Applying a knowledge management modeling tool for manufacturing vision (MV) development

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Keywords

Knowledge management, Manufacturing industries, Decision making

Abstract

This paper introduces an empirical application of an experimental model for knowledge management within an organization, namely a case-based reasoning model for manufacturing vision development (CBRM). The model integrates the development process of manufacturing vision with the methodology of case-based reasoning. This paper briefly describes the model's theoretical fundamentals and its conceptual structure; conducts a detailed introduction of the critical elements within the model; exhibits a real world application of the model; and summarizes the review of the model through academia and practice. Finds that the CBRM is supportive to the decision-making process of applying and augmenting organizational knowledge. It provides a new angle to tackle strategic management issues within the manufacturing system of a business operation. Explores a new proposition within strategic manufacturing management by enriching and extending the concept of MV while trying to lead the CBR methodology into a new domain by applying it in strategic management.

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Industrial Management & Data Systems
Volume 104 · Number 9 · 2004 · pp. 735-743
© Emerald Group Publishing Limited · ISSN 0263-5577
DOI 10.1108/02635570410567720

Introduction

Globalized competition and volatile market environment are the significant characteristics of the contemporary economic situation that provides both the challenges and opportunities to the enterprises (Beckett *et al.*, 2000; Nemati and Barko, 2003). Under such a condition, it is a prerequisite to have a proactive corporate strategy for an enterprise's continuous development and healthy survival. However, it is only when the corporate strategy is translated into tactical activity patterns that lead to the daily routine work that the corporate general targets can eventually be achieved. Among the fields that need a translation to link to the corporate strategy, manufacturing is the one that should receive more attention. Although manufacturing is considered by many to be the "necessary devil", it is in fact one of the most important cornerstones of an enterprise. Many researchers have noted this, among them, Skinner could be one of the pioneers, according to him, an enterprise's manufacturing functions as a very strong cornerstone supporting to achieve the competitive advantage; the relationship between the success of a corporate and the effectiveness and efficiency of its manufacturing system is very significant and critical (Skinner, 1969, p. 136).

Manufacturing is an important field, its essential meaningfulness to a business makes it a fundamental function assuring an enterprise's success and a critical part that should be understood clearly by an organization; it is vital that manufacturing plays an active role in a corporate strategy formulation if the manufacturing enterprises desire to hold a sustained development (Brown, 1996; Hill, 1996).

However, how to connect the manufacturing function and the corporate strategy is a key question. To answer this question, one approach, manufacturing vision (MV) emerges. As a relatively new concept within the strategic management field, MV has its special flare to shed light on some unwillingly touched aspects of a business – the manufacturing system development and improvement. Hopefully, it will help to turn the "necessary devil" of the role of manufacturing within a business to an "indispensable angel". Of course, it is not an easy task.

MV is espoused by several researchers within recent years. There are two representative definitions on MV from Riis and Johansen (2001)

The authors extend their appreciation to the individuals who attended the group sessions for reviewing the elements of the model and in the real world sessions for applying the model, in Denmark and the USA, for their constructive comments and active participation.

and Maslen and Platts (1997). These two definitions view the same entity from different angles. Inspired by their definitions, we would like to describe MV in this way: it is both a concept and a process; by developing an MV, people will understand and create a holistic, organization-wide shared blueprint and activity patterns to improve and maintain an enterprise's manufacturing competence to assure its continuous development and future prosperity.

As a new concept, the practical, effective and efficient development of MV still needs a significant research effort. In order to better facilitate the MV creation process, we launched a research project targeting the development of an experimental model. The model is based on the understanding and integration of MV and case-based reasoning (CBR) methodology.

CBR is also a quite new branch within the artificial intelligence (AI) field. It is a methodology to support human reasoning (Bergmann, 1998) by using the relevant previous knowledge that is stored in an entity called a case in a CBR system. CBR is excellent at dealing with open-ended real world problems, such as MV development, with the tenet that for present problems it is always possible to find some previous similar ones, and naturally, the solutions for the former ones could be used to tackle the new problems (adapted from Leake, 1996). Perhaps, the proverb "history repeats itself" captures the CBR concept.

