

TOWARDS A KNOWLEDGE MANAGEMENT STANDARD FOR THE NETWORK OF THE SENAI INNOVATION INSTITUTES

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Abstract: *This paper describes how a KM framework for the Brazilian network of SENAI innovation institutes is being developed using a multi-stage, participatory approach. First, selected KM standards are presented. They form the basis for a workshop series aimed at gathering KM requirements from representatives of the SENAI institutes. In addition to a short online survey, the challenges and success factors of the KM introduction are the focus of attention on the basis of five phases of KM implementation and anchoring.*

Keywords: *framework; standards; implementation procedure; research and technology organization*

Resumo: *Este artigo descreve como está sendo desenvolvida uma estrutura de Gestão do Conhecimento (GC) para a rede brasileira de institutos de inovação do SENAI, utilizando uma abordagem participativa em várias etapas. Primeiro, são apresentadas normas de GC selecionadas. Elas formam a base para uma série de workshops com o objetivo de coletar requisitos de GC de representantes dos institutos do SENAI. Além de uma breve pesquisa online, os desafios e os fatores de sucesso da introdução da gestão do conhecimento estão no centro das atenções, com base em cinco fases de implementação e ancoragem da gestão do conhecimento.*

Palavras-chave: *estrutura; normas; procedimento de aplicação; instituição de ciência e tecnologia*

Resumen: *Este artículo describe cómo se está desarrollando una estructura de gestión del conocimiento para la red brasileña de institutos de innovación SENAI mediante un enfoque participativo en varias fases. En primer lugar, se presenta una selección de normas de gestión del conocimiento. Éstas constituyen la base de una serie de eventos destinados a colectar los requisitos de gestión de conocimientos de los representantes de los institutos SENAI. Además de una breve encuesta online, los desafíos y factores de éxito de la introducción de la gestión del conocimiento son el centro de la atención sobre la base de cinco fases de implantación y anclaje de la gestión del conocimiento.*

Palabras clave: *estructura; normas; procedimiento de aplicación; organización de investigación y tecnología*

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1 INTRODUCTION

More than 10 years ago, SENAI began to build a network of over 25 innovation institutes in Brazil (Kohl et al.2020). The core business of any Research and Technology Organisation (RTO) is to provide the market suitable solutions through applied research and technological innovation that improve societal standards. This is a very knowledge-intensive business, which must constantly adapt and evolve over time to meet industrial, governmental and societal expectations.

For that reason, RTOs such as the SENAI Innovation Institutes network need to be capable of growing on top of existing knowledge (tacit/explicit), disseminating and assuring knowledge availability, satisfying customer needs with state-of-the-art technology, as well as maintaining its relevance/attractiveness through a strong and updated unique selling proposition.

This is a strategic challenge for any RTO, considering that the main source of knowledge within these institutions comes from and flows among very qualified employees (considering researchers, specialists, consultants, technicians and many experienced corporative administrative levels). Learn to deal with turnover rates, fast onboarding of new employees, mapping critical competences, constantly training people, debriefing of the knowledge of senior experts, as well as systematically managing technological knowledge becomes imperative to this sort of innovation-oriented organizations.

2 KM AT THE SENAI INNOVATION INSTITUTES: BACKGROUND AND WHY

From a subject perspective, the SENAI Innovation Institutes have different technological R&D focuses. In terms of their daily work, however, they have a lot in common. The research and development work in the SENAI Innovation Institutes (ISI) is almost largely carried out in projects. These projects must be acquired by the individual institutes in competition on the market and/or within the framework of public tenders in the national and international context. The activities of project acquisition, project management and project execution represent the main tasks for the scientific staff and managers in the SENAI institutes. The high demand for application-oriented research at SENAI requires a permanent adaptation to the requirements of the customers and a continuous further development of the research and development results.

Although projects in the research and development area often have a unique character, the concrete tasks in project acquisition, project management and project execution are characterized by similar, repetitive activities. These include, for example, clarification of customer's needs, elaboration of the state-of-the-art and derivation of the research need, detailed analyses and capture of user requirements, specification of solutions, prototypical realisation and documentation of results. Furthermore, project management, post-calculation and project accounting, as well as scientific publication of the research results belong to these activities.

In order to process these tasks efficiently and with high quality, SENAI employees use their personal knowledge as well as the knowledge of their colleagues within the department, the institute, their research community but also the knowledge of their customers and competitors on a daily basis. They apply their knowledge and develop it continuously.

