# KEY FACTORS FOR SUCCESSFUL SHOP FLOOR KNOWLEDGE MANAGEMENT


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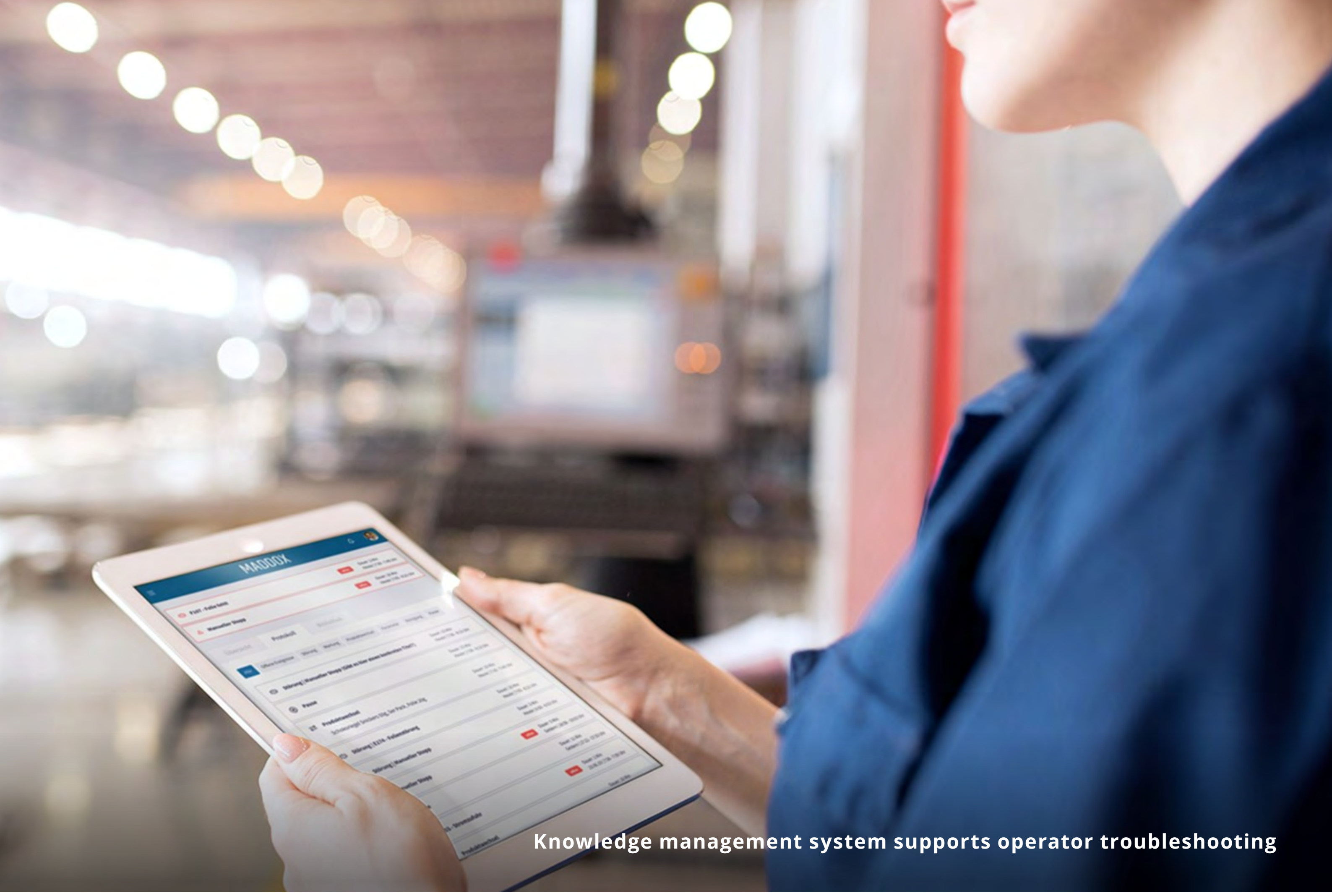
## THE IMPORTANCE OF EXPERIENTIAL KNOWLEDGE IN PRODUCTION

