyzed and adapted by employees. Finally, this section shows what positive impacts the use of the tools had on the companies.

Table 3
Example of questions and the concepts involved in their design.

Question	Concepts	References
How are complex or new solutions that are solved by trial and error and workers' experience documented? • Through LL • Using processes and flowcharts • Through problem solving • There is no set standard for documenting this kind of knowledge • Other	Internalization	[31,8,44,45]
To access the contents contained in the repository of knowledge, there are: • Access restrictions according to the design • Access restrictions according to the client that the project is allocated • Access restrictions according to the employee's function • No access restrictions • Other	Community of practice	[7]

4.1. Overview of the tools

The first set of results showed which technologies the tools used by the companies to store knowledge are based on. This is illustrated in Fig. 4, where it can be seen that the most frequently used tool for entering content is the *repository of shared documents*, followed by *wikis*.

The next set of results showed which tools or technologies enable better knowledge sharing and reuse and which tools are used for this purpose.

Although *wikis* are not the most commonly used tool for entering content (Fig. 4), they are considered the best technology for knowledge sharing and reuse and are the tool most widely used for this purpose, as shown in Fig. 5.

The second most frequently used technology is the *repository of shared documents*. However, despite being widely used, it is not considered one of the best technologies for knowledge sharing and reuse: only 38% of the companies surveyed consider it one of the best ways to share and reuse knowledge although 70% use this technology. *Blogs* and *other collaborative writing tools* (e.g., Google Docs) were also cited as being one of the best ways to share and reuse knowledge.

Grouping the data used to generate Figs. 4 and 5, we created Table 4, from which it can be seen that:

- Eight companies adopt a *repository of shared documents* as an organizational tool, and nine use this tool for knowledge sharing and reuse even though it is not part of their policies. However, of the nine companies that use this tool, only four consider it one of the best tools for knowledge sharing and reuse. Furthermore, one company that does not use this tool also considers it is one of the best tools.
- Seven companies adopt *wikis* as an organizational tool. However, in three other companies employees use *wikis* for knowledge sharing and reuse even though the tool is not part of their policies. Furthermore, all companies that use *wikis*, whether they are part of their corporate policies or not, consider them one of the best tools for knowledge sharing and reuse.

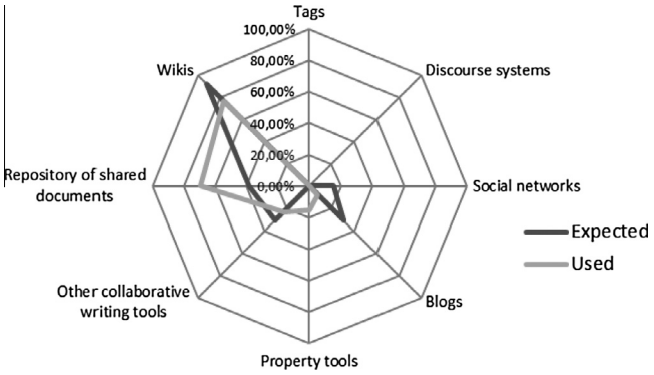

Fig. 5. Best tools for sharing knowledge according to the companies surveyed (percentage). *Note*: The question allowed multiple responses.

- Three companies adopt some type of *property tool* as an organizational tool. However, none of them considers this type of tool to be among the best for knowledge sharing and reuse. Moreover, although these tools are part of its policies, one company does not use them for knowledge sharing and reuse.
- As with wikis, all companies that use *other collaborative writing tools*, whether as part of the company's policies or not, consider that them to be some of the best tools for knowledge sharing and reuse.
- Just one company uses *blogs*, but four companies consider them one of the best tools. The same is true for *social networks*: although these are not used by any of the companies surveyed, two companies consider them to be one of the best tools. Thus, although companies feel that these tools are good for knowledge sharing and reuse, we cannot confirm this, as we were able to with *wikis* and *other collaborative writing tools*.

The next result identifies how often the companies use the tools. Fig. 4 shows that all surveyed company use some kind of tool for improving OL. Although the companies report that the tools are

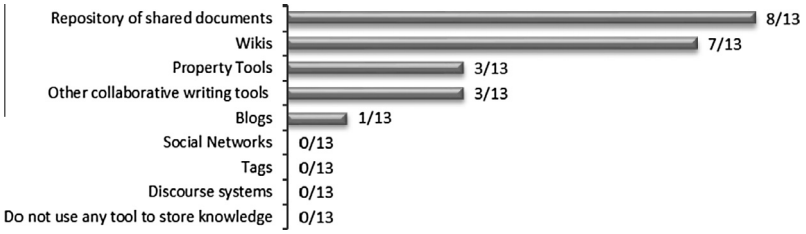

Fig. 4. Most widely used tools for storing knowledge. *Note*: The question allowed multiple responses.

