Management of a Knowledge Base by a Trainee in an Industrial Company: Application to Industrial Maintenance

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Abstract: ***In this article, we present an innovative strategy to build and manage a knowledge base for a student trainee in an internship program.This knowledge base is built from the knowledge and skills gathered from the implementation during various maintenance activities in an industrial company. Throughout this article, we will show how this knowledge base is built and how students can use it to familiarize themselves with the professional world to build their own knowledge and skills.***

Keywords: internship in industrial companies - Case-based reasoning approach - learning - Industrial maintenance

1. Introduction

Participating in an Internship program in an industrial company has become an essential step in training courses. It has a pedagogical purpose and is an essential element of the curriculum. The internship is a stage of the training where the student becomes familiar with the professional world.It is in this stage of the training that a student trainee can apply his or her knowledge to facilitate the transition from the world of training to that of the company. The stages in an internship includes observation, imitation, immersion and realization of small projects or large-scale projects. These skills and knowledge acquired and transmitted during an internship is unique and cannot be carried out in an artificial learning environment. According to Escourrou (Escourrou, 08), the internship improves the match between the initial training and the job market by reinforcing professionalism and the knowledge transmitted, the know-how and skills.It is in itself a powerful tool for individualization of training courses, an effective tool for professionalismand a tool to complement both qualitative and quantitative aspects of the initial training.

Analysis of the current operating modes of internship programs show that this function is often not very formalized in the sense that the tutor's activities are not precisely defined (Wittorski, 1996).These are often informal acts that follow a logic of training by the work situation: then develop situations of exchange or meetings in work situation where are activated, mobilized, transmitted and produced knowledge and how to do.

In order for the internship program to be successful, participation of the learner and the progress of the internship must be planned and organized by the two entities organizing the internship, in this case the school and the industrial company. Forthere. According to our investigations in industrial companies, Student Trainees (ST) in Vocational and Technical Training Centers (VTTC) face real difficulties during their stay in business. Indeed, we noticed a total disorientation of the latter during their participation in the maintenance activities. They are very often confronted with an availability of documentation of follow-up of the interventions not adapted to their level of comprehension.

We propose in this paper the construction of an evolutionary knowledge base inspired by the Case- based Reasoning (CBR). We chose the CBR because it promotes learning. In each problem-solving activity, one always tries to find similar situations in a case base and then adapt them to the new situation.We will make sure that all documents in this knowledge base are really adapted to the ST’s level of understanding. Thus before each maintenance activity, the ST is able to consult this knowledge base and release the documents that will help him better understand the activities of the intervention team. After the maintenance activity, he or she will, with the help of his or her supervisor, update the knowledge base with a report he or she has written.

In this article, we will start by reviewing the main concepts and elements of the CBR, to inform the theoretical base for this paper.We will then present each element of the proposed knowledge base. Finally, we will look at the process used to write the report which constitutes the element of knowledge to be transferred to the knowledge base.

2. Case-based reasoning approach (CBR)

In the current industrial context, it is necessary to have approaches and tools to help with maintenance activities in the industrial companies. These tools must generate new knowledge which could help to reduce the time of maintenance activities. To use these tools we can use methods based on feedback of experiences. These experiences are full of special interests and new knowledge which have been acquired during the previous maintenance activities and the supervision of the experts at the industrial companies.

2.1 Thekey elements of CBR

CBR is a methodology that finds its origin and development in the work of artificial intelligence and cognitive and problem-oriented psychology. It is an analogical reasoning that involves using past experiences to solve new problems (known and previously solved problems), each of which constitutes a case. The objective of this method is to use knowledge from previous cases and adapt them to solve new problems.Each case refers to a set of problems associated with their solutions. A "source case" corresponds to a previous experience and can serve as a similar case to solve by analogy an ongoing problem called the "target case". The main steps of the CBR are the recall (selection in the base of a case considered similar to the target problem), the adaptation (resolution of the target problem based on the recalled case) then the revision and memorization (or learning: validation of the newly formed case and possible storage in the database).In order to better understand the functioning of a RAC cycle we will start with an example. This example starts from the observation made during the creation of a process. A case in this situation represents the different parameters of a past design (specifications, operating conditions, thermodynamic models, diagrams, etc.). In search for information needed to create a new process, the engineer can compare his needs with those of past conceptions summarized, for example, in the form of a flowsheet (see Figure 1). A similar flowsheet can then be used and modified, if necessary, to be adapted to the new situation. In this example, we can see that a CBR system is able to solve new problems by adapting past problem solutions (R. Reyes, 12).