Within our research, the CBR methodology supported MV development model is termed the CBRM (Figure 1) that is a creative application of the CBR methodology. Until now, the authors have not found any literature regarding CBR applied to the strategy category of a manufacturing system. Although there are some real world applications of CBR focusing on maintenance trouble-shooting, etc. these are all concentrated on the sub-fields of a manufacturing decision area. The details about the CBRM as well as MV and CBR methodology are provided in Wang *et al.* (2003a).

This paper focuses on the empirical application of the CBRM in practice. The important factors affecting the effectiveness of the model's application include the cases' structure and contents, the integration of the procedural and content elements of the model, and the situation of the case company. In the next sections, we introduce the knowledge containers – cases within the CBRM and their representation formats and contents. Then the functionality of the model in generating solution possibilities as well as its review in academic circles is briefly described. Also, a real world application of the CBRM in a case company is illustrated. Conclusions and future research finalize the paper.

The cases and case base in the CBRM

Information and knowledge are becoming the most critical elements for an enterprise's competitiveness (Paiva *et al.*, 2002). But they need certain types of containers to hold them for retention and reuse. A case is just this kind of entity.

A case involves the storage of knowledge and information, and acts as a kind of organizational shared knowledge asset. It is the fundamental unit of a CBR system. Without cases, CBR cannot function in any domain. The case base is the collection of cases, and the cases are arranged using a certain representation structure into a case base (see the next sections).

Within the CBRM, for effective knowledge representation and application, we categorize two types of cases – a general supportive case and an event case. These two types of cases are complementary to one another, and compose the entire case base of the model, to fulfill the tasks for knowledge vending and augmentation. The case base's scope and scale could be flexible corresponding to the practical situation of the CBRM's application. The following sub-sections introduce the two types of cases regarding their contents, structure and interaction when functioning.

General supportive case (GSC)

A general supportive case (GSC) normally consists of the extracted or abstracted practices, techniques or methods that are used to fulfill the determined target/s within a large range of industrial circumstances. The contents of a GSC are widely tested and proven to be good approaches, so called "best practices" in some literatures. These approaches are globally applicable, i.e. they can be used in any similar industrial organizations without much change of the contents and the application form. These approaches could be directly integrated into a new MV to deal with a similar current situation.

The description structure of a GSC consists of four parts:

(1) Title, indicating the general contribution of the case.
(2) The problems and/or the environment description for the "best practices".
(3) The description of certain best practices.
(4) The consequences of using the best practices when available, and the ways to apply them.

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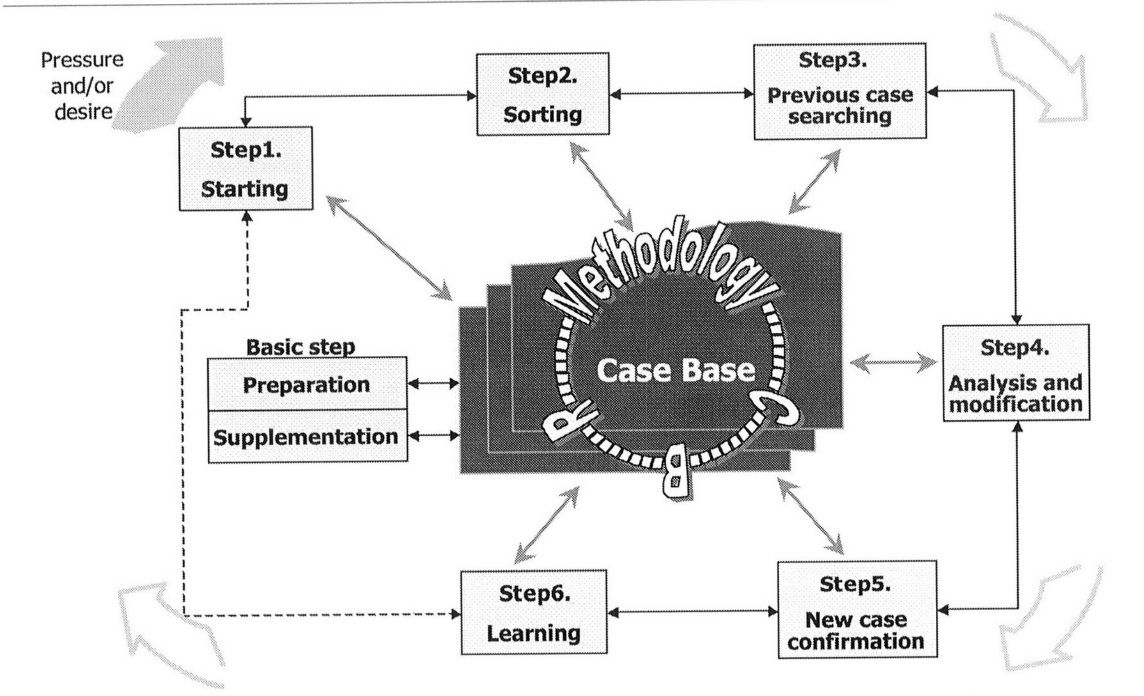
Figure 1 Conceptual structure for the CBR model for MV development (CBRM)



