The Lack of Knowledge? Change the Way You Work

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Abstract

We defined a model of allocating company available knowledge on company business processes requirements. Our model is based on an employee knowledge structure and on business process structural indexes. We found a conclusion that is useful to “destroy” a process to some level (and consequently decrease its efficiency) to reach a better knowledge alignment with existed employees (and consequently increase a process efficiency). This model is useful when we need a fast reaction on a new business opportunity without having enough time to re-educate employees. This article includes also an example of using proposed knowledge allocation model at the end.

1. Introduction

The characteristics of the companies of the modern world that are dealing with information systems and technologies are the variety of products (or services) and the dynamics of their change, brought by business demands [4].

When the company must change itself from operational level because of a new product, it adjusts processes. Requirements of a new process are typically new or adjusted information system requirements, assets requirements or knowledge requirements. Knowledge requirements are typically aggregated on work positions definitions [13]. We can say that each process change could changes the knowledge structure of a specific work position. In such case, existing employee isn’t educated enough from a view of process knowledge requirements [7]. This is the starting point of our article.

Classical models [5] are searching for an optimal solution called assignment problem, where the knowledge structure of a specific work position is matched with the knowledge structure of all available employees. There is always a criterion that measures difference between required and available knowledge and its strength. The criterion of optimization is like searching for global minimal negative difference (deficit of knowledge) between knowledge requirements of all work positions and all actual knowledge of employees, searching for global maximal positive difference (surplus of knowledge) between all knowledge requirements of work positions and all actual knowledge of employees, or searching for global best allocation of employees on work positions according to minimal knowledge deficit/surplus (absolute) gap.

If the difference is too high, especially in case of knowledge deficit, we make assumption that the work is less efficient. Because of that the company forces education of employees when it has enough time. Or in case of no time, the company recruits a new employee from the market that has a required strength (level) of specific knowledge. The question for second option is, if the company has any other management action to perform, because hiring a new employee and firing an old one cost a lot.

Our idea comes from the business process management area [14]. Regarding to one of the business process theory, the process will be efficient the most if all activities of the process will be performed by the same work position and consequently, by the same employee [16]. This is explained by reducing waiting time in the process flow that occurs between each change of work position. The theory works, if the business process is very simple. But in a large and very complicated process from knowledge view (like a process of information system development) one employee doesn’t have enough knowledge to perform all process activities. Because of that, we split activities between many different work positions. Each work position has its own knowledge requirements. But the management still needs to take care that the number of work positions changes is on minimum so that the process is still efficient enough.

The business process has also the characteristic of output quantity [1]. Having a “super” employee and only one work position that could perform all activities from knowledge view isn’t enough because the process output quantity varies. If we have in mind the theory of minimization work positions changes, the duplication of output quantity means searching for another “super”
employee that must cover the whole process. From the economic view this is not a cost effective solution. Because of that, we are splitting activities between different work positions, on that with simple knowledge requirements and on that with complex knowledge requirements. And by the nature of the work, the simple or complex activities are never together in terms of sequence of the process. This is the next limitation for process efficiency.

Because of the knowledge alignment theory and according to this two process limitations we search for the model that will give as an answer of how much could we cut the process efficiency while searching for better allocation of current available knowledge of employees, until the process will be so inefficient that is better to hire a new employee with required knowledge.

2. The model of an algorithm

Our model is based on a classical assignment problem [10] that assumes that we have \( n \) employees \( E_1, E_2, \ldots, E_n \) and \( n \) work positions \( W_1, W_2, \ldots, W_n \). This problem is classified as a linear integer problem that could be solved with a simplex optimization algorithm. The mathematical model for this problem looks like:

\[
Max \quad z = \sum_{i=1}^{n} \sum_{j=1}^{n} c_{ij} x_{ij}
\]

This model has two limitations. Each employee can be allocated to exactly one work position and each work position must be allocated to exactly one employee. This isn’t very useful for practical purposes but the model is good enough for explanation of our model. The criterion for the value of \( c_{ij} \) (that means increment of value if employee \( i \) occupies work position \( j \)) is represented as ability of employee to perform work of a specific work position. The model assumes that the value of criteria function is presented as a maximization of profit. This was the first problem because we must measure the difference of required and actual knowledge and we want that it is minimized.

The second problem was how to measure process inefficiency. In the process structural indexes theory [9] we found an index that measures the number of work position changes during the process flow:

\[
K_{wpc} = \frac{C_{wp}}{P_a} \cdot 100
\]

\( P_a \) represents a number of process activities and \( C_{wp} \) represents a number of work position changes. In a process of \( n \) activities we could have maximal of \( n-1 \) work position changes. The value of this process key performance indicator (KPI) should be low if the process is efficient.