Table 4
Tools used by the companies surveyed.

Tools	Number of organizations that use the tool to store knowledge generated	Number of organizations that believe the tool allows better knowledge sharing and reuse	Number of organizations that use the tool for better knowledge sharing and reuse
Blogs	1	4	1
Other collaborative writing tools	3	4	3
Property tools	3	0	2
Wikis	7	12	10
Repository of shared documents	8	5	9
Social networks	0	2	0

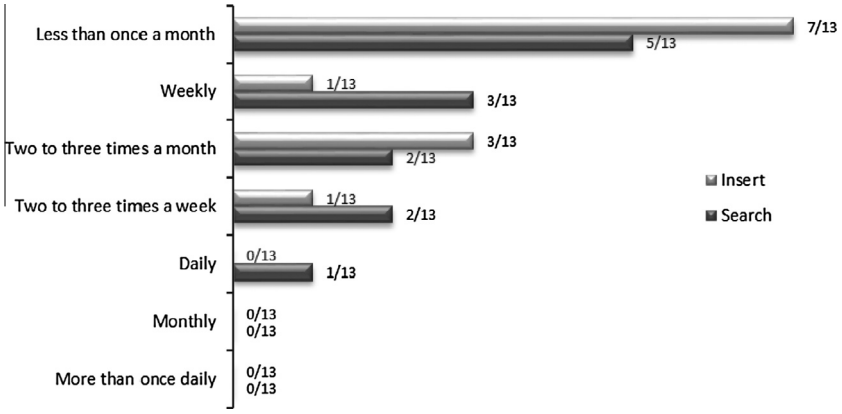

Fig. 6. Frequency with which employees enter content in and search the knowledge base. *Note*: The question allowed multiple responses.

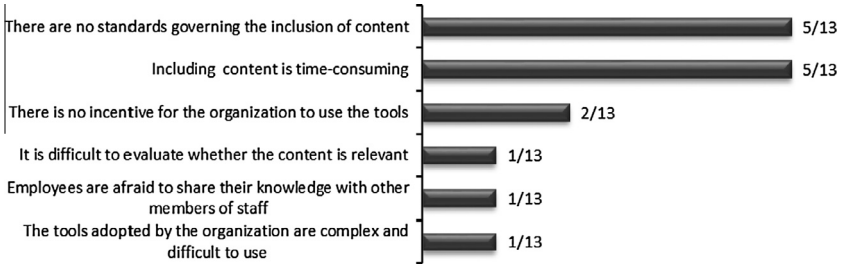

Fig. 7. Main reasons for not entering content in tools. *Note*: The question allowed multiple responses.

important, their employees do not often use them, as shown in Fig. 6, either for entering or searching for content in the knowledge base. The knowledge base is the base generated by entering content in the tools used by the companies.

The next step was to identify the main reasons why employees do not often use tools to enter and consult content. Fig. 7 shows that the main reason for this is that the inclusion of content is difficult and time-consuming.

Fig. 8 shows the main reasons why employees do not search for content in the tools. The main reason is that the organization of information in the tools is not efficient, and the second that employees prefer to use an extra-organizational repository. However, this reason is a consequence of all the other reasons shown in Fig. 8.

Respondents were also asked whether employees only use the content or modify it. Fig. 9 shows that they do not normally update it very often.

4.2. Use of tools and their impact

The first set of results showed whether companies organize the content entered in the tools and how it is classified. Fig. 10 shows that the content is classified almost entirely according to the knowledge area that generates it or the project that enters it. Fig. 11 shows the restrictions on accessing and modifying the content generated. As can be seen, 76% of the companies impose no restrictions.

Looking at the relationships between the answers represented by Figs. 6–11, it can be seen that all the companies that have restrictions on access to the knowledge repository take more than one month to enter content, unlike companies in which there are no access restrictions. In addition, most companies that took more than a month to enter content justified the time taken on the basis that entering content is time-consuming. It was also observed that the frequency with which tools are used is proportional to the frequency with which employees include content. Companies in which content is included more often use the tools more often. Thus, it is clear that the use of tools is a problem that is not related to technology but to organizational factors, since limited use of the tools can be attributed to restrictions on access to them and a lack of time available to use them.

