PLM Serious Game Approach Available Both for Change Management and Knowledge Assessment

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Abstract. Minimizing the reluctance of actors in change management is a well-known and key issue that can be resolved thanks to a serious game approach during the upstream PLM deployment phase. If our initial choices have already allowed us to validate the relevance of a serious 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. We thus tried to take into account these unexpected observation results to also address the downstream phase concerning knowledge identification and assessment. Indeed, the capitalization of industrial knowledge is an important issue for enterprises who wish to master the development and the innovative element of their product. A substantial amount of knowledge extraction methods has the drawback to require expensive work by KM experts. We witnessed that besides this, it is necessary to evaluate both knowledge and knowledge use. In this article, we present the two uses synthesized in a same Serious Game Environment. From an identification methodology based on an analysis under a PLM (Product Lifecycle Management) deployment, we developed and experimented a Serious Game platform to both minimize the reluctance of actors and validate the identification work of KM experts.

1 Introduction

The deployment of a PLM project is an opportunity for companies, even for SMEs/ SMIs, 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. This approach is called combined because it combines three different objectives (deployment methodology, change management and knowledge capitalization approach). The first part of this paper will present the

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methodology MPPI (Methodology for PLM Project Implementation) that is a global approach for coupling a deployment methodology (implementation of a new information system) and a phase for integrating knowledge (company specific configuration). Thanks to our previous works on PLM system deployment, we acknowledged that this phase is particularly favorable to identify tacit knowledge. Nevertheless, these method presents some drawbacks in terms of cost and attractiveness. We decided then to bare on recent educational trends where playful approaches are supporting learning content.

The second part of this article focuses thus on the integration of the use of gaming techniques inside the MPPI method. In this part, we will characterize the gamification of industrial processes as well as the emergence of new usages and some specific scenarios to facilitate change management and knowledge integration in two particular and relevant steps of the method.

The third section will describe the serious game platform designed for supporting this integration method. This section is then illustrated by the way of a real case study concerning a project of coupling between a PLM platform and a Serious Game environment.

The last part will focus on results and feedback concerning the experiments that have been set up.

2   Methodology for PLM Project Implementation

The companies which deploy a PLM system wish to reduce the development cycle to promote innovation. For the implementation of a PLM system, these companies must analyze their information and processes. It seems interesting to take advantage of this revision of information system to make explicit the crucial knowledge in order to manage it more efficiently. Through MPPI method, we want to integrate and capitalize on the knowledge generated by a process in a PLM system.

2.1   Description of the Approach

The following figure (Fig.1) schematizes the approach proposed in MPPI [2] [3]. Thus, MPPI is structured around two processes: the process of draft (pre-project) and deployment process. We can note that the accompanying and adaptation process must be considered as a transversal subprocess included in the first two.

The overall approach MPPI exhibits a comprehensive process implementation modeling of an information system focused on the product. A specific part concerning the deployment process is called MPPI-KI (for Knowledge-Integration). MPPI-KI approach 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 that concern the first two stages. Thus, the identification step consists in characterizing

from the PPO model, the activities which contain knowledge. From these activities (built from business processes), the knowledge expert makes explicit the elements of the data model that are knowledge-containing and enriches this model with the necessary attributes. Subsequently, the modeling phase will consist in completing the PPO model enriched by the business rules that formalizes this knowledge. The advantage of this approach is to facilitate this expertise by mapping relevant areas from the viewpoint of business processes.

2.2   Discussion

As explained before, these steps are difficult, expensive to exploit and do not resolve the problem of reluctance of the users. In this article, our main proposal concerns the use of a serious game for specific stages of MPPI approach. From our experience and in the context of our work, the use of a serious game is suitable for two aspects of the MPPI method. The first aspect concerns the transversal process of change management, the second aspect relates to the stages of evaluation of the MPPI-KI process.

