When talking about knowledge and how to capture, store and exploit it, kmowledge models are rarely mentioned. Here, Richard Miller explains where and how models can be used to deliver real improvements across many organizational functions.

MODEL–DRIVEN PROJECTS IN THE CHEMICAL INDUSTRY

Why using knowledge models is becoming more popular

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We all use models all the time. From the mental models that help us find our way home after shopping, to the mathematical models we use to work out interest and repayments on our debts. Models are part of our everyday life. Patrick Rivett, one of the founding fathers of operational research, said: "The whole history of man, even in his most non-scientific activities, shows that he is essentially a model-building animal."

Yet, when we're talking about knowledge and how to capture, store and exploit it, we rarely mention models as knowledge objects. There is plenty of discussion in the literature about models for different aspects of the KM process; plenty about models in the theory of KM, but little about their use as knowledge objects in their own right.

This is surprising because models can deliver real benefits everywhere from developing new products and reducing manufacturing costs to helping frontline support staff to solve customer problems.

Types of Models

There are many different types of models that help us to think about a subject, but the most interesting for practical KM are those that can help us to make better decisions. In this article I'll focus on models expressed as a series of mathematical relationships and made into a computer program that we can use to help us with our daily tasks – computer models.

There are two key types of computer models and two different ways we can use them. Some models are based on a detailed understanding of a system and the way its parts work together. These are called "prescriptive models." For example, because we understand how heat is transmitted and the properties of different building materials, we can design a building and know where the hot and cold spots will be, what size of heating system will be needed and how it will respond in different weather conditions. Because the model includes all the key physical relationships we can ask questions like "why is the kitchen always the warmest room?" and get a sensible answer.

The other type of model is based on the statistics of a large number of observations. There is no "understanding" of the system built into it. A credit rating model may be able to reliably tell you that a given set of customer circumstances represent an unacceptable credit risk, but there is nothing in the model that can tell you why that is so. Models based on underlying theory are like explicit knowledge and those based on statistical methods are like tacit knowledge.

Knowing what kind of model you are using is important. A statistical model breaks down very easily when pushed outside the boundaries of the original observations. In the credit rating example, if all your sample population were single professionals, trying to apply the model to married

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KEYPOINTS

- Knowledge models can provide real benefits everywhere from developing new products and reducing manufacturing costs to helping frontline support staff to solve customer problems.
- Models allow users to ask questions that are extremely difficult with other kinds of knowledge objects. At their best, models enable the user to make their ideas come alive.
- Your organization is probably using hundreds of models everday. Consider if they are being properly documented and maintained and how well they have been distributed.
- If you cannot see much evidence of models being used in your business you might be missing an opportunity.

manual workers with young children might not be very useful. Prescriptive models can be applied in a wider range of circumstances and it is more obvious when something is going wrong. They are harder to put together, but easier to update.

There are also two basic ways of using a model; for optimization or simulation. Optimization is the process of finding the best way to reach a defined goal. It's a search through what's possible to find the best outcome. In contrast, simulation is the process of modelling a real system to find out what will happen under certain circumstances. What will be the outcome given a particular set of conditions? Optimization asks the question "how do I best...?" and simulation the question "what happens if...?"

Many uses of models as knowledge objects involve both prescriptive and statistical models used for both optimization and simulation. Because many decisions need to be taken in conditions of limited and perhaps confusing information, models are often combined with the experience and judgement of the expert decision taker. Compared to other knowledge objects, models have some specific benefits:

- They encapsulate expert knowledge in a way that is extremely compact and transportable.
- They can be made much easier for the non-expert to use.
- They can be transferred from one knowledge domain to another and from business to business.
- They make excellent boundary objects for sharing knowledge across organizational boundaries.[1]
- A good model can spread knowledge through an organization allowing non-experts to access the expertise of the model builders.

Models allow users to ask questions that are extremely difficult with other kinds of knowledge objects. At their best, models enable the user to make their ideas come alive. A user can conduct experiments with the model that would be impractical, too costly or unethical in real life.

Models can be used in a variety of ways. One familiar example is in training. Flight simulators have been used for many years to allow pilots to experience and react to various rare but hazardous situations that would be too dangerous to reproduce in live flight. Simulators are now used to train everyone from paramedics to nuclear power plant technicians. Anywhere where cost and safety makes live training difficult.