Finally, the results show that if some changes were made to the tools, they would be used more frequently. Most companies reported that information is classified by knowledge area or pro-

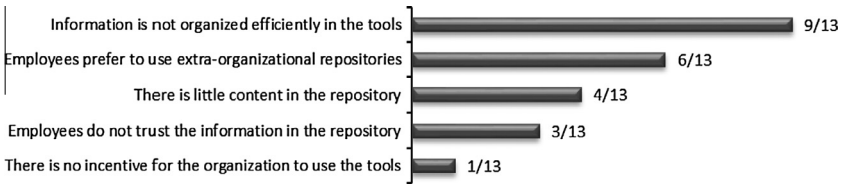

Fig. 8. Main reasons for not searching for content in tools. *Note*: The question allowed multiple responses.

Fig. 9. Frequency with which the content of the knowledge base is updated or modified.

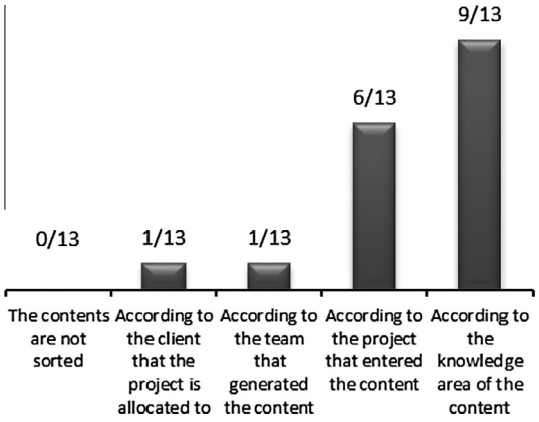

Fig. 10. Classification of content after it has been entered in the tools. *Note*: The question allowed multiple responses.

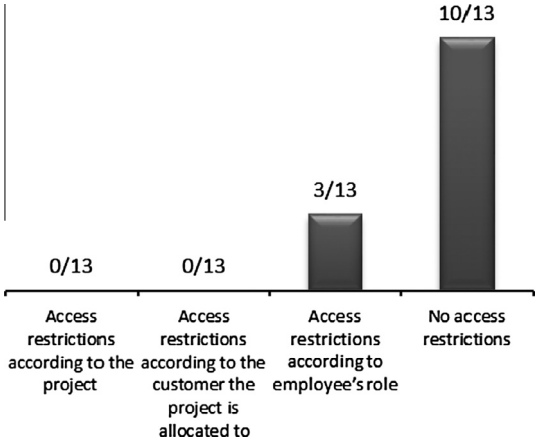

Fig. 11. Restrictions on access to the knowledge repository. *Note*: The question allowed multiple responses.

ject. However, nine of the thirteen companies reported that the organization of knowledge in tools constitutes a problem, i.e., they consider the classification they use inadequate.

The frequency with which content is entered, queried and modified was analyzed and compared with the methods used to document generated knowledge. This information was used to produce Tables 5 and 6. The former shows how the method used to document the content influences the frequency with which the content is modified, while the latter shows how the method used to document knowledge influences the frequency with which content is entered and consulted. Together the tables show that:

- Companies that have a defined method for documenting generated knowledge, such as LL or flowcharts, consult and modify existing knowledge more often than companies that do not have a defined method. Furthermore, companies that adapt or modify generated knowledge more often, in most cases use wikis, other collaborative tools or both.
- In companies that have a defined method for documenting generated knowledge, the frequency with which new content is entered is low and similar to or even lower than the corresponding frequency for companies that do not have an established method.

Fig. 12 shows times at which employees access the knowledge base during a project. Normally, they access the contents when there are technical or domain problems questions.

In addition to being asked when they access the knowledge base, respondents were also asked in which situations they access it. The responses are summarized in Fig. 13, which shows that the knowledge base is accessed to answer all kinds of questions.

Fig. 14 shows the situations in which the knowledge base is analyzed and adapted by employees. As shown in Fig. 9, users do not modify the content very frequently, and when they do, they are fairly knowledgeable about the subject in question.

The last set of results identified whether the use of new technologies in the companies surveyed can help them to reduce problems that are common to knowledge-intensive organizations such as software-development companies [23]. Tiwana [12] describes several common problems in this kind of organization, such as failure to know what is already known, the loss of key employees or difficulty finding existing critical knowledge.

Fig. 15 shows the positive impact that the use of the tools or technologies studied here has had on the organizations surveyed. Almost all the companies reported that use of the tools or technologies results in certain advantages, particularly the rapid dissemination of knowledge, less dependence on key employees and greater ability to solve recurring problems.