The resources for obtaining the GSCs are mainly the literature containing the generalized proven good practices/techniques from empirical study, and the "best practices" from books concerned with manufacturing and management or any related discipline. In order to achieve the effective and efficient reading and understanding by the practitioners, we have designed a standardized format for all the GSCs. Figure 2 provides an example.

Event case (EC)

An event case (EC) consists of the information regarding the real-world comprehensive, concrete strategic and tactical activities performed by organizations to deal with their weakness, to improve competence, to enhance their strength,

Figure 2 Example structure/contents of a GSC

Training methods in famous companies

1. **Strategic target**
   - Providing the most productive training for supporting employees' competence improvement
2. **Focused Problem/activities**
   - Training arrangement and focused points
3. **Strategic approaches**
   - Continuous training for all level employees ……
   - Introduction training for new employees lasting for ……
   - On job training ……, both on and off the line
   - ……

Outcome:
   - Upgraded skill
   - Achievement both for the employees and the organization

etc. It contains the individualized information of a certain enterprise. An EC has more focused areas than a GSC does, and a combination of different targets to achieve and problems to cope with.

The structural components of an EC normally are the following:

- case profile – indicating the key points the case is tackling and sometimes, the industry segments the source case originated in;
- the problem situation description – including the present problems faced by the firm and/or the future targets to achieve;
- the solutions – including the countermeasures to deal with the problems in a long-term strategic view and the means to achieve the future targets;
- the outcome or anticipated outcome – by implementing the case solution, if possible; and
- the action plan – to implement the strategies, when available.

It is obvious that the content of an EC is larger and is also more complicated regarding the structure when compared with a GSC. The standardized EC structure and contents are shown as Figure 3.

The ECs normally are acquired from real world case reports, the literature, and the cases conducted by the authors and the other research colleagues through either case study and/or "action research". Also, a few cases from books regarding manufacturing or production/operations management are included.

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Figure 3 Example structure/components of an EC

Case Company XYZ

1. **Company profile:**
- Manufacturing
- Employees 2500
- ...

2. **Company facing problems:**

General
- ......

------Hard factors---------

Issues on process-product related
- New products were easily 'copied' by competitors, product life cycle is short
- ......

Issues on quality:
- Quality management needs to improve to assure continuous perfection

......

------Soft factors---------

......

3. **Company targets to achieve**

......

4. **Manufacturing strategic approaches**

------Hard factors------

Issues on product related:
- Product differentiation, set up a research department to create differentiated products; Cooperation with customers......

Issues on Quality:
- Quality circle: quality circle was partly voluntary and partly assigned. Each circle has ......

The relationship between GSC and EC

Considering both the structure and contents, GSCs and ECs are not the same, the major differences between a GSC and an EC are: a GSC contains globally applicable knowledge that can be functional in any similar industrial circumstance; while an EC is substantially proven exactly suitable for a certain enterprise, if another organization wants to implement it, normally an adaptation is necessary to make it suitable to support the new situation. Typically, a GSC has far less content than an EC does, and is more focused on a certain field, sometime even a sub-field within a manufacturing decision area.

As previously mentioned, this research focuses on creating the CBRM to accommodate the productive running of an MV development process, by effectively collecting and efficiently using the experts' experiences and expertise and the general domain knowledge in the concerned areas that are recorded in the forms of GSC and/or EC, obtained from both industrial segments and academia.

