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Industrial Knowledge Assessment for Capitalization Purpose via Learning Techniques

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Abstract: Capitalization of industrial knowledge is an important issue for enterprises who want to master the development and the innovative part of their product. Of course, there are many knowledge extraction methods, but they involve an expertise work by KM experts. Besides this, it is necessary to evaluate both knowledge and knowledge use. In this paper, we present an approach to evaluate this knowledge use with a Serious Game (SG). From an identification methodology based on an analysis under a PLM (Product Lifecycle Management) deployment, we experienced a SG platform for minimize the reluctance of actors and validate the identification work of KM experts. Based on serious game first, we extend our approach to a SPOC (Small Private Online Course).

Key words: PLM ・ Knowledge Management ・ Serious Game ・ SPOC

INTRODUCTION

For most companies, the capitalization of the know-how often encounters the difficulty to make explicit the whole industrial knowledge. In this context, a lot of works exists in the literature, focused on the extraction of such knowledge (section 2). These methods are effective in a certain context (context of specialized business knowledge), but they require a very difficult expertise work, often done externally. In the context of our activities on PLM system (Product Lifecycle Management), we opted for a different approach of knowledge capitalization.

Thanks to previous works on PLM system deployment [1, 2], we acknowledged that this phase is particularly favorable to identify tacit knowledge. Some knowledge is interlinked with various elements handled within the company's activity such as products, customers, marketing strategies, the expertise stemmed from projects. Furthermore, a PLM system deployment is an opportunity to map out its current business processes and the data concerning its products. The Project Implementation Methodology for PLM (MPPI) is based on these assumptions. Thus, MPPI is a global approach for coupling a deployment methodology (implementation of a new information system) and a phase for integrating knowledge (company specific configuration). As explained further below, PLM systems contain knowledge that can be extracted by a suitable method. Unfortunately, such methods have also some drawbacks: they are all faced with the need to conduct interviews with the actors of the company. They are, in fact, highly dependent on the actual level of actor's involvement in the project.

This article proposes an innovative approach to address this point and thus to facilitate the work of experts by the use of a serious game. Indeed, the aim of this work is to facilitate the emergence of unidentified knowledge extraction hidden within PLM systems.

In the area of education, some new learning methods provide significant added values (motivation, immersion, collaborative aspects, behavior observation) [3-5]. The use of serious games allows to reach this aim by minimizing the reluctance of actors and by validating the identification work of KM expert. As we will explain, this discover was quite unexpected.

We already realized previously a serious game platform that helps for change management and PLM system training for all company employees [6]. But in some cases, very rich and interesting discussions concerning the models have emerged of our first serious games experimentations. These latter were done with domain experts. In order to pursue further this research result, we changed the initial objectives of our serious game in order to facilitate knowledge management and enhance this point.

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As recent trends in learning domain, our approach for increasing motivation of users relies on the concepts and techniques of the game field. The purpose of this paper is to present an innovative approach increasing the actor motivation and at the same time, offering the possibility to identify more industrial knowledge and build a knowledge repository.

In the first section, we present a method focused on knowledge integration in PLM systems. This method is designed to be used during the deployment of PLM system. It relies on the analysis of business processes to identify business artifacts relevant of high business knowledge. In the second section, we present the use of a Serious Game platform designed for supporting this integration method. This section is based on a real case study concerning a project of coupling between PLM platform and Serious Game. In this part, we will characterize new usages and some specific scenarios to facilitate knowledge integration. The last part will propose an extension of our vision in order to grant a more important access to these tools and methods. This will allow us to adapt our approach to the current SPOC (Small Private Online Courses) trend and their benefits.

From Product Data to Industrial Knowledge: PLM systems have become an essential component of the information system for managing data and processes related to product manufacturers. On one hand, they help to preserve information related to products. On the other hand, they also reduce the product development time and the cost of new products. Naturally, a productivity gain exists but the new actual and current enterprises need is to better reuse the information in order to enhance innovation. In this case, PLM systems must evolve towards an ability to manage knowledge or at least facilitate their extraction.