Table 5
Frequency with which content is modified vs. method used to document knowledge.

		Frequency with which contents of the knowledge base are adapted to the problem context and this new information is updated in the knowledge base				
		Always	In most cases	Sometimes	Rarely	Only use existing knowledge and are not concerned about examining it
Method used to document complex or new problems solved by trial and error and by workers' experience	LL	1	3	3		
	There is no standard for documenting this kind of knowledge			2	1	1
	Processes and flowcharts	1	1			

Table 6
Frequency with which content is entered and consulted vs. method used to document knowledge.

		Frequency with which employees use the knowledge base. Enter data in knowledge base (E)/Consult knowledge base (C)				
		Daily	Two to three times a week	Weekly	Two to three times a month	Less than once a month
Method used to document complex or new problems solved by trial and error and by workers' experience	LL	C(1)		E(1)/C(2)	E(2)/C(2)	E(4)/C(2)
	There is no standard for documenting this kind of knowledge		E(1)/C(1)		E(1)	E(2)/C(3)
	Processes and flowcharts	C(1)		C(1)		E(2)

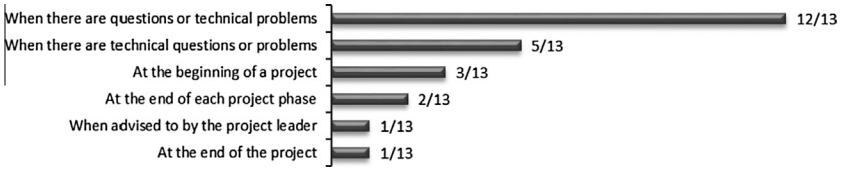

Fig. 12. Times at which employees access the knowledge base during projects. *Note*: The question allowed multiple responses.

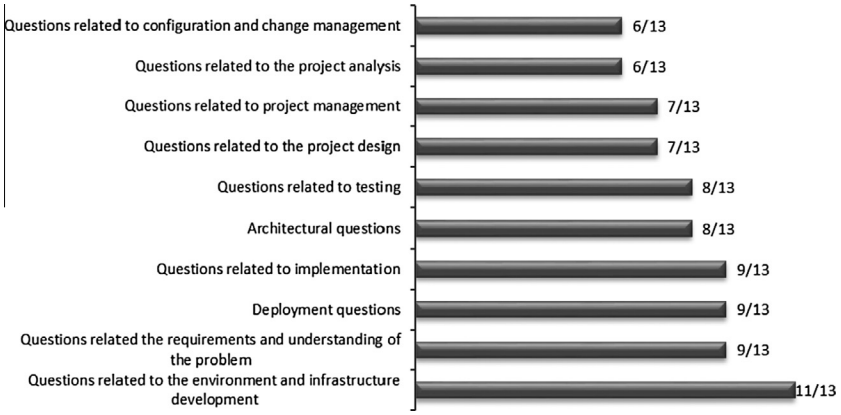

Fig. 13. Situations in which the knowledge base is consulted by employees. *Note*: The question allowed multiple responses.

5. Analysis of the results

After the survey results had been organized quantitatively, as described in Section 4, the data were analyzed qualitatively to answer the questions in Section 1. The analysis was conducted using discursive textual analysis [46]. This type of analysis is recommended for qualitative research and shares many of the assumptions of other methodologies in the field of textual analysis, such as content analysis [47] and discourse analysis [48].

In content analysis, the research objectives are defined by the researcher, who explains the contexts that he wishes to analyze. Thus, the first step of the analysis is to define the categories, which

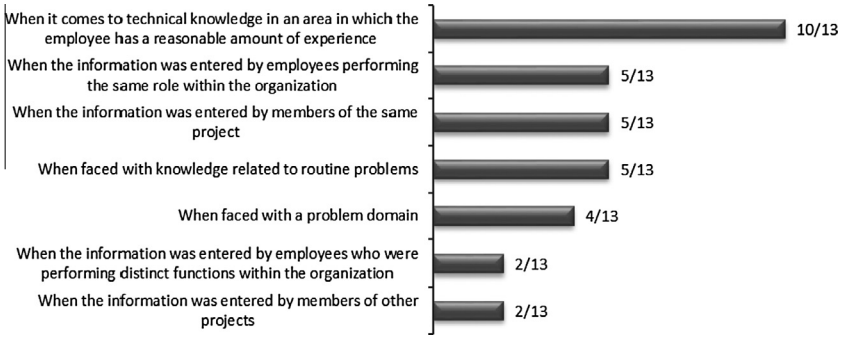

Fig. 14. Situations in which the knowledge base is analyzed and adapted by employees. *Note*: The question allowed multiple responses.