Any knowledge management solution that wants to further improve the existing handling of knowledge in the SENAI ISIs must start with the concrete application and generation of knowledge in the projects and in pre-project acquisition in order to contribute to increasing the efficiency of SENAI research as a whole and the individual research performance of the individual scientist.

Nevertheless, it can be stated that so far there is no standardized procedure for designing a KM concept for the SENAI institutes. The exchange and transfer of good practices in the area of KM between the institutes has also not yet taken place systematically. This is disadvantageous, as the institutes face similar knowledge challenges and therefore great synergy potentials can be expected through better networking.

3 CONCEPTUAL APPROACH

As outlined above, knowledge is the central resource for the success of the institutes. A systematic use of knowledge is therefore a central goal in order to ensure the future viability of the institutes. This results in the need for systematic approaches, proven instruments and procedures to successfully manage knowledge in the institutes. In short, a standard for KM seems worthwhile.

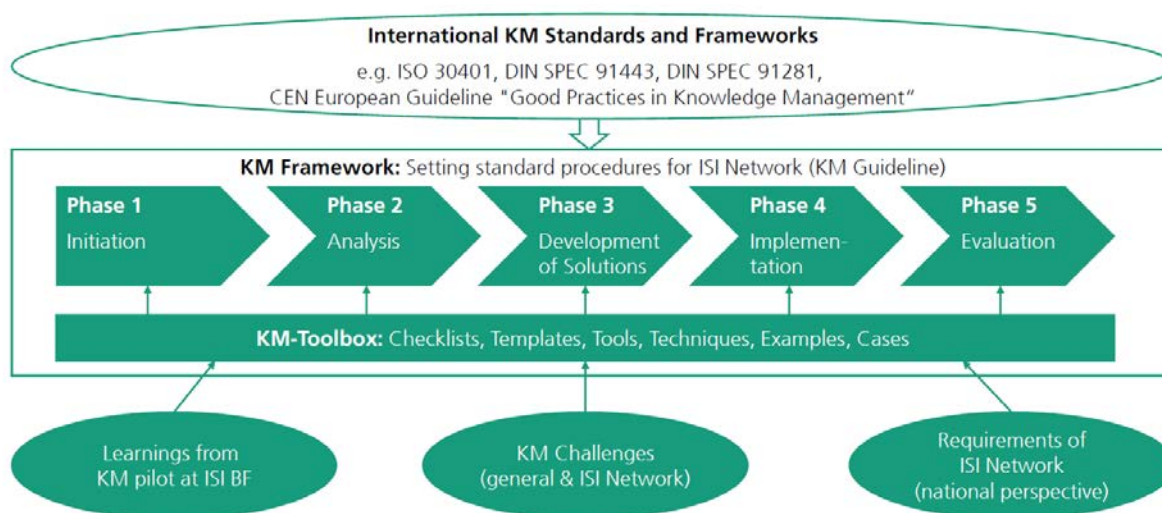
The methodological approach underlying the development of the SENAI KM Framework is method engineering. Method engineering focuses on the modification of one or more existing methods or on the development of completely new methods using a systematic approach (Henderson-Sellers et al. 2014, Hecklau et al. 2020). The general steps of method engineering are the systematic analysis of existing methods, followed by a comparison and the

development of a (new) method. Five basic elements are the focus of systematic consideration: metamodel, results, techniques, activities and roles (Gutzwiller 1994).

Against this background, figure 1 shows the approach used in this initiative. In order to develop a KM standard for the SENAI institutes, a top down approach was combined with a bottom up approach.

In order to build on proven procedures and knowledge on the one hand, different standards related to KM were analyzed in a first step and used as a basis for the further procedure. On the other hand, the specific needs derived from the characteristics of the SENAI institutes were considered in more detail. Furthermore, good KM practices already in use were evaluated (Will et al. 2022). These requirements and findings were also incorporated into the process (bottom up).

Figure 1 – Conceptual Approach: Towards a KM Framework for ISI Network



Source: own illustration

Through a multi-stage workshop series, both perspectives were interlinked in order to develop a customized KM standard for the SENAI institutes. On the one hand, this standard should provide an appropriate framework for identifying relevant influencing factors, describe a procedure for KM implementation and provide suitable tools. On the other hand, the standard should still provide enough freedom to take into account the requirements and particularities of the individual institutes in the implementation of KM.