Methodologies issued from knowledge engineering are designed to help companies defining an explicit knowledge. They are based on information collection directly from different employees. For example, we can cite CommonKADS [7], PROMOTE [8]. These methods or similar ones require an external expertise and a high availability level of the employees, which is rarely realistic for SME/SMI (Small and Medium Enterprise/Industry).

A knowledge capitalization method: MPPI: PLM systems are information systems whose main function is to manage information related to product development (from design to recycling). Moreover, they contain valuable information and implicit knowledge unexploited by experts in knowledge management. Indeed, the interest of these

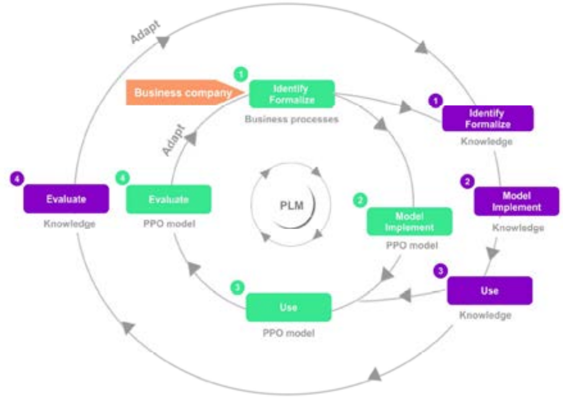

Fig. 1: Steps of MPPI Methods.

information systems is to provide very structured technical information (i.e. with a high potential of knowledge).

As a matter of fact, the deployment of a PLM project is thus an opportunity for companies, even for SME/SMI, to reconsider their work methods. It involves a formalization of the processes currently in place. The MPPI method (Fig. 1) is based on this observation and offers a combined approach to take into account capitalization of know-how during stages of PLM project discussions. Our approach is called combined or dual because it combines two different objectives (deployment methodology and knowledge capitalization approach).

Many information and data are linked to the business process of companies [9]. From these information, it can be extracted a large amount of knowledge that has to be capitalized and reused. So, in complement of deployment analysis, we completed our method with specific knowledge identification tasks. In fact, a full analysis of business processes highlights certain implicit knowledge.

Steps of MPPI Methods: PPI approach is summarized in the figure 1 and can be divided into two cycles. In the first cycle (Identify, Modeling, Use, Evaluate), the goal is to characterize the global model of the information system called ”PPO” model (Product / Process / Organization). In the second cycle (outer circle), the objective is then the integration of a specifically knowledge perspective.

As for the PPO model cycle, this integration is performed through 4 steps: Identify, Modeling, Use and Evaluate. In this article, we are interested in the problems concerning the first two stages. Thus, the identification step consists in characterizing from the PPO model, the activities which are knowledge holder. From these activities (built from business process), the knowledge expert makes explicit the elements of the data model that are knowledge holder and enriches this model with the necessary attributes. Subsequently, the modeling phase will consist in completing the PPO model enriched by the business rules formalizing this knowledge. The advantage of this approach is to facilitate this expertise by mapping relevant areas from the viewpoint of business processes. This method of identification has been successfully used and validated in the deployment of PLM in a plastics manufacturing enterprise.

Discussion about MPPI: The MPPI approach aims to reduce and facilitate the expert work by identifying "areas" of technical data that may contain tacit knowledge (with time saving and efficiency compared to other methods). However, it is nevertheless necessary to perform actors' interviews to formalize this knowledge. These interview are unattractive (for actors), difficult and expensive to implement.

The logical process of our cycle (Use, Evaluate) is then relevant to validate this expertise work and has been proved as being as important as the previous ones (Identification, Formalization). Nevertheless, the use shows that users tend to reject the entire system if the "good rules" are not properly identified at the beginning.

As a matter of fact, the difficulty for the KM expert still stays the same and raises new questions:

errors occur?

- How to check the "good" use of identified knowledge and how to find a "good" actor that will allow to validate it.

In the next section, we will present a tool that allows us to answer to these objectives. This tool is based on a Serious Game platform.