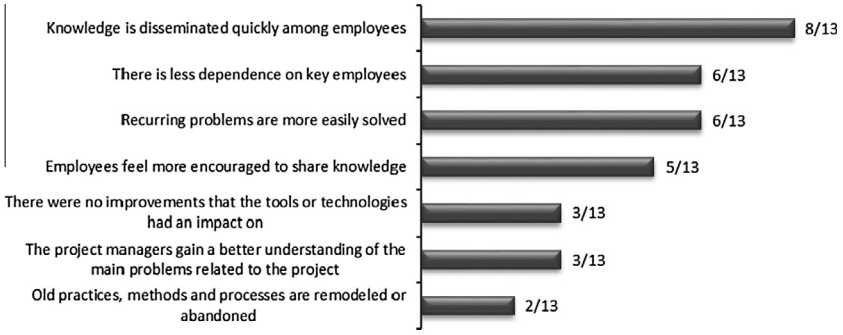

Fig. 15. Organizational improvements resulting from the positive impact of tools or technologies. *Note*: The question allowed multiple responses.

are general context units, and set limits for the analysis [46]. In this survey, the categories were the three theories. Each category generally contains several units of analysis, a unit of analysis being the basic content element that will be submitted to further classification [46], i.e., the entities that are analyzed in the study. For each category, units of analysis were defined as shown in Fig. 16, where seven units of analysis are organized into three categories.

Each category represents a theory presented in Section 2, and the units of analysis are the concepts explored by these theories. The data collected in the survey therefore allowed us to identify whether the tools make use of the concepts described in the theories.

The following sections describe the analysis for each unit of analysis and shows whether the technologies investigated use concepts from the three theories and how these technologies relate to the theories.

5.1. SECI model

The results reported in the previous sections were used to analyze whether the new technologies can help with each of the conversion processes described in the SECI model: externalization, internalization, combination and socialization.

Externalization is the process by which tacit knowledge is converted to explicit knowledge. In companies that use a knowledge repository, externalization is often a particularly important conversion mechanism, albeit one that is particularly difficult to achieve. Tacit knowledge is codified into documents and manuals so that it can be disseminated more easily through the organization.

The technologies most used to externalize knowledge, as shown in Fig. 4, are the *repository of shared documents* and *wikis*; however, any collaborative tool can aid this process because users supplement or modify a document or article on a particular topic using their own knowledge, which then exists independently of the user in the form of information in the collaborative tool and is accessible to anyone. This process also leads to the development of knowledge in the individual user's cognitive system [49]. Writing or modifying texts becomes a tool for individual knowledge acquisition [50] as it requires a person to deal more thoroughly with existing knowledge [51], leading to a realignment or improvement of cognitive schemas [49], aiding the externalization process. Although collaborative tools are an efficient way to promote externalization, company employees do not use them often to externalize their knowledge, mainly because they consider them hard to use and time-consuming.

Internalization deals with the conversion of explicit knowledge to tacit knowledge. Explicit knowledge becomes part of an individual's knowledge and an asset for the organization. Internalization is also a process of continuous individual and collective reflection, as well as the ability to see connections, recognize patterns and make sense between fields, ideas and concepts. Collaborative tools can help this process, mainly because when an employee modifies an existing text, information from the text is decoded and incorporated into existing internal knowledge structures, creating new knowledge entities in that person's cognitive system, new associations between knowledge entities and new schemas. [49]. New technologies can aid the internalization process, particularly tools that enable more efficient collaborative writing, such as *wikis* and *collaborative writing tools*. Nevertheless, although collaborative tools are a good way to promote internalization, the use of these tools does not guarantee this process as one of the steps required to promote internalization is searching and modifying existing content, which is not done very often in the companies surveyed here, as shown in Figs. 6 and 9.