In the next section, we will then focus on the integration of gaming concepts into the MPPI method.
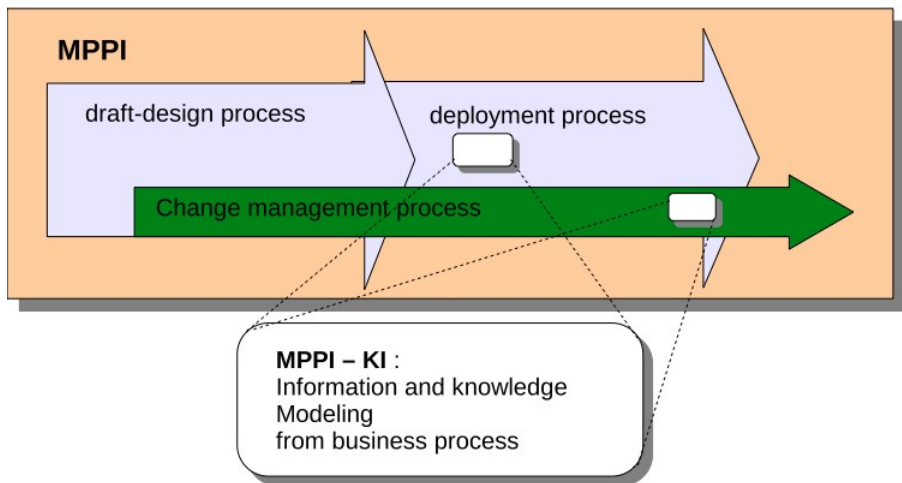

Fig. 1. Principles of the MPPI method

3   Gamifying a PLM Method

3.1   Gamification of Industrial Context

In the context of change management within MPPI, we used a gamification approach [6] 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) [5].

From the previous example (section 2.2), we initiated gamification process with the following choices:

- A contemporary and realistic world, quite close of the real enterprise (with the complete 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 feeling of immersion and the user's motivation (implicit competition, possibility of exchanging messages, etc.).
- Another, nonlinear scenario, 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 advance.
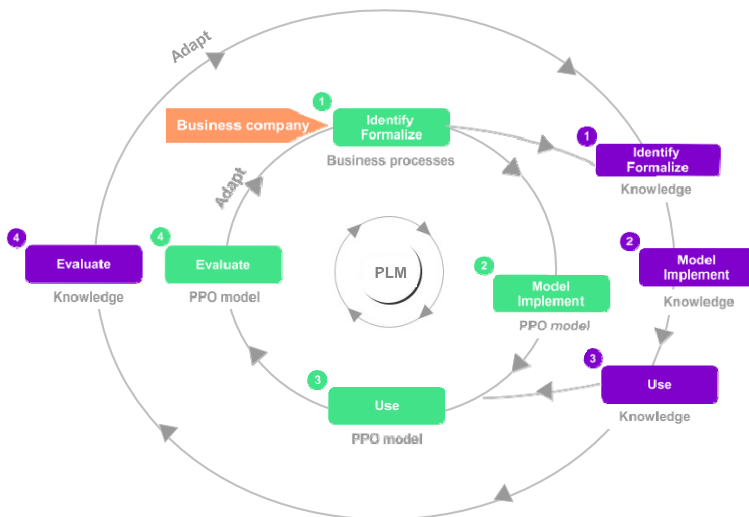
Fig. 2. Steps in the MPPI-KI method

As we will see now, our main assumption is to use a role play approach where the user with her/his avatar is faced with practical problems of her/his everyday work (see below screenshots in Fig. 4 and 3).

3.2 Change Management Process

Indeed, the change management (identified in the MPPI method as a transversal process) is a sensitive issue at the origin of many failures. The causes of these problems are diverse (system malfunctions, poor ergonomics, ...). But they are often due to the reluctance of actors to use a new information system. The real cause of these rejections is relatively conventional: Users are forced to change from an informal environment to a formal one (their personal information becomes collective). It is thus important to make the user experiment effectively the gain brought by the new system.

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. As it was defined, this approach is based on scenarios designed for including connections with the PLM system, as well as metaphors to introduce the game concepts concerning business process.