Developing new products is another successful area of application of computer models. Drug designers test possible drug structures for fit with biological receptors and chemists design biodegradable detergents. In the automobile industry, crash performance is thoroughly tested in the computer before the final and expensive live test of a production car, as well as for the more mundane task of checking that all the engine components will fit into the space under the bonnet. Throughout the manufacturing industries, models allow designers to explore many more options before finalizing a product design and be more certain that a product will work as expected.

Service industries also use models in decision-making. Banks use statistical models to spot fraudulent transactions and to evaluate credit applications. Media services companies use models to decide how to allocate advertising spend across different channels. And customer support staff throughout business use models to help customers select the right product or to solve user problems.

Computer models in use

One example of the practical use of models as knowledge objects was their use to improve manufacturing processes by Unichema International, a company making specialist products from natural oils and fats. Unichema used a batch process to manufacture a range of industrial chemicals. A batch process is rather like a cooking recipe; ingredients are mixed together in a defined way at the start of the process and reacted together to produce the final product. To make more you simply make another batch. In contrast a continuous process makes a standard product all the time in a continuous flow. Continuous processes are good for making very large volumes of a small number of products, and batch processes are more often used to make smaller amounts of a wide range of related products.

Although Unichema had a great deal of experience in making these products, there were several areas where they wanted to improve. Chemical producers always want to make their processes more efficient. They want to use less energy and raw materials, produce less waste and

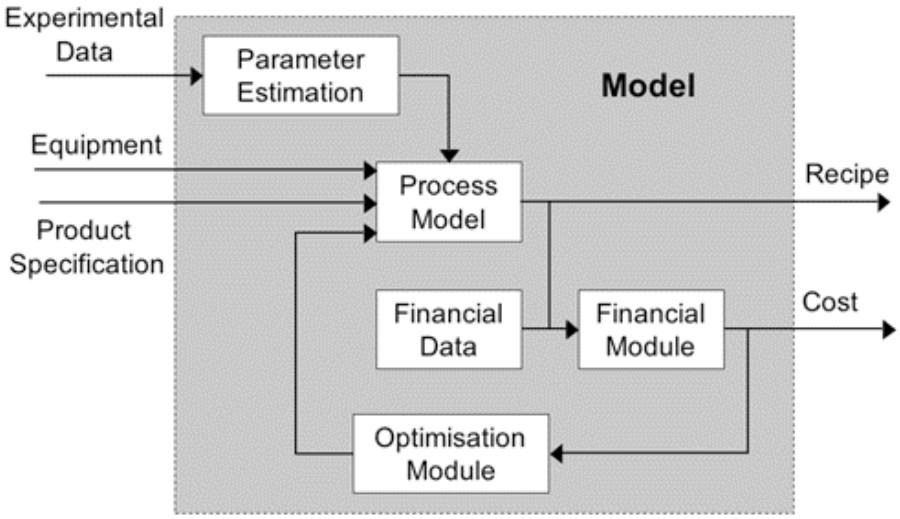

Figure 1. The Unichema knowledge model

Shows the main building blocks and information flows in the Unichema knowledge model. To optimize existing products, the user provides the product and specification and the equipment to be used in manufacturing. The process model calculates a recipe that will meet the specification, and the cost of this recipe is calculated in the financial module based on historical data.

make the products faster. For such a diverse range of products it was too costly and time consuming to make sure the process was optimized for each one. At the same time scaling up new products from laboratory experiments to full production was slow, expensive and uncertain; acting as a barrier to innovation. A further problem was that customers often wanted tailored grades of products to meet their specific needs and it was hard to be sure without a lot of trials what a different grade would cost to make and therefore what the selling price should be.

Unichema's solution was to develop a sophisticated process model that encapsulated all their knowledge and experience of making these products. Figure 1 (above), shows the main building blocks and information flows in the Unichema model.

To optimize existing products, the user provides the product and specification and the equipment to be used in manufacturing. The process model calculates a recipe that will meet the specification, and the cost of this recipe is calculated in the financial module based on historical data. An optimization module takes the output from the financial module and changes the recipe to minimize the cost of manufacture. The output is the lowest cost recipe to deliver the desired product. A range of nearly 200 products was optimized in this way. The main cost savings were in reducing the time to make the product – the batch cycle-time. The average saving in cycle-time was just over 40 percent. This is nearly equivalent to creating a duplicate factory out of thin air, and without any investment. It dramatically improved the economics of this manufacturing operation.