The process of combination occurs when explicit knowledge is collected from inside or outside the organization and then combined, edited or processed to form new knowledge. The use of computerized communication networks and knowledge bases can support this mode of knowledge conversion. The new explicit knowledge is then disseminated among the members of the orga-

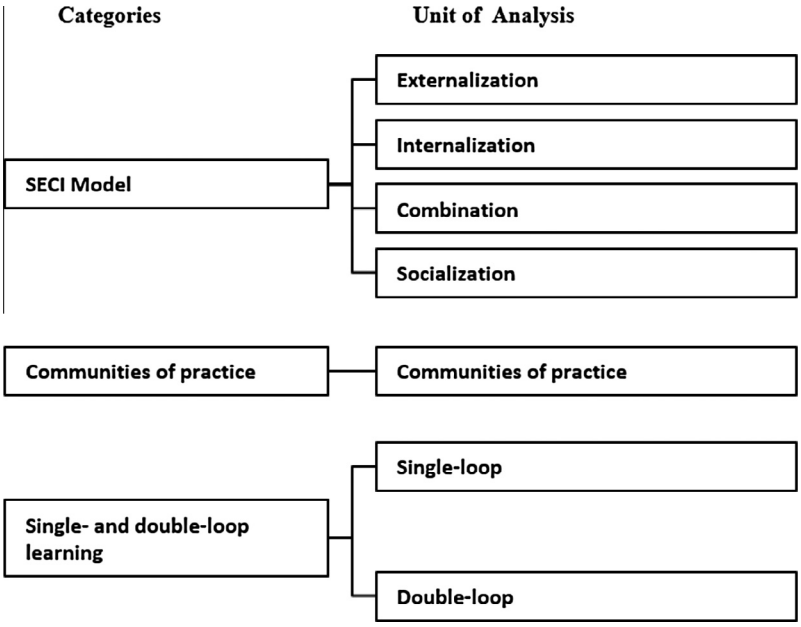

Fig. 16. General structure of discursive textual analysis.

nization. The impact that the use of new technologies can have on the combination process was analyzed to determine whether these technologies improve knowledge dissemination. Fig. 6 shows that all the companies have some kind of tool to improve OL. However, employees do not often use these tools either to enter or search for content. While the use of any collaborative tool can help promote combination, merely having such a tool in a company does not ensure that combination is promoted efficiently.

Socialization is probably the most difficult mode of knowledge conversion in the SECI model to achieve. In this mode tacit knowledge is shared through shared experiences, and shared knowledge is constructed in the socialization process. For socialization to occur using social tools, there must be a complete information flow. First, a person's tacit knowledge must be codified, after which the codified knowledge must become another person's tacit knowledge. This rarely happens without human contact. However, tools that allow the use of different resources, such as video and text, can help this process by codifying more complex knowledge. Furthermore, collaborative tools help to transform explicit knowledge into tacit knowledge through internalization. This occurs when an employee modifies previously entered content, creating new knowledge entities in his cognitive system, new associations between knowledge entities and new schemas. Only tools that enable the use of different resources and allow effective complex collaborative writing schemes can be potential promoters of socialization. *Wikis* stand out mainly because tools such as Mediawiki [52] support a large number of extensions that allow different types of resources to be used. Moreover, as cited previously, *wikis* can facilitate internalization. For these reasons, they can help promote socialization. Another such tool is the *collaborative writing tool*, which has similar characteristics to the wiki.

5.2. Communities of practice

In a community of practice, people work together to find ways to improve what they do, i.e., they solve a problem in the community or in daily learning through regular interaction. Sometimes companies form groups within the organization to share information, but as there is no affinity between group members, the potential of the group is not exploited.

This analysis attempts to identify whether there are communities of practice in the software-development companies surveyed here and, if so, what the most common ones are. Analysis of Figs. 10 and 11 shows that the companies normally organize content by knowledge area and do not promote communities of practice. As a result and as shown in Fig. 8, three of the thirteen companies surveyed said that employees do not use existing content because they do not trust the information in the repository. Furthermore, nine out of the thirteen surveyed said that the information is not organized efficiently. There is therefore a need to improve the use of new technologies and promote communities of practice in order to improve the organization of information.

Clearly, the use of collaborative tools does not promote communities of practice. However, many collaborative tools, such as *wikis*, *social networks* and *other collaborative writing tools*, have resources that facilitate the application of this concept by helping to create communities with different access levels. However, the companies in this study rarely use these resources.

5.3. Single- and double-loop learning

This section analyzes whether the tools considered here can help the two forms of learning proposed by Argyris and Schön [6]: single- and double-loop learning. It also analyzes those situations in which the use of tools can support these types of learning.