A Serious Game Approach for Knowledge Management: In this section, we present the initial steps that have led us to propose an original or innovative approach for this knowledge assessment based on the use of a serious game. Initially, this serious game was intended to improve the change management within MPPI. However, the different experiments that have been performed and some unexpected behaviors led us to adapt it in order to use it also to validate another step of MPPI.

- A Serious Game use for MPPI enactment
- A generic Serious Game platform: Learning Adventure

Fig. 2: The Learning Adventure Serious Game Environment.

In the context of a project called PEGASE [10], we developed and used a serious game, which couples a 3D gaming platform (called "Learning Adventure" - see screenshots on Fig. 2) and a PLM platform (Audros) in order to facilitate the change management. As a matter of fact, the change management (identified in the MPPI method as a transversal process) is a sensitive issue at the origin of many failures. Studies of practices highlight the existence of difficulties for 45 per-cent of deployments [11]. The causes of these problems are diverse (system malfunctions, poor ergonomics, etc.). But they are often due to the reluctance of actors to use a new information system. The real causes of these rejects are relatively conventional: the user is forced to change from an informal environment to a formal one (their personal information becomes collective). Finally, the analysis of these results underscores the need to conduct a policy of change management that clearly explains the constraints of the system and the overall gain for the company and each of its actors. This behavior change is clearly identified in the MPPI and enacted in our approach with the use of a Serious Games with specific scenarios. This approach is thus based on scenarios designed for including connections with the PLM system, as well as metaphors to introduce the game concepts concerning business process.

Learning Adventure (L.A.) is a generic serious game environment based on a role-play approach [12, 13]. The players (students or teachers), possibly represented by their own avatars, can move through the environment, performing a sequence of sub activities in order to acquire knowledge. This environment is generic in the sense that the teacher can adapt the environment before the session by setting pre-requisites between sub activities and by providing different resources (documents, videos, quizzes) linked to the course. The collaboration takes place in L.A. by constituting groups of users. The Non-Playable Characters (NPCs) give objectives to the members of a group and provide them with access to collaborative tools. We have modeled a company building from the actual architectural plans in order to ensure the players immersion. As a matter of fact, it is easier for them to find the different places (e.g. coffee room, secretary office) in the game if they are located in the same places as in the real building and besides they understand that this is not an external system: it is actually made for them. A compass for helping reach a specific place is however available in the game (see the upper right circle on Fig. 2).

Gamification of Industrial Processes: In the context of change management within MPPI, we used a gamification [14] approach for industrial processes. In this approach, the game designer must choose some specific target characteristics of the platform (e.g. what has to be learnt) [15]. From the previous research questions (section 2), we initiated gamification process with the following choices:

- An oneiric world but enough close of the real enterprise (modeling of a production building of the enterprise)
- A first linear scenario, multi-user: every player has the same scenario. Being together simultaneously in the same ”virtual world” strengthens the immersion feeling and the user motivation (implicit competition, possibility of exchanging messages, etc.).
- Another scenario nonlinear, multi-user, multi-role, collaborative: In this context, the game actions are not necessarily predetermined. Players may have different roles and must work together to continue to progress.

We experimented thus several scenarios for change management [16]. For example, we developed a scenario around RFQ process (Request For Quotation). In these scenarios, the players must perform both game activities and business activities with or without a PLM system to better understand the credit of these systems.

Serendipity Effect of Experiment Feedback: Experiments conducted with industrials (PLM day, CERN workshop) [17] helped us to highlight a characteristic behavior of some actors to assess the knowledge about industrial development processes. Indeed, the script originally developed around the ordering process in the plastics industry was made with some players belonging to the business domain and some others not. If our initial choices have allowed us to validate the relevance of the game for change management process, we found that the participants, who were familiar with the area of technology in question, have systematically initiated a high level discussion about the models used in the PLM.