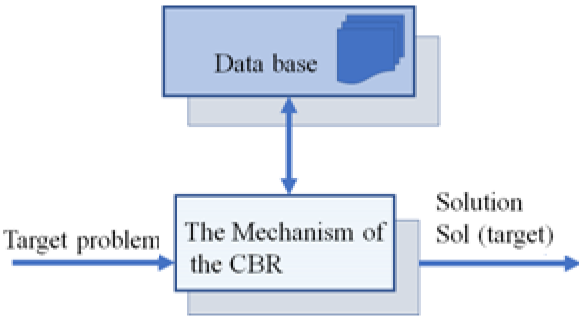

Figure 1: Principle of CBR (Lieber et al, 04)

2.2 The CBR cycle

According to (Kol, 92), CBR can be defined as a methodology capable of reasoning and learning, based on the specific knowledge of past problems. The knowledge gained from past problems is reused to provide a solution to a new problem. In the literature, there are a multitude of models that are used to represent the different sequential steps of the process deployed in a CBR for example see (All, 94), (Hun, 95) and (Lea, 96).

In Figure 2, we find an R5 cycle proposed by (Finnie et al., 03) that is used to model and construct a typical CBR system. This cycle is an extension of the R4 model introduced by (Aamod, 94). In the R5 cycle each R refers to one of the following steps: (R. Reyes, 12)

- Represent: It is about formatting the target problem for the purpose of remembrance by completing its description with the knowledge of the domain.
- Remember: Its goal is to select and extract a source case similar to the target. The key point of this step is the similarity measure.
  (Target, Data base) → (source, Sol(source)) ε Data base
- Reuse: Based on the recalled case, reuse seeks to resolve the target. The CBR system adapts the solution of a recalled case to meet the requirements of the new problem. This phase is also known as "case adaptation", it can be formalized by
  (Source, Sol (source), target) → Sol(target).

There are many approaches to adapting Sol (source) to the target. Reuse can be as trivial as Sol (source) direct proposition as a solution for the target, with no change (used for decision support or justification). Most of the time, however, this adaptation step only seeks to define the gap between source and target problems and then modify Sol (source). Adaptation methods must therefore answer the following two questions: What should be changed in Sol (source)? How should this change be made?

- Revise: Following the adaptation, the proposed Sol (target) is tested by simulation or experimentation to check its adequacy and relevance to the target. If the test fails, the solution is corrected to eliminate discrepancies. Note that these test and repair steps can be an integral part of the adaptation.
- Retain: If it is appropriate, it is necessary to make a contribution of a real added value to the base of case, the new episode of resolution is stored in the base. This step makes the CBR a self-learning system, which gives it the advantage of extending its coverage of the space of possible problems and increasing its efficiency. With this step inevitably arises the problem of maintenance of the case base and in particular knowledge management in such a system.