The GSCs and ECs within the case base of the CBRM are complementary to one another. According to the model's performance procedure, a GSC will be first used to help with the idea generation and problems identification, then an EC will be considered when dealing with a determined problem or target. Meanwhile, when a problem cannot find its solutions from the ECs, or the solutions are not so satisfying, the GSCs will be consulted for answers or inspirations along with the participants' general domain knowledge. The generated results from using ECs/GSCs/domain knowledge are called "solution possibilities" due to the non-unique character of the solutions for real world, open-ended problems.

Solution possibilities generation on the CBRM platform

In our research, we refer to the solutions within a created MV as "possibilities". Since the MV problems are so complicated that though (a) retrieved case(s) will definitely provide the information for generating the solutions to cope with the new situation, it is quite plausible that they are not the only answers, and there could be some other possible answers, i.e. the case solutions we use are only one set of possible options, there could be some other alternatives. The contents of the solution possibilities are blends of the countermeasures regarding all the relevant elements to a certain circumstance within a manufacturing system. This is confirmed by the contention from Wild *et al.* (2002) that knowledge management is concerned with the application of the collective knowledge.

Generally, the CBRM is a structured platform, supported by computer programs to encapsulate the whole cycle of knowledge acquisition, information retrieval and application, knowledge creation and augmentation, in the process of an MV's generation. The solution possibilities are the products from running this platform.

As shown in Figure 1, the CBRM has seven steps. Except the basic steps, the other six steps comprise the routine procedure of the model. Here is the simple description on the functionality of the seven steps:

(1) Basic step – preparation and supplementation, this step involves adding cases into the case base.
(2) Step 1 – information pooling, is to gather the ideas from the participants.
(3) Step 2 – sorting, is to concretize, generalize and prioritize the ideas, and to extract the information for applying in the software for case searching.
(4) Step 3 – previous case searching, is to find the similar cases for the creation of possible solutions.

(5) Step 4 – analysis and modification, is to formulate the solution possibilities based on the information from the last step.
(6) Step 5 – confirmation, is to verify the created solution possibilities for their practical goodness.
(7) Step 6 – learning, is to retain the confirmed new case into the case base for knowledge augmentation and application.

Accordingly, the application of the CBRM could be clustered into four main phases. The first phase corresponds to the step 1 in the model's procedural structure and a part of step 2 that focus on idea generation and categorization as well as prioritization. In this part, the CBRM provides three programmed tables to facilitate the idea generation, sorting and prioritizing work. For the idea generation, we designed a systematic inspiration walk-through process (SIWAP), by following a set of inspiring questions to support the process. SIWAP is based on the indexing vocabulary (Wang *et al.*, 2003b) of the CBRM. The idea sorting is obtained by using brainstorming or the modified nominal group technique (MNGT) (Wang, 2003) to select and clarify the ideas espoused by the participants. All the selected ideas are recorded into the information pooling table for the next step's prioritization. The prioritization is performed by assigning the scores to each selected idea, and then the ideas will be automatically prioritized in a set of charts. By ideas, we refer to the current problems to solve and the future targets to achieve, they appear in the form of situational descriptions in natural language. This phase is illustrated in Figure 4.

The second phase consists of another part of step 2 and step 3 of the CBRM. In this phase, first, the problems or targets are indexed according to the indexing vocabulary of the CBRM into a set of feature-value pairs (Watson, 1997) description. Second, the feature-values pairs are input into the Intellix Designer 4.1[1], which is a tool supporting information retrieval and retention. By running the software, the previous similar case is retrieved for suggesting solution possibilities. Third, the retrieved case is analyzed for selecting the needed information to conduct the solution possibilities' development in next phase. See Figure 5 as an example.

The third phase includes steps 4 and 5. In these two steps, the most important portion of a new MV is created and verified. This phase is performed by using expert adaptation and expert evaluation approaches, details seen in (Wang *et al.*, 2003a).

The last phase includes only step 6, learning. In this step, the whole new MV case is formulated by combining the problem description and solution description, and is ready for real world application. Then, by following the indexing vocabulary, the confirmed solution parts are indexed, and combined with the indexes for the problem parts in step 2; then both the case and its indexes are stored in the case base for further knowledge application and creation.

Review of the CBRM within academic circles

Before the model may be used in real world applications, we tested and reviewed the model within academic circles in both the USA and Denmark. The reviewing group is composed of individuals who have both theoretical and empirical backgrounds.