The basics, procedure and results are presented in the following sections.

4 KNOWLEDGE MANAGEMENT STANDARDS AND SPECIFICATIONS

Standards are an important catalyst for the spread of innovations. They define the milestones of technology and pave the way for innovative ideas to succeed on the market. In addition, standards define minimum requirements for quality and safety and enable interoperability. Thus, they provide a reference framework that benefits organizations, consumers, and society as a whole by establishing common practices, enhancing trust, and promoting continuous improvement. This reduces variation, leads to process stability, and reproducible quality (Fraunhofer 2020). Standardization efforts have also been identifiable in the KM sector for some time.

Figure 2 shows a selection of standards and specifications related to knowledge management that were examined in more detail as part of the framework development process for the SENAI Innovation Institutes. Thereby, the following benefits and features of the selected standards can be summarized as follows: The standards (1) provide guidance and quality assurance, and at the same time they give flexibility for organisation-specific adaptation and implementation of KM, (2) are based on the experience of specialists in the subject area and are developed through consensus-building, and (3) contain procedure models and/or recommendations for implementation and continuous improvement of KM. In addition, some of the standards address the specifics of small and medium-sized organisations in particular. This is advantageous because the individual SENAI innovation institutes belong to this size category.

Figure 2 – Selected KM standards and specifications as basis for SENAI KM framework



Source: own illustration

The selection of standards covers a time span of more than 15 years. This ensures that both historical foundations and current developments are considered. They are briefly outlined below.

The ISO 9001 standard for quality management systems is the most widely used management system standard in the world. For 2021, more than one million issued certificates

have been registered worldwide, demonstrating a successfully operated quality management system. Within the scope of its last revision in 2015, ISO 9001 was comprehensively revised. In addition to structural adjustments, new accents were also set at the content level. For the first time, the standard includes the clear requirement to manage the organization's knowledge in a targeted and systematic way.

The path to the incorporation of KM in the ISO 9001 standard has a long history. The "European Guide to good Practice in Knowledge Management" of the CEN (European Committee for Standardization) should be emphasized here. In 2004, the guide was published as a CEN Workshop Agreement (CWA), which is a consensus-based document and aims to provide readers with a practical introduction to mainstream thinking in KM. The guide covers various aspects of knowledge management and comprises five main booklets, published each as a CWA part:

1. KM Framework, which sets the overall context for KM at both the organizational and personal level (CWA 14924-1)
2. Culture and KM, which explains to readers how to create the right cultural environment for introducing KM (CWA 14924-2)
3. Implementing KM in Small and Medium-Sized Enterprises (SMEs), which provides a project management methodology to help SMEs (and other organizations) get started in KM (CWA 14924-3)
4. Measuring KM, which helps organizations assess their progress in KM (CWA 14924-4)
5. KM Terminology, which summarizes the key KM terms and concepts that readers will find useful when navigating through the guide (CWA 14924-5)

A further milestone for the field of KM at international level was the publication of ISO 30401 "Knowledge management systems - Requirements" in 2018. ISO 3041 was developed by representatives of the ISO Technical Committee (ISO/TC) 260 "Human Resource Management", in which experts from over 30 countries work together.

The purpose of this ISO management system standard for knowledge management is to support organizations to develop a management system that effectively promotes and enables value-creation through knowledge. ISO 30401 outlines the principles, concepts, and processes involved in knowledge management and provides a framework for establishing, implementing, maintaining, and continually improving a knowledge management system. It focuses on enabling organizations to identify, capture, organize, share, and utilize knowledge to achieve their objectives (ISO 2018, Collison et al. 2019).

The standard emphasizes the importance of aligning knowledge management with the organization's strategic goals and ensuring that knowledge is effectively shared among employees and stakeholders. It encourages organizations to foster a knowledge-sharing culture, promote collaboration, and facilitate learning and innovation. Against this background, each organization should craft a knowledge management approach, with respect to its own business and operational environment, reflecting their specific needs and desired outcomes.

The ISO standards outlined above define requirements and provide a good frame for the development and operation of management systems in general and knowledge management systems in particular. At the same time, they remain quite generic in many places, so that there is room for designing the system. This is justified with the freedom of flexibility that enables conformity and adaptability for every type of organization and alignment with all characteristics and needs.