The core idea of our proposal here is a direct result of these findings (serendipity = the fact to discover something non expected). We have changed the scenario to validate certain processes and tacit knowledge. In the next section, we describe the changes made to the script/scenario so that the use of the Serious Game is now not limited to the conduct of change but also available for the validation of business knowledge as explained in the MPPI method in the previous section.

A Serious Game for Knowledge Use: Finally, the main question for that purpose was: How to adapt our scenario in order to actively promote the identification and validation of knowledge? Our proposal is to provide additional context that allows the player to explicitly validate his skills about the domain. We have established a dual strategy to answer this question: on the one hand, we added some quests specifically dedicated to knowledge use. On the other hand, we have added new artifacts in the game.

New indicators, an annotation tool and the ability to learn new skills characterize this new game context:

- The new K-quests are game activities (or industrial activities in PLM) concerning knowledge or result from an acquaintance. A K-quest can be individual or collective.
- The K-indicators that may be individual (or collective) ones, represent the level of expertise of the player (or group of players). This indicator is viewable by the player and the value of his skill level is affected by some particular game actions including the use of the annotation tool.
- The K-annotation tool is an artifact that the player can use in some situations (interaction with NPC, object, etc.). Annotation is a simple marking (grading system equivalent to ”I like”) or a marking type description (with additional text). The use of this tool automatically modifies the previous indicator.
- The new K-skills explicitly characterize the actors (or groups of actors) whose expertise level indicator is considered as relevant at the end of the scenario.

Quest and Annotation for Knowledge: These mini-quests are designed to validate the good use of knowledge. For this, we employ a range of techniques to promote user engagement and motivation. In order to illustrate this purpose, let's take a real example of specific knowledge. In the context of plastics enterprise, the expert identified the elements around the mold, the manufactured parts and the material as holders of knowledge. We have thus modified the original pedagogical scenario to focus on the use of these elements (mold, part, material). For example, we added a quest in order to choose the best speed injection for molding. This speed is calculated from a business rule and proposed, among other choices, to the players. Depending on their actual level of expertise and their knowledge, the players will be able to check if the proposal from the knowledge model is relevant. At the end of the quest, they will mark the mold or NPC who proposed the speed injection molding in order to increase its performance indicator level of expertise in this field.

With this example, we wanted to show that it is possible to enrich an initial scenario around mini-quests specifically dedicated to the validation of knowledge. Of course, a necessary expert work on knowledge formalization has always been done in advance. In addition, one of the biggest advantages of this approach is that annotation can be performed via a mini-quest (individually or collectively) and fits well with the vision of a flexible serious game scenario (adaptation / evolution without any question). In this example, we could also validate the speed injection for molding through some collective actions (voting, discussion, etc.). In all cases, the trainer's job is to analyze produced traces with these mini-quests.

Traces Analysis and Indicators: The implemented system uses all significant traces: game traces (interactions, movement, etc.) and activity traces within the PLM system (document consultation, creation, etc.). The aim of these traces is to improve the user monitoring for individual actions but also and especially during interactions and group actions [18]. Annotation traces will complement game traces and activity traces. The interest of these annotation traces is twofold: on the one hand, they are used to validate PLM data and business rules that were identified as holder of knowledge by expert. On the other hand, they can implicitly define an "organizational mapping" of knowledge. Here, the meaning mapping concerns actors' identification with a level of professional expertise in relation to the formalized knowledge.

In the previous example, relevant traces for the expert analysis are:

- Moves and passed time in interaction with the NPC that informs the mini-quest.
- Dialogues (with "chat" = instant messaging) between the players during this period
- Consultations within the PLM system on the data related to the injection speed
- Player's responses at the proposal
- Number of annotation by player and their descriptions

They are used by the trainer to validate with the business expert, the relevance of formalized knowledge and the actors identified as mastering this knowledge.

Aggregating different indicators allows us to define a K-indicator. This K-indicator is a visual element of motivation for players.

Skills and Expertise Level: Traces collection aims to be able and provide indicators and also to calculate the user model of each player. This user model characterizes the whole user skills. We define a user model simply from a declarative manner as the following set:

$$UM_p = \{(p, skill_i)/p = player, skill_i = (field, value)i > 0\}$$

The user model is used to calculate, for each player, a set of characteristics acquired during the game. In our case, game activities, activities within the PLM and annotations will provide the traces needed to calculate the user model of each player.