In the case of a new product, experimental data from the laboratory trials is also fed into the model. The parameter estimation module translates the data into the form needed by the process model allowing recipe calculations to be made on a new material. The optimization process works in the same way to give an optimized recipe. As a result a new product could be scaled up to full production in one step without the usual series of cautious trials, and with confidence that the process will work right first time.

Using models to mimic situations

As well as being used for optimization the model allowed "what-if?" simulation. Engineers could play with new equipment options and radical changes to the chemistry on the virtual plant in a way that would have been impossible in reality. From this they learned that they could halve the cycle time again with further investment in equipment. Combining this with standard business spreadsheet models for investment decisions they could decide whether it was worth installing the additional equipment.

The model even allowed the marketing department to get involved in manufacturing

decisions. Tailored product grades are a frequent request, but it is difficult to cost these properly. The model allowed marketing to find out the cost implications of variations in specification and so to price them properly. This meant that their conversations with customers were based on a much more solid understanding of what was feasible and what were the realistic options for meeting the customer's requirements.

These are just a few examples of the different ways in which Unichema used this model to offer a better customer service and to extract more value.

A much simpler (and publicly available) example of a simulation model is found at www.washpoint.com. Washpoint is a business within Linde Gas and AGA that provides the dry-cleaning industry with liquid CO_2 cleaning systems as an alternative to current petrochemical solvent systems. Liquid CO_2 is non-toxic and when used in dry-cleaning produces no hazardous waste or emissions. It also uses less energy and is a faster cleaning process. However, Washpoint need to sell these benefits to thousands of individual dry-cleaning operators and chains. Bringing new technology to fragmented markets is always difficult. Washpoint need to convince potential customers that the benefits make economic sense for their business, but cannot afford to have hundreds of people on the road looking at individual business cases.

Washpoint's solution was to provide an online calculator that allows a potential customer to model the costs and benefits of switching to liquid CO_2 cleaning for their own business. The expertise and knowledge of Washpoint's own engineers and accountants has been encapsulated in a way that can be readily used by customers to look at a range of different scenarios.

Similar methods are now widely used in the electrical and electronic equipment worlds to help sales professionals and customers to configure equipment for specific applications. There are so many different components that can be specified, and so many rules and constraints about which ones can be used in which situations, that it's almost impossible for any individual to understand and remember them all. Configuration models or "wizards" are used to help create a design that will meet the needs of the target application, and can be guaranteed to work as intended. These models save enormous amounts of time for the manufacturer's staff, and are essential in e-commerce environments where customers need to specify their own equipment.

Another area where models are in wide use is in scheduling. This is the process of sorting out the best order to carry out a number of tasks and how to distribute them among the available resources. It is used everywhere from computing, to manufacturing to logistics. It's a core competency of companies like FedEx and DHL.

Using models in the transport and oil industries

Sabre (www.sabreairlinesolutions.com) provides sophisticated modelling tools to allow airlines to allocate cargo across all their flights to optimize the revenue generated from the available cargo space. Small mistakes in scheduling can quickly result in an unprofitable business if they are repeated and the problem is too complicated for unaided human decision making. Instead, all the physical constraints together with everything that has been learned about cargo scheduling are loaded into the model and an optimum allocation calculated. A benefit of this approach is that deliveries can be re-scheduled very quickly if the circumstances change. If a plane is grounded or a priority delivery is suddenly required a new schedule can be calculated.

Similar methods are used in manufacturing. One company manufactured specialised catalysts for the oil industry. Manufacturing was complicated and demand was lumpy; orders were typically quite large and could come in at any time for any one of a range of products. They used a scheduling model to work out the best way to operate their plant given the orders on hand. This was sufficiently valuable and quick to use that the production schedule was re-calculated after each new order arrived to find the best way to satisfy the customers.

Consider the models in your organization

Computer models can be valuable knowledge objects and can be used in many different ways to support decision-making. You probably have many such models in use in your business. If so, ask yourself two questions; are these models being properly documented and maintained as knowledge objects, and have they been used to distribute the knowledge to all those who can benefit? The experts who build the models to help them make better decisions may not have considered the advantages of allowing others to use them as well.

If you cannot see much evidence of models being used in your business perhaps you are missing an opportunity. Models are compact, transferable, easy to use, and allow people to ask those two critical questions: "how do I best...?" and "what happens if...?" KM REVIEW

References

[1] *Creating boundary objects to aid knowledge transfer*, by Richard Miller, KM Review 8.2 May/June 2005.

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