For this reason, it is not unusual in the context of standardization for so-called specifications to be developed as a supplement to the standards. These specifications do not have the binding character and organizations cannot be certified on the basis of them, but they offer more concrete practical assistance, go into more depth on selected topics and provide guidance and recommendations for action. At the same time, the specifications are also developed through a multi-stakeholder process, integrating different experts' opinions and thus representing a general consensus.

In the context of KM and in the procedure chosen here, two further specifications were examined more closely. Both specifications are related to the initiatives outlined above: (1) The DIN SPEC 91281 - Implementation of process-oriented knowledge management in small and medium-sized enterprises is based on the CEN KM Guide (CWA 14924). (2) The DIN SPEC 91443 - Systematic knowledge management for SMEs - Tools and procedures is based on ISO 30401 management system standard.

Both specifications are aimed at organizations of small and medium-sized organizations. This is advantageous in this context, as all SENAI innovation institutes also fall into this size category.

DIN SPEC 91281 emphasizes the particular need to integrate KM activities and measures into the organization's business processes. For implementation, reference is made to the procedure in five phases described in the above mentioned third booklet of the CEN guide (CWA 14924-3). Process modelling and knowledge structuring are recommended, as well as the use of a potential check (KM self-assessment) to identify the main fields of action that need to be addressed during the introduction of process-oriented knowledge management.

Furthermore, eight case studies are presented that illustrate the procedure and the company-specific solutions and experiences.

DIN SPEC 91443 - Systematic knowledge management for SMEs - Tools and procedures uses the same structure for setting up a KM management system as described in ISO 30401. This structure is also known as HLS (high level structure) for setting up management systems. However, DIN SPEC 91443 goes into much more depth. Among other things, this is made clear by the fact that 14 specific guidelines are formulated that an organization should take into account when planning and implementing a KM system. All steps are clearly described with the help of short descriptions and thus provide recommendations that guide action, which can ultimately also be understood as a specification of ISO 30401 and its implementation. The main recommendations of DIN SPEC 91443 for action can be summarized as follows:

- The organization should first be considered as a whole to determine the scope (location, processes) and areas of knowledge.
- Effective knowledge management supports the achievement of strategic corporate goals. Therefore, knowledge management should be aligned with these goals.
- External view: The organization should gain knowledge about its external environment in order to identify opportunities and risks that require a changed handling of knowledge.
- Internal view: The organization should look inwards to define the key knowledge areas.
- The organization should look at internal influencing factors (enablers) that support the successful implementation and operation of knowledge management (strengths/weaknesses profile).
- Specific knowledge management objectives should be derived from strategic corporate goals, defined knowledge areas and the results of the analysis.
- When designing KM measures, it is important to ensure that they are coordinated with each other. In addition, performance indicators should be defined to measure success.
- Knowledge management measures should be continuously monitored and reflected upon in order to be able to adjust them if necessary (e.g. PDCA cycle).
- To ensure long-term operation and adaptations to changing conditions, the organization should have a KM governance structure and KM controlling.