We thus experimented several scenarios for change management [7]. The following figure shows an example of scenario around the RFQ[1] process. In these scenarios, the players must perform both game activities and business activities without then with a PLM system to better understand the benefits of these systems.

For example, the part without a PLM system exhibits the difficulty to retrieve a correct product reference at the right moment, at the right place. As everybody knows, a company with services, protocols, agents is always evolving and there is a gap between theory and practice.

3.3   Knowledge Use and Evaluation Step

Concerning the second step, the final approach is similar but the cause is different. It is well-known that it is difficult to extract tacit expert knowledge from the workers. We faced the same problems when exploiting the method or even conceiving the serious game. Nevertheless each serious game is finished with a debriefing discussion in order to better incorporate the acquired knowledge and surprisingly, we observed that the experts have naturally exposed their reticences or doubts concerning the models they found in the game during such a discussion with the others.

We decided then to adapt our scenarios 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 the knowledge use; on the other hand, we have added new artifacts in the game.

This new game context is characterized by new indicators, an annotation tool and the ability to learn new skills (Fig. 3):

- 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 its 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[2], object, ...). 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.

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[1] Request For Quotation.

[2] Non Playable Character.

- New *K-skills* explicitly characterize the actors (or groups of actors) whose expertise level indicator is considered relevant at the end of the scenario.

In order to be able to evaluate dynamically the concept acquisition, the whole system is traced: the business system and the serious game environment as we will see later. This allow us to assess the skills and the expertise level.

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:

$$UM_p = \{(p, skill_i)/p = player, skill_i = (field, value)i > 0\} \quad (1)$$

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 traces needed to calculate the user model of each player.

The user model skills have two uses: On one hand, it allows to obtain game artifacts that increase player motivation; on the other hand, it identifies 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 should help especially characterized 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. All these scenarios have been experimented several times in real situations with a specific serious game environment that will be described in the following sections.

4 A Serious Game Use for MPPI Enactment

4.1 A Generic Serious Game Platform : Learning Adventure

Learning Adventure (L.A.) is a generic Serious Game based on a role-play approach [1, 8]. 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 NonPlayableCharacters (NPCs) give objectives to the members of a group and provide them with access to collaborative tools. As said before, we have modeled a company building from the actual architectural plans in order to ensure the players' immersion. Indeed, it is easier for them to find the different locations (e.g. coffee room, secretary's office) in the game if they are situated in the same places as in the real building. A compass to help players reach a specific place is however available in the

game (see the upper right circle in Fig. 4). Moreover, the fact that the users understand that this game or formation is specifically dedicated to them is a great factor of motivation.
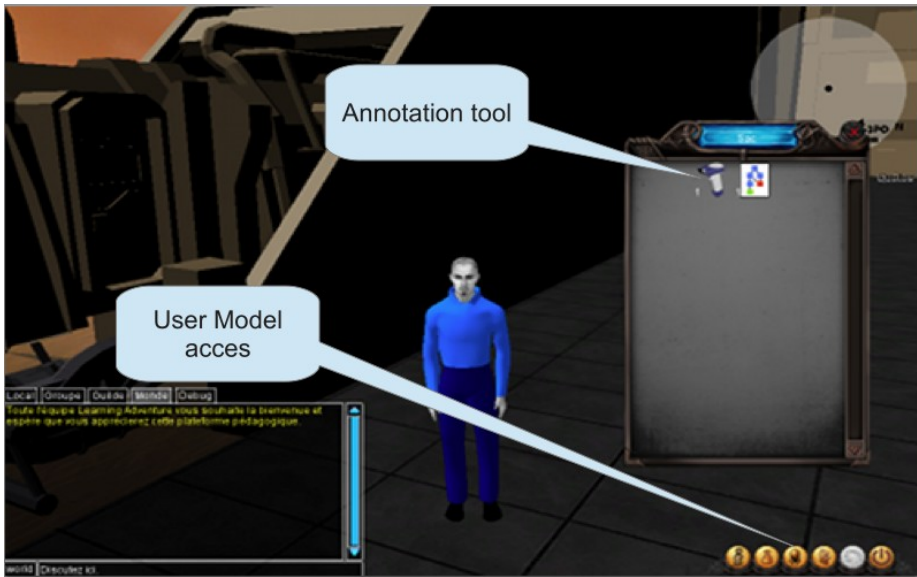
Fig. 3. Additional device for knowledge

As mentioned in the previous section, in the game environment we also get a lot of trace left by the users in order to adapt the system.