In single-loop learning, the event and effect are observed, producing feedback, which is followed by actions to change or improve the process based on this feedback. Single-loop learning occurs when employees use the knowledge base to find a solution to a problem without worrying about improving the content of the knowledge base. We therefore sought to analyze in which situations single-loop learning is more common in the companies surveyed. In general, all the tools used by the companies help to apply single-loop learning. Figs. 12 and 13 show that employees access the knowledge base to solve any kind of question they may have, and that they do not access it at any particular time in the project. In general, there is no organizational policy to encourage employees to consult the contents of the knowledge base regularly.

Double-loop learning is more complex. Not only does the user use the content, but he also understands the factors that influence

Table 7
The best tools for promoting each of the concepts described in the three knowledge-sharing and learning theories.

Theory	Concept	Best tools
SECI model	Externalization	Repository of shared documents, wikis, collaborative writing tools, social networks, blogs, property tools and discourse systems
	Internalization	Wikis and collaborative writing tools
	Combination	Social networks, wikis, collaborative writing tools, repository of shared documents, blogs, property tools and discourse systems
	Socialization	Wikis and collaborative writing tools
Communities of practice	Communities of practice	Social networks, wikis, collaborative writing tools and repository of shared documents
Single- and double-loop learning	Single-loop	Social networks, wikis, collaborative writing tools, repository of shared documents, blogs, property tools, discourse systems and tags
	Double-loop	Wikis and collaborative writing tools

the effects. This means that users adapt the content to their particular situation. Double-loop learning is similar to internalization, since the user needs to understand the previously existing information and adapt it. Hence, tools that allow effective complex collaborative writing schemes, such as *wikis* and *collaborative writing tools*, can promote double-loop learning. Fig. 9 shows that double-loop learning is not very common in software-development companies, although it is used in some. Fig. 14 shows that this type of learning usually occurs when an employee has substantial experience in the subject or when employees are working on the same project or performing the same role. Double-loop learning is a function not only of technology (*wikis* and *collaborative writing tools* are able to promote this type of learning more effectively), but also of external factors such as how comfortable employees feel about modifying content.

6. Discussion

Promoting the use of new technologies by employees, which can help companies to improve OL significantly, is not an easy task. Employees have a natural resistance to such technologies, which makes KM more difficult. This resistance is occasioned by several factors, the most widely reported in this study being that employees prefer to use extra-organizational repositories and that entering content in tools is time-consuming.

Although the adoption of technology by companies will always face employee resistance regardless of the solution adopted as this stems strictly from individual, organizational and social factors, this study found that addressing certain technology-related issues can help to decrease this resistance. For instance, restrictions on access to the knowledge repository influence the frequency with which employees enter, update or consult content and the way that the content is categorized influences the frequency with which it is used. The correct choice of technology and correct configuration of these tools ensures that content is better organized and better communicated among employees. Thus, using the appropriate technology can help decrease resistance to the use of new technologies to manage knowledge.

This study investigated the main new technologies used by software-development companies and how they relate to three learning and knowledge-sharing theories. To this end, five questions were asked, each of which is discussed below.

The first question was "*which tools or technologies do the software-development companies surveyed use as a repository of knowledge?*" The most widely-used technology was a *repository of shared documents*, which was used by 61.54% of the companies, followed by *wikis*, for which the corresponding figure was 53.85%.

The second question was "*which OL theories do the new technologies or tools cover?*" In general, the concepts in all the theories can be put into practice with one or other of the technologies or tools. However, in most cases the extent to which this actually happens depends not only on the technologies or tools, but also on external factors such as organizational issues, which need to be addressed by the companies.

To understand better how each theory relates to the new technologies and tools, the third question was "*to which new technologies or tools is each theory related?*". To answer this question, Table 7 summarizes the theories and concepts and shows which are the best tools or technologies to promote each concept. Following is an explanation of the table:

- SECI: collaborative tools can facilitate the conversion process, but for each process the technologies play different roles, as described below:
  - Externalization can be significantly improved by the use of collaborative tools, particularly *wikis* and *collaborative writing tools*. However, employees do not externalize knowledge frequently.
  - Internalization is more difficult to achieve than externalization. It occurs when the content of the knowledge repository is consistently searched and modified. Tools that enable efficient collaborative writing, such as *wikis* and *collaborative writing tools*, are the best facilitators of this process.
  - Combination is related to how knowledge is disseminated among individuals in a company. The use of any collaborative tool can help promote combination, but the process is highly dependent on organizational routines.
  - Socialization is very difficult to achieve. The use of collaborative tools in general cannot be guaranteed to help promote socialization, which can only be achieved with those tools that allow effective complex collaborative writing, such as *collaborative writing tool*s and *wikis*.
- Communities of Practice: the use of new technologies or tools does not in itself promote communities of practice, although many collaborative tools have the resources to do so. Rather, companies must encourage the use of existing resources to promote communities of practice, as employees prefer to modify and access content produced by someone in the same role or allocated to the same project.
- Single- and double-loop learning can be achieved using new technologies and tools, as described below:
  - Single-loop learning: this does not take place at any particular time during a project. When employees have questions, they usually consult the knowledge base. Furthermore, all the technologies and tools used by the companies surveyed help single-loop learning.
  - Double-loop learning: this is not very common in the companies studied and normally occurs when employees are working on the same project or have the same role and have a certain amount of experience. The tools that can best promote double-loop learning are *wikis* and *collaborative writing tools*.