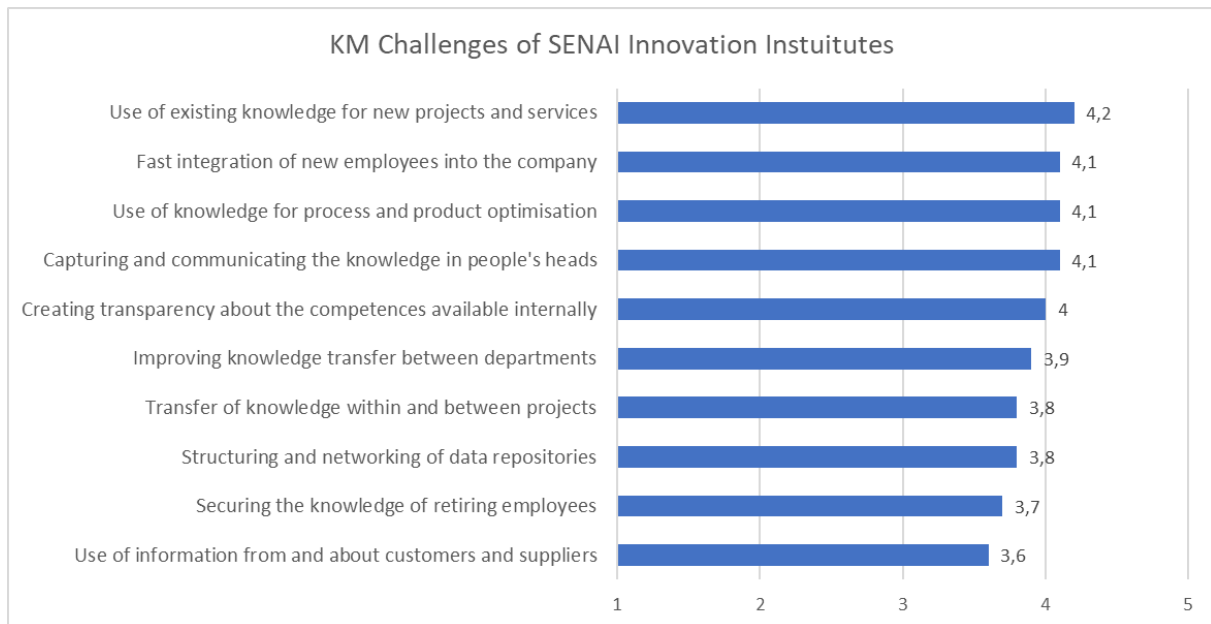
5 TOWARDS A KM FRAMEWOK AND STANDARD FOR SENAI ISI NETWORK

Against this background, a multi-level workshop series was conducted with a group of over 30 people from the SENAI Innovation Institutes. The aim was to develop a common understanding of KM, its benefits and goals. In addition, the standards outlined above were to be used as a basis for jointly developing a suitable structure and procedure for KM implementation for the SENAI institutes. General requirements, but also current challenges, possible barriers and success factors should be identified and taken into account. In addition, good practices and experiences in KM that already existed in the SENAI network were integrated into the development process. The procedure and the central results are outlined in more detail in this chapter.

5.1. Current Challenges in KM (online survey)

As a first step, in order to find out which challenges are currently particularly acute from a KM perspective from the viewpoint of ISI employees, an online survey was conducted as part of a workshop. The items listed are based on a study previously conducted with companies from the business sector. Respondents answered on a level from 1 = no challenge to 5 = very high challenge. The results show that the five biggest challenges are the (re-)use of existing knowledge for new projects and services, the fast integration of new employees into the organization (e.g. systematic onboarding process), the use of knowledge to optimize processes and products as well as the capturing and communicating the knowledge in people's heads and a lack of transparency regarding the internally available competences (figure 3).

Figure 3 – KM Challenges of SENAI Innovation Institutes



Source: own illustration

The subsequent discussion with the participants revealed that the challenge of "Securing the knowledge of retiring employees" is far more important than the quantitative assessment might initially suggest. If one did not only consider the retention of knowledge of employees who leave the institute for reasons of age, but extended the perspective to all employees who leave the institute (e.g. to take a new job with another company), the challenge would probably be among the top 3 challenges.

5.2. KM Framework: Design Fields

Based on the analysis of the standards, it became clear during the discussions that at least three dimensions have to be considered in the planning, implementation and operation of KM. In order to allow for appropriate freedom in the design at the institute level, the three classic KM design dimensions are considered: people, organization and technology.

People: As carriers of knowledge, experience and competences, the employees of an organisation represent a central success factor of knowledge management. In the field of human resources, the aim is therefore to examine key qualifications for knowledge management and to identify development needs.

Organisation: The term organization encompasses both the organizational structure and the process organization. The level of knowledge management penetration in the

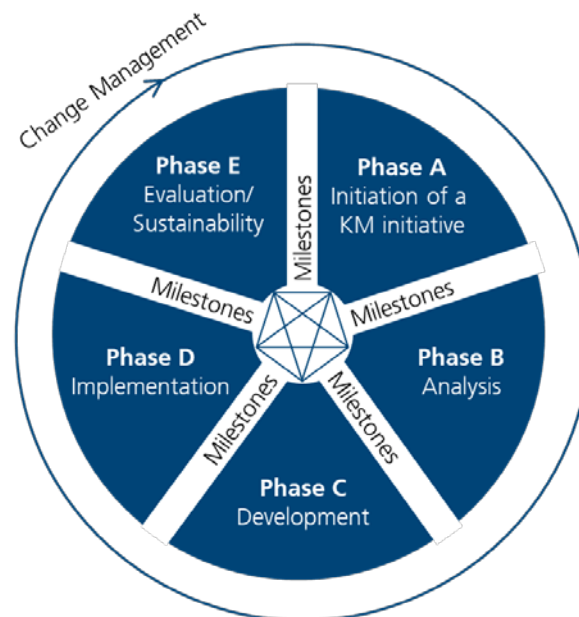
organization depends largely on the extent to which the existing structures and processes enable the smooth execution of the KM core activities (create, store, distribute and apply knowledge).