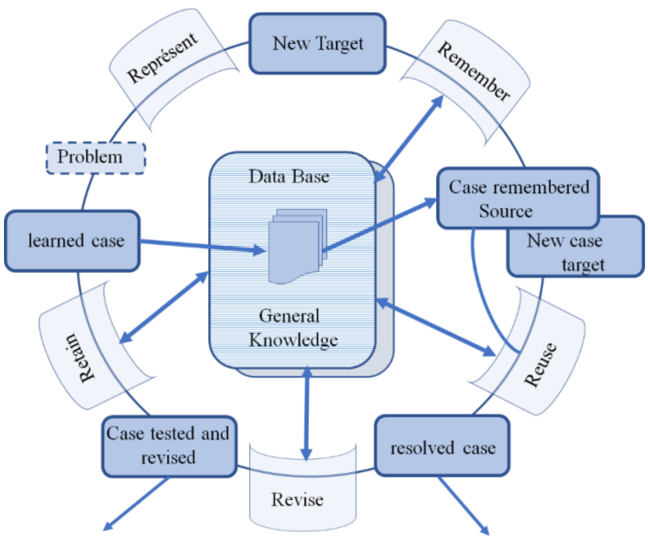

Figure 2: The R5 CBR Cycle (Veloso et al, 94)

Several strategies and mechanisms are proposed in the literature to meet the needs of each step. We are interested here in the phase of similarity research. It should be noted, however, that even though the CBR is capable of developing knowledge-based systems that work rather well and that have achieved significant industrial success (Jabrouni, et al., 09), its engineering remains a difficult problem.Thus, even though it has many qualities, CBR is not really a knowledge-based system that "learns to solve problems by solving problems" because it cannot dynamically evolve its own representation of experiences. Three main causes for this limitation are proposed in (Bernard, 07): a case model "too well structured and therefore too constrained", paradox of "frozen knowledge that evolves" and reducing hypothesis of "it's good for me now so what will always be good for everyone."

As for the effectiveness of Case-based reasoning approach(CBR), its proven effectiveness in the management of knowledge and especially in the field of industrial maintenance encourages us to use it in our work.

2.3 Presentation of the Knowledge Base

The Knowledge Base, inspired by the CBR, is represented in the model in Figure 3. The ST is required, in the diagnostic phase of a breakdown, to use the following sub-model and under the control of the supervisor. Thus, to encourage learning in each problem-solving activity, he or she always tries to find similar situations in this knowledge base and then adapt them to the new situation.

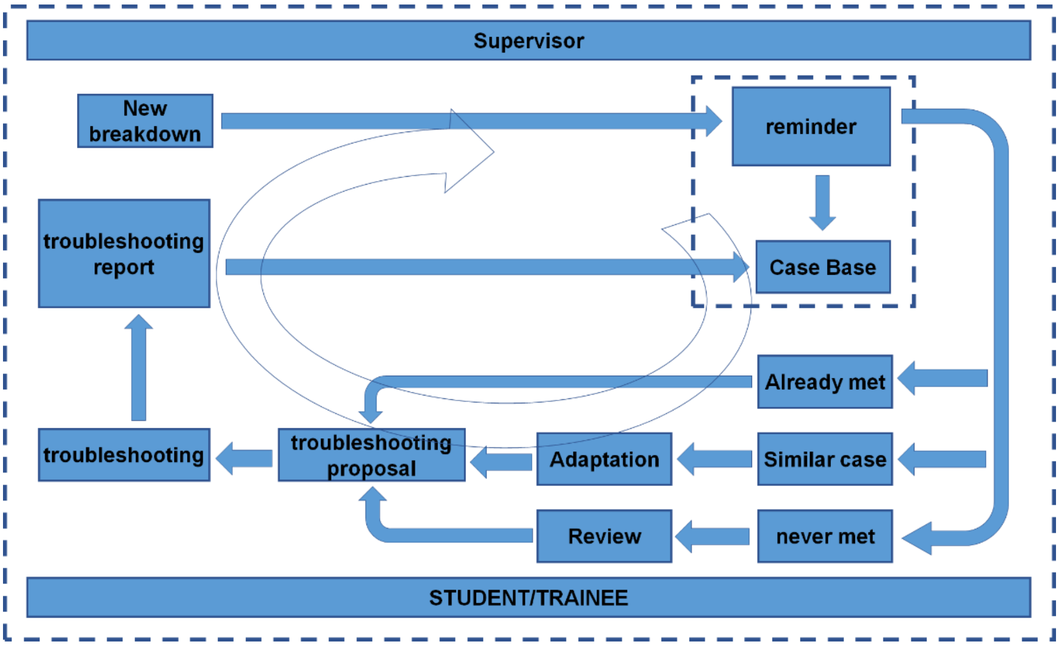

Figure 3: Finding information in the case base (I Gueye, 18)