Natural products such as fiber based materials (paper, cardboard etc.) or food, often show large deviations in their properties, which can be hard to measure inline. However, these properties have a strong impact on the stability of production and packaging processes; just think of the importance of paper humidity. In many cases it is possible to adapt machine settings and process parameters such that the OEE (Overall Equipment Effectiveness) remains high even though the properties of the manufactured materials are changing. This is challenging because the changes need to be captured somehow and the right conclusions on the complex interrelations to the large set of process parameters need to be drawn. Surprisingly, humans can become especially good at this. They have advanced optical, acoustic, haptic and chemical “sensors” (eyes, ears, fingertips, nose), can handle incomplete and imprecise input fairly well and use heuristics to find good solutions in situations with complex boundary conditions. Throughout most industries, from pharmaceutical packaging to food processing to paper production, the OEE of production lines operated by skilled, experienced workers is 15% to 40% higher compared to novice operators (1,2). Consequently, the OEE potential of the production factor “skills & experience” outperforms most economically feasible technical improvements.

## CURRENT PROBLEMS OF KNOWLEDGE MANAGEMENT SYSTEMS

Current circumstances such as the current lack of skilled workers, high employee turnover, globalisation integrating plants around the world and shift work limit the availability of valuable knowledge. For this reason many companies are setting up knowledge management systems such as wikis, expert databases, troubleshooting guides, shift logs or simple MS Word documents to make knowledge available regardless of the availability of experts. Examples in which such systems thrive under real-life conditions over long periods of time are rare. The usual criticism is that users don’t feed the system with enough input; often followed by the conclusion that such approaches simply don’t work in production scenarios. But they do in other areas of life: Wikipedia has become the world’s most successful knowledge management system without any (e.g. monetary rewards) for contributors. Other examples are stackoverflow.com and topic-related forums like doityourself.com. This leads to the hypothesis that there are certain key success factors for such systems that are often missing in production environments. Based on seven years of practical experience and research projects with scientists from the Department


Knowledge management system supports operator troubleshooting

of Engineering Psychology and Applied Cognitive Research at the Dresden University of Technology we have identified the following key factors.

## KEY FACTORS FOR SUCCESSFUL KNOWLEDGE MANAGEMENT

### *TENDENCY OF ACCUMULATION*

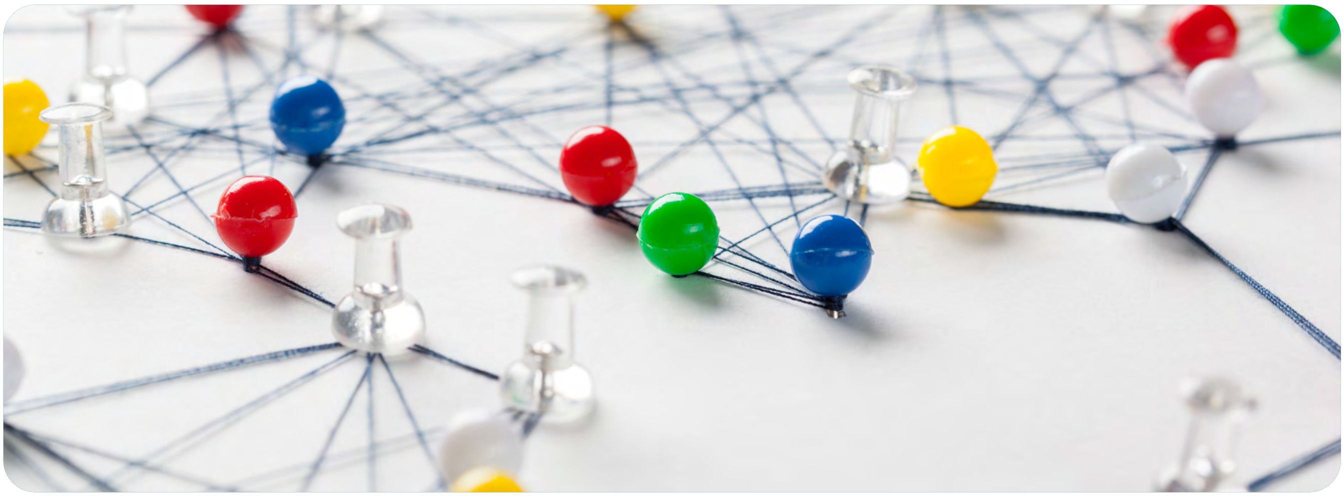
What is the second largest collaborative general encyclopedia after Wikipedia? Measured against Wikipedia's 6.67 billion monthly visits (3), there is de facto none. This makes perfect sense from the contributors' point of view: Sharing knowledge takes effort. You have to write texts, create images, etc. The "revenue" is a positive contribution to society and personal self-esteem. From an economic or game theory point of view, maximising the revenue for a given effort means publishing to the largest available audience. That is why the second platform is so unattractive.