Technology: In the field of information technology, numerous solutions can be found that support effective knowledge management, e.g. to facilitate communication, cooperation and access to information and knowledge resources. In this respect, the choice of adequate instruments from ICT area is decisive for the success of knowledge management.

5.3. KM IMPLEMENTATION PROCEDURE

In order to develop recommendations for a suitable procedure for KM implementation at the SENAI Innovation Institutes, the proven structure from the CEN guide and DIN SPEC 91281 was used as a basis. According to this, a distinction is made between five phases of implementation. In addition, the aspect of change management as an accompanying programme is emphasised as particularly important (figure 4).

Figure 4 – KM Cycle as basis for systematic planning and implementation



Source: Adapted from CEN and DIN SPEC

Based on this structure, a workshop was held with the working group to determine step by step which success factors are important, which challenges exist and which barriers may arise in the respective phases. The aim was to jointly design a procedure adapted to the requirements of the ISIs. In this context, the following results were developed:

Table 1- KM Framework Phases: Objectives, Challenges, Success Factors

Phase	(A) Initiation of a KM project/initiative	
Objectives	In this phase you clarify the goals of the project and put together the project team.	
Challenges & Barriers	Success Factors	
<ul style="list-style-type: none"> Identifying the proper stakeholders from all relevant research and support areas (e.g. HR, IT, PMO) to build a representative KM project team Difficulties to define strategic KM goals and expected impact on business Find out the real requirements of the project with all relevant stakeholders Convince high-level managers about the importance of KM Lack of a strong sponsor to engage people at the ISI and corporative areas Lack of time and/or engagement from researchers and supporting staff Lack of experienced people to conduct the process internally 	<ul style="list-style-type: none"> Select and put a "well balanced" team to work together Involve the researchers and supporting staff to represent research areas and core business processes Strong sponsor at the ISI and corporative level willing to establish a KM standard and culture Establish a committee of engaged employees from ISI and corporative areas to discuss and implement the KM standard and promote a KM culture Understanding the importance of this work by all the ISI members Use language, documentation or process that is easy to understand for all levels and actors involved Persist in training and actions until KM becomes something natural in the institution Monitored/ assisted process (e.g. support from central unit or community of practice) 	
Phase	(B) Analysis	
Objectives	By using suitable diagnostic tools you identify strengths and weaknesses in the handling of knowledge in your organization.	
Challenges & Barriers	Success Factors	
<ul style="list-style-type: none"> Define a suitable instrument for the diagnostic tool (i.e. with strategic and suitable questions for the target public) Access to proper tools Not considering specificities regarding local ISI operation and about each research area Lack of data / not enough data gathered to constitute a proper or representative diagnostic result for the KM program Data with poor reliability (e.g. qualitative questions in survey) Availability of target public (all areas) Not achieving proper consensus among KM committee/team regarding the priorities highlighted by the KM diagnostic results 	<ul style="list-style-type: none"> Kick Off / meeting to inform all employees about KM project and mobilize them to fill the questionnaire Proper sensitization of target public to guarantee good diagnostic results (quanti and quali) Provide enough time for analysis, reflection and preparation to answer the questionnaire Consider the opinion of employees on the most appropriate subjects that should be included in the questionnaire Provide enough and correct resources Make presentation as part of the project phase Conduct a (presental) meeting with the KM team and relevant stakeholders from different areas to validate results and understanding of priorities for all involved areas in the process (exercise collective intelligence) Analyze and show risks of not implementing KM (e.g. turnover rates, lack of seniority, need to retrain people constantly, too much double work to achieve business goals) Consolidate information of KM diagnosis and connect with business and organizational processes 	