2.4 The case base

A case is a specific problem that has been identified, solved, stored and indexed in a memory with its solution, and possibly the process of obtaining it. The case base is the set of system cases, these are given by the user in our system.
In the retrieval phase, we will search, from the description of the problem, all the previous cases that can help to solve the failure of a system. It is a search for knowledge that will be done in the case base.It is essentially a set of knowledge reconstruction operations that extracts the knowledge needed to solve the system failure. This phase of recalling similar cases essentially depends on the representation of cases, the structure of the case base, similarity measures and the accuracy of the expected response.This similarity measure looks for correspondence between the problem descriptors of the source cases (case base) and those of the target case (new cases). The purpose of these similarity measures is to find in the case base, the case similar to the current problem in the sense that it is easily adaptable to this new problem. When a problem is identified and matched with a well-standardized description, the remembrance module launches the algorithm to look for similar models in the case base.

In our system, we used the Levenshtein algorithm (Levenshtein, 66) to estimate the percentage of similarity between the source case and the target case.

2.5 Principle of the Levenshtein algorithm

This commonly called Levenshtein distance algorithm measures the degree of similarity between two strings. It is equal to the minimum number of characters that must be deleted, inserted or replaced to go from one channel to another. It is a distance in the mathematical sense of the term, so in particular it is a positive or zero number, and two strings are identical if and only if their distance is zero.

The algorithm verifies the properties of symmetry, and the triangular inequality of the geometry. We used this algorithm to perform the application on Digital Solver which allows us to look for similar cases in the case base. This similarity search algorithm is implemented in a Solver which contains all the reports of the maintenance activities carried out by the trainees during their internship program. This workbook is therefore evolutionary and will represent the case base.

Using an example (see Figure 4), in search of a case in the case base, the code of the failed machine is AC341, the nature of the failure declared is a faulty thermal relay ("burnt"). We see here that the search gave a score of 100%. So in the case base we find that the same machine broke down on April 12, 2015for this same problem.

Please enter your search here

CODE	DECLARED FAILURE		
AC341	thermal relay burnt	xxxxxxx	

CODE	DIAGNOSTIC PANEL	SCORE	DATE	CR Document
AC341	thermal relay burnt	score (100,00%)	April 12, 2015	
EC212	contactor KM1 out of service score	score (16,30%)	April 13, 2015	
LC105	PLC fault		April 14, 2015	
DC215	bearing burst		April 15, 2015	
RC311	lack of lubrication		April 16, 2015	
AC345	thermal relay burnt	score (80,00%)	April 17, 2015	
EC212	contactor KM1 out of service	score (16,30%)	April 18, 2015	
TC514	disjunctor out of order		April 19, 2015	
KC111	defect of the tree to cock		April 20, 2015	
RC322	voltage drop fault		April 21, 2015	
EC212	contactor KM1 out of service	score (16,30%)	April 22, 2015	
RC311	lack of lubrication		April 23, 2015	
RC312	lack of lubrication		April 24, 2015	

Figure 4: Similarity search in the case base (I Gueye, 18)

This phase of determining similarity leads us to three possibilities:

Case never met: percentage 0%

We are facing an unknown situation. For its resolution, we propose the following generic diagnostic methodology, usable in various fields of application (G Paquette, 02). It consists of five principles that controls four diagnostic sub-procedures. It allows generating and testing one by one, and systematically, the various components of the target system.