The User Model Skills Have Two Uses:

- Obtain game artifacts that increase player motivation;
- Identify motivated people and those who are able to validate a specific knowledge. The definition of K-skill can be seen as a motivating factor, but it also should help to characterize specifically and objectively the actors expertise according to activities that have been traced in the game.

Finally, it is the combined use of these tools (K-Quest, K-Annotation, K-Indicator, K-Skill), which allows us to define a global scenario of knowledge validation.

Limitation De Notre Approche: All these experiments around the use of a serious game shows that increasing

[1]SPOC is a more restrictive version of initial MOOC (Massively Open Online Courses)

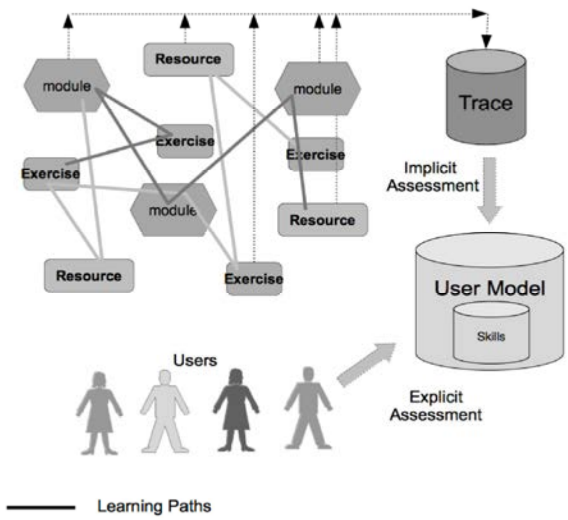

Fig. 3: SPOC Vision of the Serious Game

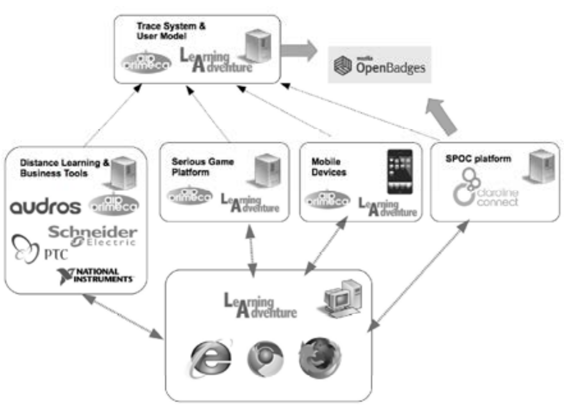

Fig. 4: Whole system architecture

motivation promotes effectively change management and validation of knowledge as defined in the MPPI method.

However, we found that the Serious Game does not, by itself, ensure skills gain over the long term. In our case, the serious game is a catalyst for motivation, collaboration without a deep knowledge incorporating.

In another experiment [19], we proposed to combine the serious game with very concrete activities. In fact, we have shown that mixed reality (Virtual & Real activities) promotes a better knowledge incorporating. Unfortunately the implementation of such scenarios is very complex and costly in resources. It is not suitable for an industrial environment type SMEs / SMIs whereas the method is initially intended for these structures.

Therefore we hypothesized that a comprehensive approach for accessing (multiple media and any time 24/7) real resources could be an interesting alternative to mixed reality scenario. In that purpose, we propose to use the concepts of SPOC (Small Private Online Course)[1] to offer a simple alternative to the industrial structures of SMEs / SMIs type.

The following chapter presents an approach coupling SPOC and Serious Game.

From Serious Game to SPOC: Thus, we adapted our serious game approach to SPOC approach. The methodology is quite simple. First, we focus on a SPOC (Small Private Online Classes or Courses) to control the scalability and the next/final step will consist later in opening the access to a massive set of persons.