Phase	(C) Development	
Objectives	You define requirements, assess the feasibility of selected KM solutions for your organization and plan their implementation.	
Challenges & Barriers		Success Factors
<ul style="list-style-type: none"> • Underestimation of time and resources needed to implement envisioned KM solutions • Not capable to maintain people engagement and interest for a KM program and culture • Not achieving consensus on which methods, tools and practices contribute better for higher productivity or business results • Established goals leading to a solution that is too expensive/long/complex to be maintained in long-term • Absence of intermediate goals to keep motivation high • Lack of information, or poorly defined requirements 		<ul style="list-style-type: none"> • Good overview on available methods and tools for KM solutions (e.g. norms, guidelines, toolbox, success cases) • Conduct benchmarking with other organizations successfully applying KM good practices to grasp different opinions • Good overview on Business Process streams, goals and how to add value to it with KM solutions • Planning/roadmapping a proper sequence of activities that lead to achieving the KM program goals (i.e. business orientation) • Engage people and bring right stakeholders close to planning • Being able to "restart" some aspects/assumptions based on the initial inputs (until this point). So, some extra time/efforts may be required in order to assure the next steps
Phase	(D) Implementation	
Objectives	In this phase you implement selected KM solutions in your organisation and, if necessary, conduct accompanying user training.	
Challenges & Barriers		Success Factors
<ul style="list-style-type: none"> • Lack of resources (e.g. budget, hardware/software) to implement some of the envisioned KM solutions • Loss of commitment of team over time • Understand the governance of each activity • Convincing target public to adhere to the KM practices and reinforcing the KM culture with its benefits • Guarantee proper use of the methods, tools and practices by all users • Adequate training for the users to guarantee the use of the proposed methods • Assure that new employees are adequately introduced in the KM effort • Keep/ retain projects' technical knowledge and lessons learned inside ISI 		<ul style="list-style-type: none"> • Define a regular timeline for applying KM practices and/or feeding up / updating KM systems • Show regularly results from the KM adopted solutions, to motivate and convince people on contributing to it • Provide trainings for the use of the methods, tools and practices • Train the team recursively with workshops and show lessons learned • ISI, DR and Federation corporative levels have the feeling that they contribute and get value out of the KM approaches • Register and maintain project knowledge (e.g. in a wiki)
Phase	(E) Evaluation/Sustainability	
Objectives	In this phase you carefully evaluate the project and plan measures to further anchor knowledge management in your organization.	
Challenges & Barriers		Success Factors
<ul style="list-style-type: none"> • Defining proper indicators to measure success of the application of KM solutions • Not defined metrics to verify success accomplishment • Not being capable to measure properly the metrics defined by the agreed indicators 		<ul style="list-style-type: none"> • Well defined and calibrated KM KPI system to support measurement and target definition • After sales indicators to measure client satisfaction

<ul style="list-style-type: none"> • Measured results do not satisfy target public in order to engage continuous improvement or the establishment of a KM culture • Keeping newcomers updated with the methodology and maintaining “oldtimers” motivated • Results (or the communication of it) not good enough to motivate the continuation or new KM solutions • Keep best practices updated considering new parameters 	<ul style="list-style-type: none"> • Stakeholders that are responsible for decision taking are informed and evaluate together the results of the KM implemented solutions • Recognition of the efforts and incentives for the main contributors to the KM practices and culture • KM PDCA process is established and followed up by important stakeholders and the team representatives
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Source: KM workshop with ISI network – interactive whiteboard session (online, May 2023)

5.4. Change Management

Figure 4 also highlights the importance of change management for the success of KM implementation. It shows that change management activities are important in all five phases. In essence, it is a matter of transparently communicating the goals, the procedure and the benefits as well as the interim results of individual steps. In addition, employees should have the opportunity to actively participate in the process of KM implementation. A systematic and comprehensive management helps to ensure that the subsequent solutions are accepted and used by the users. This is the only way that the success of KM can spread throughout the organization.

6 DISCUSSION AND OUTLOOK

In this paper, different standards in the field of KM were presented. Based on the methods engineering approach, this served as a starting point for developing an adapted procedure for the introduction of KM at the institutes of the SENAI network. It can be stated that KM is to be understood as a socio-technical construct. The introduction of KM should therefore consider the aspects of people, organization and technology in equal measure. For the introduction and anchoring of KM, a procedure in five phases is proposed. These phases were jointly reflected with representatives of the SENAI network in order to identify special requirements from the perspective of the institutes and to take these into account in the procedure.

In the future, a KM toolbox will be developed. Along the individual phases, the KM toolbox should provide suitable resources. These include appropriate diagnostic procedures, tools for capturing and describing relevant areas of knowledge (e.g. knowledge maps), descriptions of business processes and examples of good practice solutions in KM. When

selecting suitable solutions, particular attention should be paid to ensuring that they address the challenges identified by the ISI representatives.

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