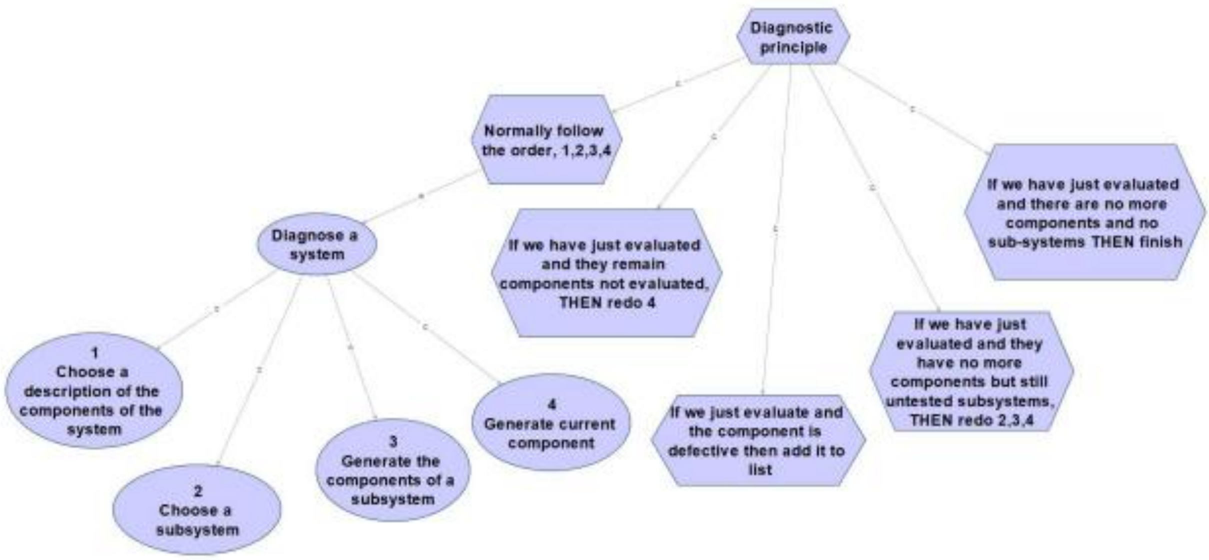

Figure 5: Generic diagnostic methodology. (G Paquette, 02)

Similar cases: percentage 80%

According to the percentage of similarity between the source case and the target case (80% for our system), we will propose an adaptation strategy which consists of finding a solution to the new problem from the solutions belonging to the recalled source cases (Lopez de Mantaras et al., 05).This phase can be done either through human intervention (manual) or automatically using algorithms, methods, formulas, rules, etc. In our case, given the importance of ST attachments in the maintenance activity, we recommend for this phase a manual intervention for this adaptation process. This adaptation phase consists in transforming the source solutions (Sol (source)) into an appropriate solution Sol (target) and we propose the resolution process below.

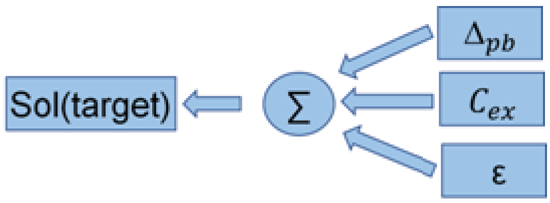

Figure 6: Problem-solving approach for a case similar to 80%

Δpb: Contains all information about links between source and target problems

C_{ex}: The set of experiential knowledge that the internship master is able to mobilize for the resolution of the target case

ε: the experiential knowledge of the trainee

Information on the links between source and target problems (Δpb) is obtained from the case base. To obtain this information, run a similarity search between a target case and a source case. Once the similarity search algorithm has found one or more similar cases, all Maintenance Reports related to this similar case are retrieved through the links. It is enough to study these documents to retrieve the Δpb and this synthesis work will be done by the ST. The goal is to help the ST develop capabilities to identify and classify the characteristics and dimensions of a problem, then compare the elements of the problem and finally find the relations between them.

To implement the experiential knowledge in this relationship we will rely on the theory of socialization and externalization of knowledge (Nonaka and Takeuchi, 95).

Cases already met: percentage 100%

In this phase, the target solution is located at 100% in the case base, as long as a problem resolution troubleshooting report exists. The difficulty here therefore is how to solve the new problem from an earlier solution. This phase will allow us to encourage metacognitive activities by the ST to better promote his or her autonomy.