Technically, all the content is reusable; we just transform the scenario into a set of several modules (ex activities). It is important to identify the independent parts in order to be able to propose some alternatives or choices between activities (non linear progression). The most time-consuming part concerns the realization of videos supporting the course/domain/context explanation. The implementation via a web platform is simplified by the existence of specific ones.

In order to integrate the SPOC and the Serious Game (Fig.3), we propose to move from a procedural logic to a "resource pool logic" where the construction of learning paths is dynamically achieved by profiling (Thematic profile, Temporal, Playful, etc.). Thus, the different scenarios may be defined in terms of acquisition objectives of skills. The dynamic aspects may be implemented by regulation mechanisms (e.g. deadlock detection, increase or decrease of activities number according to the progress, evolution of the profile, etc.).

SPOC Vision of the Serious Game: With this approach pool, we can offer fun and adapted activities that will help maintain the attractiveness and motivation of learners. Some courses may even have a stronger playful connotation (journey of discovery or change management).

Whole System Architecture: Access to resources is centered on skills. In this context, the evaluation mechanisms are typically explicit (based on a classic knowledge control). As indicated in the previous paragraphs, the activity traces will enrich explicit assessments by implicit feedback ratings (based on the analysis of these traces of activities). These traces and the resulting assessments are important insofar as they contribute to the enrichment of the acquired skills. Moreover, we think it is essential to capitalize the acquired skill and make them viewable (skills could be capitalized by digital badges type Open Badge of the Mozilla Foundation).

Discussion about long life Learning : Nowadays, the habits of people change and an easier access to knowledge or long life learning certifications are more pregnant. Although the Serious Game approach gave us good results, the sessions are long to set up and are currently limited to small groups; even if this has been experimented for several years and concerns now more than 500 persons. The new objective is to propose a more general access to these scenarios (a more scalable approach). The trend of MOOC (Massively Online Open Course) is able to be a valuable support for this objective. Moreover, the serious game layer will ensure a good and persistent motivation and the modular scheduling of the learning activities will avoid the generally very linear aspect of such types of formations that are from our point of view and in our context, the main drawbacks of MOOC and naturally SPOC.

As explained before, traces and indicators are used and a very first evaluation (quiz) of the learner will propose a particular sequence of relevant modules for that learner. Then, three modalities will thus be proposed: full serious game (download a client program: 3D world as described before), web serious game (more static, 2D world: for example for low resources or nomad devices) and « help yourself »: some « ready to use » modules to be integrated in other formation.

The whole system, applied to different domain and public (PLM and Language correctness) for validating purpose, will be beta-tested and available in June. The economic model is not set but in your mind, the main use will be free at the beginning.

CONCLUSION

In this paper, we have presented an approach to validate knowledge extracted from the PLM system deployment based on a serious game. The main insight is to use a Serious Game as a validation tool in a knowledge capitalization methodology. In an initial approach, the use of Serious Games had been introduced with the goal of change management. However, thanks to the experiments performed in this context, we have identified a new use concerning also the knowledge validation phase. In fact, early outcomes in the context of PLM with a specialist audience spontaneously generated very interesting debates concerning the models of PLM. To support this innovative behavior in the usage of resources, we imagined some specific tools in the game (level indicator, annotation tool, skills). The knowledge, validated by the serious game, allow to identify and to represent the corporate memory of a both more explicit and more precise manner.

Naturally, from our point of view, a serious game approach does not substitute to the knowledge extraction methods (whether manual or automatic) but helps to engage seriously the persons. We propose then to use them as a complement to verification and are working on an extension of this approach for scalability purpose. We explained our methodology to evolve from the serious game to a SPOC and finally to a MOOC. Currently, this last part is still under development. Some experiments in ecological (i.e. real) context are planned for June: trying to develop a SPOC/MOOC allowing to maintain the people motivated and immersed.

Finally, the interest of this approach is twofold: On the one hand, the design cost is low since we reuse what has been created for the change management or training in terms of content and for serious game in terms of structure and graphics. Other hand, it is effective because the game approach is very motivating and less linear than similar types of formation.

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