The review focused on three critical elements of the CBRM: the indexing vocabulary, the expert adaptation approach, and the expert evaluation approach. The other elements of the model are designed to be reviewed in the case company, since due to their functionality, it is easier to test them in practice. Of course, these three elements tested within academia will also be tested again in practice.

To review the indexing vocabulary, we selected graduate and undergraduate students with various backgrounds. Some of the students have a very deep knowledge both in theories and practice; some of them only have the theoretical knowledge. The aim is to combine the various types of participants to check the applicability of the indexing vocabulary by viewing it from different angles, to make sure it is usable for different users to index the knowledge at hand. The testing index work is performed by providing the participants with a hypothetical case story, and by asking them to index the information using the items in the indexing vocabulary. After indexing the same case story, we input the indexes of the different participants to the model to retrieve the previous cases, and to compare the retrieval effectiveness. The results show that the vocabulary is workable; of course, there is a need to refine some contents of the vocabulary.

For testing the expert adaptation approach and expert evaluation approach, we designed two focus groups, in Denmark and the USA, respectively. These two approaches were tested together within the same sessions. The participants of these testing sessions are either the Master students at their graduation stage with a lot of practical operation knowledge of an enterprise, or the students re-entering the university after some years of practical working in the relevant fields.

We held two sessions for testing and reviewing the two approaches, and each took about half a day. The case contents were the same as we used

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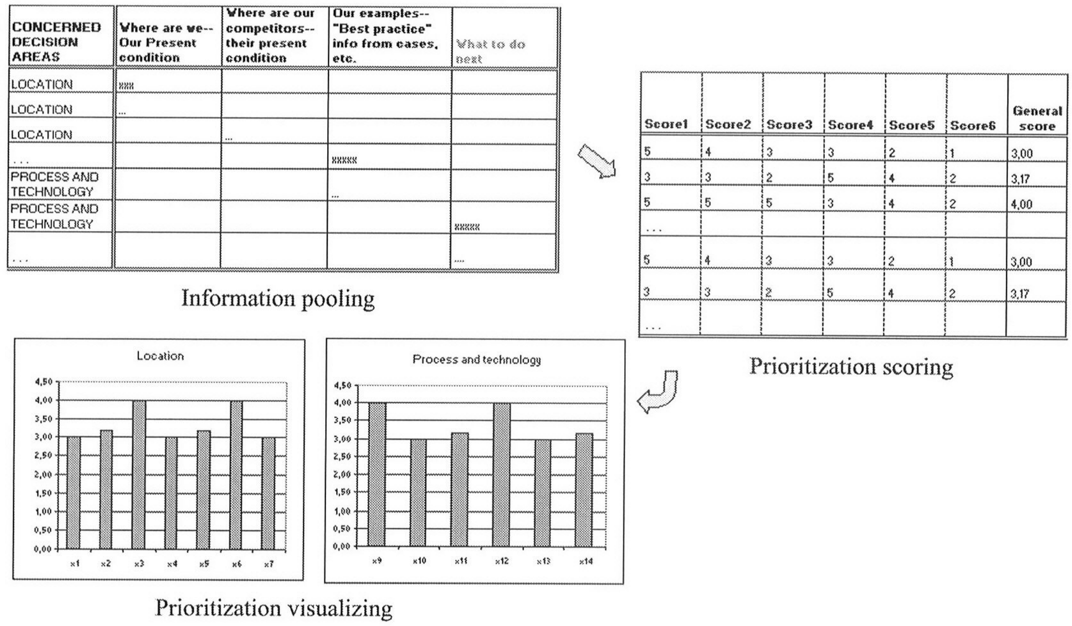
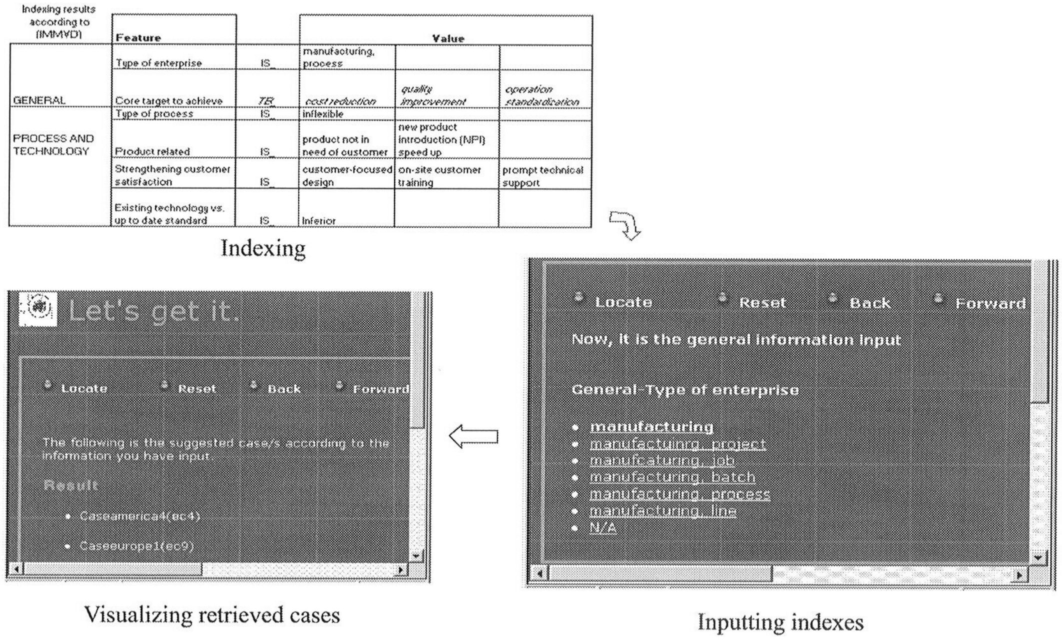
Figure 4 Process flow example of phase 1 of the CBRM