This will entail getting him or her to understand, use, and master the problem-solving process by relying on the source case solution. By becoming more autonomous, the ST will develop self-management skills of learning that will be used throughout his life (Belmont, Butterfield and Ferretti, 82). Although we favor the autonomy of the ST supervision of each of his or her activities is always done by the supervisor who is the expert of the field, one who has the experiential knowledge that we wish to implement for the resolution of the target case.

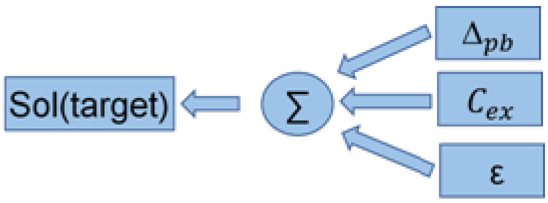

Figure 7: Problem-solving approach for a 100% similar case

3. Knowledge Base Document: The Report

In order for the document to be transferred to the knowledge base, we will use the technique of trying to access the subjective experience of the ST during the maintenance activity (this experience includes the sensory and the emotional, the thought and gestures not yet conscious). This necessarily involves verbal reporting of each of his or her maintenance activity during the internship. This developed technique facilitates the expression of the internalized knowledge and attempts to access the subjective experience of the subject (Buysse, Vanhulle, 09), (Huard, 10), (Mouchet et al., 11), (Vermersch, 06) using the method of posteriori verbalization of the action (Theureau, 92) cited by (Leroy, 11). Therefore, after each maintenance activity, the ST will be given the opportunity to comment on his or her performance. This report will allow the ST to reflect on the activity carried out.

After the verbal reflection, a written report and an oral presentation of the report must be made to the supervisor. These forms of report after each maintenance activity gives a good reflection on the experience gained during the internship program.

(Garcia, 12) addresses this methodology as one that allows a person to be "…aware of one's lived experiences at one's disposal". The interaction with the adult "internship supervisor" appears to be the driving force behind the development of thought, which becomes autonomous at the end of the process of internalization. (Lefeuvre et al, 09) insists on the relevance of discussing his experience and having a reflective approach to professional situations to produce knowledge.

The report will be a means of communication to highlight the mastery of the progress of the maintenance activity from the beginning to end. The whole process, from the analysis to the resolution of the problem, will be told and formalized as an articulated story. The style of narration will be borrowed from Patriottta who has in one of his articles described the verbalization of a subject as a double structure of police stories:first, the description of the problem to be solved (by analogy with the crime) and then the description of the analysis and diagnosis process leading to the solution (by analogy with the police investigation). He considers that this intriguing storyline and this double structuring make it possible to bring out and share the tacit knowledge (Patriotta, 03).This report will be transferred to the knowledge base where a keyword search will find it when needed. The storage of a new case therefore enriches the case base and contributes to increasing the experience of the system (Haouchine, 09).

Thus, the case base evolves as new cases are added with the aim of taking into account the new solutions found and the way cases have been solved. In all cases, we require, for a faithful reproduction of the progress of the maintenance activity, that the intervention report include the items described in figure 8.

Figure 8: The elements that make up the Student/Trainee Maintenance Record

4. Conclusion

In this article, we have presented the Knowledge Base in a general way. Our main concern was to allow an ST to be comfortable in a maintenance pool in the industrial company during intervention activities. Indeed the tool presented allows him to have at his disposal an explicit documentation of the maintenance activities and the processes involved. In this process, we relied on the theoretical basis of the CBR study. The proposed strategy is a production by the ST of a report of the maintenance activity and work done with his or her supervisor. The explanatory interview with his master internship, from the evocation of one or more reference experiences allows the emergence of awareness promoting the appropriation of experience as a basis of knowledge.This knowledge base is intended for all students of a given section of the CFPT who will be on probation in this company. It must be updated after each maintenance activity by the ST.

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