So how can the knowledge management system become the most attractive information platform in the company (key factor one)? Getting to number one means overtaking the current number one. We interviewed more than 50 production workers and technicians from different companies with and without knowledge management systems to identify the current number one. Surprisingly, for almost all of the respondents, the best option was simply to ask experienced colleagues, even though they acknowledged the benefits of the knowledge management systems in place. This means that the benchmark is defined by the capabilities of human colleagues.

### *RELATION OF DATA, INFORMATION AND KNOWLEDGE*

A deeper understanding of the relevant human capabilities is necessary to define development goals for assistance systems. On the one hand, there is a social factor. Asking a colleague for help might lead to a little chat about the weekend, company news, and so on. This aspect is almost impossible to emulate meaningfully within technical systems. On the other hand there is the ability of humans to understand the situational context, which is the outstanding benefit for people asking for help. To illustrate this, it will help to take a brief look at the theory of data, information, and knowledge.

Data might be represented by something like "5". It becomes information when it is embedded in a semantic context. For example, "5°C" is a temperature measured on the Celsius scale. Knowledge is created when this information is related to other information in a meaningful context. For example, with the explicit information that the temperature value was recently measured in Berlin, and an understanding of the latitude



and altitude of Berlin, one can draw the conclusion that it is most likely not summer. Or, given information about human body temperature and the melting point of water, one can infer that it is necessary to wear a jacket, but that the street will not be slippery. People make these mostly unconscious inferences all the time. This ability is a main difference between most existing knowledge management systems and experienced colleagues. The former contain texts, images, videos, etc. This is actually information, not knowledge, because the context in which this information becomes relevant is not included. Another example can illustrate the difference further.

In this case the information is structured as follows: "If you are experiencing Error 127 (Product Jam), you should check the following 13 possible causes... Cause 7: Sensor B is misaligned. Loosen its screw and move it to the correct position..." Alternatively, an experienced colleague will say: "I hear the product hitting the guide rail and see that it reached the feeder too late. That's why the product jams so often. I had the same problem a few weeks ago. It's probably an alignment problem with Sensor B." So the skilled worker

(1) Captures the relevant information needed to describe the situation,
(2) Puts it in a meaningful context to infer what information is needed, and
(3) Provides that information.

When only a traditional knowledge management system is available, steps 1 and 2 are left to the novice workers seeking help. In practice, this means that they often do not know what to look for in the knowledge management system because the naming of all the machine parts is unclear. They see a physical problem (in this case a product jam) and the corresponding error message from the machine, but these refer to the symptom, whereas the workers need information about the root cause. Unfortunately, there is usually a 1 to n or even an m to n relationship between symptoms and root causes. Finding information represented by photos or videos can worsen the situation, especially if the material is not properly tagged. All in all, the hurdle is often too high, especially in the stressful situation of a production disruption. As a result, even when a knowledge management system is in place, inexperienced workers tend to ask their more experienced colleagues. When the latter realise that they have contributed to the knowledge system but are still asked the same questions, they develop the impression that they have wasted time and effort, which is usually the end of a knowledge management system. Consequently, the second key factor is the challenge of getting the right information without a traditional search, which is closely related to contextual understanding as the main aspect of knowledge.

## CHANGE MANAGEMENT

A knowledge management system that fulfills the above key factors will not automatically be successful. Better solutions usually do not spread by themselves due to the human tendency to persist, fostering an antagonistic psychological effect against change. Overcoming this inertia requires active change management. In many cases, the introduction of new technical systems and communication processes is left to people who know the production and their team very well, but who are not trained in change management. Typical reactions to the implementation of knowledge management systems are "I don't have time to document my knowledge!" (What else can you say? Otherwise, the next question would be: "Why did you have spare time before?") or "If I share all my knowledge, I won't be needed here anymore".

Objections like these are natural, expected, and follow a predictable pattern. There are scientifically proven methods to address them and to guide entire teams, with all their social dynamics, through a successful change process. A good basis for this process is the model of the "Four Rooms of Change", also known as the "House of Change" (4). The third key factor for successful knowledge management is a professional implementation and change process that is closely monitored using KPIs such as the exent of user interaction with the system.