After analyzing how each theory is related to the technologies and tools, the fourth question proposed in Section 1 (“*which new technologies or tools help to promote OL in software-development companies more efficiently?*”) can be answered. The general opinion in the companies studied is that *wikis* are the best tool for sharing knowledge. This impression is corroborated by the fact that wikis allow concepts proposed in all three theories to be put into practice. In contrast, *collaborative writing tools* are not considered one of the best technologies for sharing knowledge. However, the companies surveyed could explore this technology in greater detail as it can be as efficient as wikis for promoting the concepts involved in all three theories, thereby enhancing OL.

In conclusion, the new technologies and tools used in this study can help to improve OL as they promote the concepts described in the three learning and knowledge-sharing theories. This is particularly true of *wikis* and *collaborative writing tools*. However, the companies studied need to improve their use of these tools as the vast majority of them believe that the way information in the tools is organized is not efficient.

Finally, the last question to be answered is “w*hat organizational improvements do the tools or technologies make to the companies?*” An important finding is that the use of new technologies had a positive impact on the companies surveyed and helps to minimize some common problems that occur in knowledge-intensive organizations. Examples of this positive impact are that knowledge is disseminated faster among employees, the company is less dependent on key employees, recurring problems can be solved more easily and employees feel more encouraged to share knowledge.

6.1. Limitations

There are three main limitations to our study. Firstly, our investigation deals with new technologies that, while being used by software-development companies to manage knowledge, were not designed specifically for this purpose. To understand which aspects of OL these tools can help with, we chose three learning and knowledge-sharing theories and mapped the concepts in each theory to the respective tools.

Secondly, the data sample was relatively small. However, it was a very representative sample and there was a good response rate. Furthermore, both companies and respondents were carefully chosen, and the data collected provided a solid basis for our analysis.

Thirdly, although many of the companies surveyed sell outside Brazil, they are all Brazilian companies. This study therefore only reflects the situation in Brazil, and we cannot confirm that the findings are valid for companies from other countries.

7. Final considerations and future research

This study sought to understand how new tools and technologies relate to three “old” KM theories. To this end, a survey of Brazilian software-development companies was carried out. The findings show that the new tools and technologies identified help apply the concepts described in the theories and can improve OL. *Wikis* and *collaborative writing tools* are the most helpful tools as far as OL is concerned, as they can help promote all the concepts in all three theories. However, it is important to underline that the use of the tools described here does not in itself ensure that the learning processes related to each theory take place. While the tools can help to promote OL, for this to happen other factors, such as organizational changes, are necessary. Another important finding of this study is that although the tools help to promote OL, companies need to ensure greater use is made of these tools, as the vast majority of the companies in this study believe that the information in the tools is not organized efficiently.

While the companies surveyed benefit from the use of the tools and technologies, they do not make use of their full potential. By making simple customizations to the tools and changing their organizational routines, they could ensure that several concepts from the theories, such as communities of practice and double loop learning, are applied systematically. This would have a favorable impact as there is evidence that the theories help to improve OL. Moreover, if developing countries such as Brazil are to achieve their goal of expanding into the international software market, efforts are needed to improve software processes and products. The use of tools and technologies that promote OL can help achieve these goals.

New tools and technologies also help alleviate some common problems that occur in knowledge-intensive organizations by ensuring that knowledge is disseminated more rapidly among employees, companies are less dependent on key employees, recurring problems are more easily solved and employees feel more encouraged to share knowledge.

Although this is a preliminary study, it has shown that new tools and technologies support the concepts described in KM theories. To gain a better understanding of how the new technologies discussed here are related to the theories, we intend to carry out a more in-depth descriptive study based on personal interviews or observation. In addition to addressing how the tools relate to the theories, we hope to research in more detail the cultural and organizational factors that influence the use of tools.

Acknowledgments

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