4.2   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. 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 of 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
- Players' responses to the proposal
- Number of annotation by player and their descriptions

Fig. 4. The Learning Adventure Serious Game Environment

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 the players.

Concerning the experiments, the system is now used in education for several years (more than 500 people) but there are each year some slight evolutions in order to improve the system or to adapt to a changing context (sessions with industrial experts for example). In the following section, we will describe the general conditions of experiments in formation context and give some feedback concerning the user acceptation of the system.

5   Conditions of Experiments and Results

Experiments have taken place in general training programs (master's degrees) as well as in a further training course for interested professionals. All experiments were conducted in the same experimental context. During the experiments, all groups of people were present with a teacher and an external observer. Concerning the social presence perception [4], players were oriented one behind the other, limiting mutual

eye contact, in a row of four students. Each student accessed the virtual environment through her/his workstation and had a personal (adapted) view on the world. They were explicitly allowed to communicate through the chat tool provided with the system and were warned that they would be observed and filmed concerning the use of the system.

We did two types of experiment. The first one dealt with students who had a basic level of knowledge concerning PLM (for change management). This experiment took place in a PLM training module for the Institute of Technology in Lyon. This training module is an introductory module lasting 15 hours with second year students. These students did not know the PLM but had skills in mechanical engineering. 254 students from 18 to 21 years old were split into 20 practical work groups. 10 groups started the module by playing the game scenario, without any theoretical lesson. The other ten groups did have two hours of theoretical training on PLM before their experiment in order to evaluate the benefit of the learning game session. All the experiments took place in the same room belonging to AIP-Primeca (Regional Engineering platform organization).

The second experiment was carried out with students who had no knowledge on PLM (For knowledge evaluation). This experiment took place with a group of students preparing a master's degree in the PLM domain. Each student involved in this one-year program works part-time for his/her company (one week at the university, three weeks in his/her company). The experiment took place on the last day of the first week at the university. At this time, the students had attended theoretical lessons and practical classes concerning another PLM system than the one included in the Serious Game Scenario. The students were aged from 24 to 50 years old. They had all chosen this training program for new opportunities and jobs offered in this domain. The initial skills of the students were diverse (computer science, electrical engineering, industrial engineering).

Thanks to traces and indicators, correct actions were automatically rewarded with the relevant skill level up. Concerning these experiments, two evaluation methods were chosen:

- Quantitative, thanks to collaborative indicators elaborated with traces left by the users when collaborating,
- Qualitative, with live questions at the end of the session and explicit feedback from the teacher/PLM expert.

    We can observe :

- 90 % of the participants have identified the features and goals of the systems and 40 % would have recommended them to their manager (3% before using the game).
- The number of student requests for collaborative projects has been multiplied by two. In the second experiment, the sequence of the game session has had no measurable impact on student achievement.
- The work on the knowledge validation has implicitly validated 70% of structural models defined in the PLM system.

6   Conclusion

In this article, we explained that we tried to couple a methodology for PLM integration and a serious game in order to facilitate the change management and the knowledge capitalization. From our point of view, the results are satisfying. Indeed, these approaches are very attractive thanks to their novelty and thus reinforce the motivation of the users. The immersion is also used to help the users to exhibit tacit or expert knowledge more easily. Some drawbacks remains: some parts concerning the game elaboration are always costly in time and expensive in code/design development. The sessions are limited to around 20 persons at the same time for the moment. Nevertheless, some reuse possibilities are more and more evident when we are elaborating new scenarios indicating a certain maturity for the approach. The PLM domain is also evolving and for future work, we are studying the possibilities of extension given by Service Lifecycle Management (SLM) or Knowledge Lifecycle Management (KLM),

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