## MACHINE LEARNING AND THE "RULE OF 1%" AS A SOLUTION

On the technical side, the key factors come down to solving the search problem. A breakthrough came with the easy applicability of machine learning (ML) in terms of software frameworks and computing power. Just as an experienced operator combines various sensory inputs into a knowledge context, ML can learn and recognise characteristic patterns in machine and process data. For example, in a particular malfunction scenario, the combination of a particular machine error code, a slightly higher current in a drive, a delay in the signal change of a light barrier, and a deviation in a temperature value are characteristic of a very specific root cause. ML models can be trained by user feedback to map this data "fingerprint" to a knowledge record in the system. This enables an ML-powered knowledge management system to automatically suggest appropriate information in the event of a failure, without the need for a manual search. This is the key innovation that makes such a system the number one source of helpful information, since there is no need to make an active decision to use the system to obtain information; it is simply displayed without any interaction.

Despite the technical ability to become the number one platform, it is still necessary to feed information into the system. As the example of Wikipedia shows: Just because almost everyone uses a system does not mean that everyone will contribute to it. But that is not necessary. The scientifically proven rule of 1% (5) states that social information networks thrive when only about 1% of all users are active as authors, about 9% are responsive by liking, commenting, or improving content, and the vast majority of 90% of all users are completely passive. The key to successfully exploiting this rule is the passive users who are attracted by solving the search problem. The 1% of valuable experts who create content

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are mostly intrinsically motivated by their quest for value creation (the goal of contributing to something good) and self-efficacy (having the means to make a difference). The latter in particular makes them follow the tendency of accumulation and they will automatically be drawn to the leading platform.

Finally, we can conclude that focusing on content creation in knowledge management systems means putting the cart before the horse. The key is to attract passive users by solving the search problem, supporting the introduction of these systems with profound change management, and then everything else will take its course.

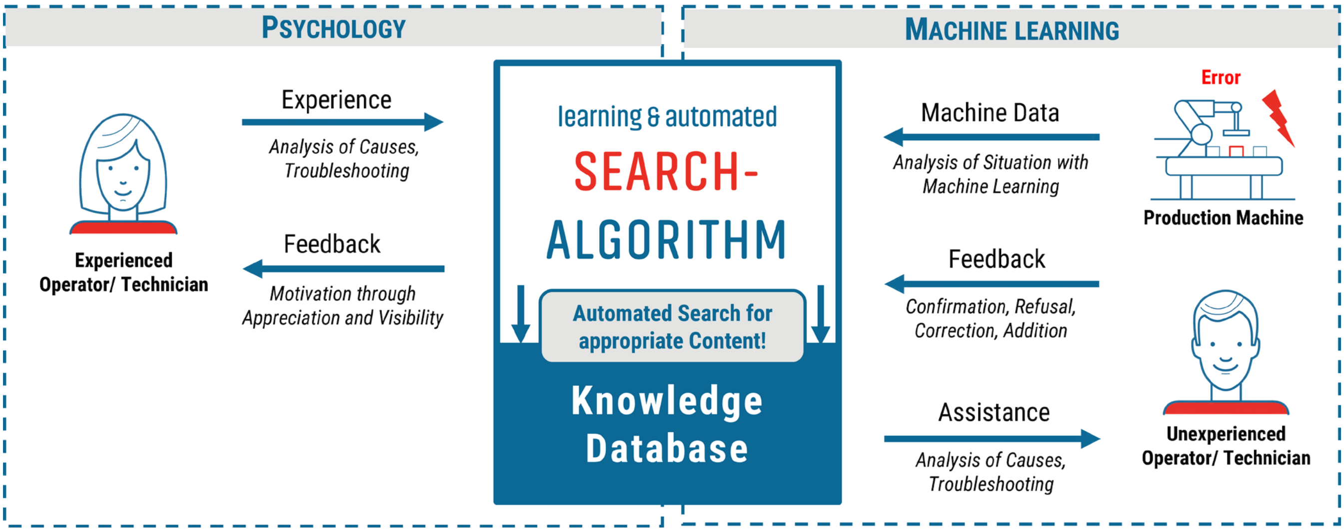


**Figure 1: Machine learning and psychology innovate knowledge management**

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