for the index vocabulary testing. The group session in Denmark was held first, and focused mainly on the expert adaptation approach. From this session, an MV dealing with the case's problems was created. Then in the USA, we conducted another group session that focused mainly on the expert evaluation approach. The composition of the participants in this group session is in accordance with what we designed for the application concept of expert evaluation, that is, it is better to invite outside participants to make the verification to minimize bias. The outcome from the expert evaluation session in the USA is quite supportive of the MV solution created in Denmark, though the participants of the two groups have obvious different cultural backgrounds, i.e. the group in Denmark are only Danish Master students, the group in the USA is composed of both American

Figure 5 Flow chart example of phase 2 of the CBRM



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and international Master students. The feedback from the participants regarding the effectiveness and efficiency of the model is very positive. We used a 5-point scale to assess the two approaches: 5 = Strongly yes; 4 = Yes; 3 = Neutral; 2 = No; 1 = Strongly no. The average score is more than 4, regarding the question that the two approaches are effective and efficient in supporting the decision-making process for an MV creation.

With the result achieved so far, we have the conviction that the experimental model is theoretically sound. The next step involves applying the model in the real world to evaluate its performance.

We selected a case company from several alternatives to apply this model; the major aims are to formulate a MV supporting the company and also to discover points for model refinement and its practical potential.

Applying the CBRM in case company Alpha

In this section, we introduce case company Alpha, in which the CBRM has been applied; the methodology of applying the model in company Alpha; and the reflections of applying the model.

Case company Alpha

Company Alpha is a leading figure in the consumer products segment. It has been established for around 50 years. The company developed very fast since its foundation, and has extended its operations from a local small business to a multi-national enterprise. Nevertheless, there are still some weak points existing in this company that slow and inhibit its continuous development.

The general background of the company is that the company's operations involve manufacturing process combined with retail operations to link the company close to the customers, and meanwhile to provide the company with competitive strength; it is a multi-national company, with several facilities located in different countries with retail shops in different locations near the customers geographically.

Methodology of applying the model in company Alpha

The methodology of applying the CBRM in the company is divided into three parts that are not exactly the same as what was done in the academic reviewing to accommodate the stringent schedule of the company.

First, a concept introduction and involvement initiation session is held, with the aim of debriefing the model and its underlying concept to the company, as well as the process and contents in the model. The purpose is to inform the company how the model can assist them to improve their manufacturing system, and to arouse their interests. A concrete schedule for conducting the sessions for running the model for creating a MV dealing with their problems is established. Second, a session to fulfill the steps of idea generation and prioritization is conducted, to determine the problems to solve and the targets to achieve. After this session, the problem information is indexed and the previous cases are retrieved. Expert adaptation may be used at this point to formulate the solution possibilities of the MV. Third, in the next session, expert evaluation is used to verify the solution possibilities of the MV; and, feedback from the personnel in the company for refinement opinions on the model is solicited.

Summaries of the model application

We conducted group sessions with participants from companies and universities, according to the aforementioned methodology. We have identified several important issues to be addressed. After the prioritization of the identified issues, we have decided that the key problems faced by the company are: inventory control within the company lacks a systematic tool; the order fulfillment from the suppliers is far from satisfied; safety problem within the shop floor still needs to be improved. Then these areas are set as the key targets to be dealt with in this MV, i.e. the targets to achieve are to reduce the inventory, to increase the suppliers' order fulfillment rate, and to decrease the safety problems.

By following the model's process, we created solution possibilities to deal with these problems/to achieve the targets. During the previous case retrieval phase, the model first attempted to identify some relevant ECs. In this case base we found two most relevant cases; from them, we identified some modules that could be used for solution possibilities after adaptation. However, these cases were insufficient to solve the problems, so we identified some GSCs for inspiration, and supplemented these with general domain knowledge. After several iterations, the primary solution part of the MV was generated.

In the session to evaluate the applicability of the solution possibilities, we used the strategic process audit (SPA) (Wang *et al.*, 2003a) to verify their goodness. SPA appears in the form of a kind of walkthrough question list, which helps the participants assess the concerned points by asking the relevant questions regarding their applicability.

The finalized MV solution possibilities from the model application are exhibited in the Appendix.

After the sessions, the general comments from the company is that the model is a potentially useful management tool, while the contents of the MV solution possibilities need more detail for practitioners who do not have extensive theoretical background of some techniques or tools. This observation is contrary to our concept at the beginning, i.e. in order to reduce the size of a case, the description of the methods within the solution are intentionally more generalized and abstracted.

Conclusions and future research

After reviewing the model in academia and a real world case company, the effectiveness of CBRM in supporting decision making regarding the manufacturing competence development and reinforcement is demonstrated. As a supportive tool, the CBRM provides a concept and a structured processing mechanism for organizational knowledge integration, sharing, and communication. Based on the CBRM platform, an enterprise could have the possibility of applying and augmenting the knowledge to the extent that it would create a competitive edge for the company to stay in the market place as a winner.

Considering the application of and the research on CBRM so far, additional research is needed, in order to make the model's process and content more enriched to serve the different users in practice:

- the refinement on the contents of the cases, to add more detailed information for the practitioners to follow when dealing with their circumstances;
- the refinement on the indexing vocabulary, to make it more distinctive regarding value description and arrangement; and
- further review of the modified model and its contents in new case companies within different industries, for further understanding of the model's application scope.

Note

1 Intellix Designer 4.1 is a product from Intellix A/S, H.C. Oersteds Vej 4, DK-1879 Frederiksberg, Denmark.

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Appendix. Partial MV extracted for case company Alpha

Target – to improve the order fulfillment from suppliers. Strategic approaches:

(1) Vertical integration on supplier side fully or partially, to monitor their production to increase the order fulfillment rate.
(2) The better choice is to make the supplier become better for order fulfillment. If cannot control the order fulfillment from the suppliers (incorrect material, lead time), maybe it is possible to control the company's internal ordering structure. The possible procedure could be as in Example 4.

Example 4. The procedure to control the company internal ordering process on raw materials regarding the low order fulfillment rate from suppliers:

(1) Make an analysis of the suppliers' supplying behavior, i.e. the most common quantity/composition of the supplied material items, lead times, find out the dispersion within a certain time period;
(2) Find out the dispersion of materials required for the company's final products within the same time period; and
(3) Based on the two groups of data, decide the economic ordering quantity and time horizon and interval for ordering each item, considering the safety stock level.

A simple analysis example: trends of supplied and demanded quantity (Figure A1).

By reading the trends of demand and supply, we can find the suppliers intend to supply at the beginning and the end of the year the higher volume, but the producer needs more at the middle of the year. Then the producer can make an ordering decision in advance that the major amount of the materials will be delivered at the beginning of the middle of the year, after gaining the lead time information by using the similar analysis method.

Figure A1 Trends of supply and demand

Season	1	2	3	4
Quantity of material supplied	2,000	300	400	1,200
Quantity of material needed	300	2,000	1,000	600