We created an allocation model on the basis of these two problems. Steps are presented in Figure 1.

![Figure 1. Allocation model](image)

2.1. Defining required knowledge definitions

We got required knowledge definitions from the business process models. Each process \( p_j \) was structured down to the level of activities \( a_i \). We noted this relation as:

\[
b_{i,j} = \begin{cases} 
1, & a_i \in p_j \\
0, & a_i \notin p_j 
\end{cases}
\]

Where \( b_{i,j} \) is a relation that process \( p_j \) includes activity \( a_i \); \( p_j \) is a list of company’s processes (\( j = 1..m \)) and \( a_i \) is a list of company’s activities (\( i = 1..n \)).

Then we asked company employees and experts which knowledge is important to have, that the work of a specific activity \( a_i \) is well performed and of what strength it must be (on a scale from 1 to 5):
each work position), the actual knowledge of each employee (each employee on a required knowledge of a specific work position and employees). Then we measured the difference between knowledge in the future.

It could be used as a company opportunity for a fast reaction on a detected (required) knowledge also. It could be used as a company part of assessment was searching for her/his tacit knowledge) and their strength on a scale from 1 to 5. A required list of knowledge (known as explicit knowledge) was a subject of this research. Instead we created a list of required knowledge and a lot of them with insignificant strength. We could use factorial analysis to determine which knowledge is important but this wasn’t a subject of this research. Instead we created a simple criterion for a definition of key knowledge of a specific work position 

\[ K_k > \bar{x}(\max k_i) + \sigma(\max k_i) \]

Key knowledge \( K_k \) of that work position are those (work position list of all knowledge \( i=1..n \)) with a knowledge strength higher than an average strength value of all required knowledge of specific work position, plus its standard deviation. That means that among all required knowledge we used in our model only high ranked required knowledge.

2.2. Defining actual knowledge definitions

We got actual knowledge definitions of a company from their employees \( E \). We used 360° feedback method [12]. Each employee was assessed on basis of required list of knowledge (known as explicit knowledge) and their strength on a scale from 1 to 5. A part of assessment was searching for her/his tacit knowledge also. It could be used as a company opportunity for a fast reaction on a detected (required) knowledge in the future.

In that case we got knowledge profiles of all employees. Then we measured the difference between required knowledge of a specific work position and actual knowledge of each employee (each employee on each work position):

\[ e_{E,i} = \begin{cases} c_i \leq v_{E,i}; & \text{surplus of knowledge } i \\ c_i > v_{E,i}; & \text{deficit of knowledge } i \end{cases} \]

Where \( e_{E,i} \) is comparison of employee specific knowledge strength on the required work position knowledge strength; \( c_i \) is required knowledge strength, \( v_{E,i} \) is actual knowledge strength. We can say when employee strength of specific knowledge is up of the work position knowledge strength, then the employee is appropriate and opposite, when she/he is low then the employee is inappropriate for that work position (from the aspect of one knowledge only).

2.3. Setting allocation criteria and target KPI

We could use any heuristic rule for allocating employees on work positions (e.g. best employee according to sum of key knowledge strength is allocated on the most difficult work position). But in our model we used an optimization criterion, where we search for a global best allocation of company available employees on all work positions according to minimal knowledge deficit/surplus (absolute) gap \( e_{d,i} \).

First, we defined that both, having “over” educated employee on non difficult work position and having non educated employee on a very difficult work position, is inappropriate (only from view of work position key knowledge \( K_k \)):

\[ |\Delta K_k| = |e_{E,i}| \]

Then we put this definition into the classical assignment problem Equation (1) and we formed the definition of \( c_{ij} \) for this optimization function (by its nature it is very similar to a definition of MAD from area of measuring forecast error [13]):

\[ c_{ij} = \sum_{i=1}^{n} \frac{|\Delta K_k|}{n} \]

We interpret this like: each employee \( i \) is compared to each work position \( j \) on basis of an average difference of sum of absolute values of all \( n \) key work position knowledge \( K_k \). The search for maximum is changed to a minimum of course (searching for a minimal knowledge absolute gap).

As a process KPI we used criterion of Equation (2).

2.4. Calculating criteria and target KPI

We used Aris [3] information tool for a definition of processes, actual knowledge definitions, required knowledge definitions, \( \Delta K_k \) and KPI calculations.

We used WhatsBest [11] information tool for a calculation of optimal solution. WhatsBest tool uses a simplex method for a calculation of optimal solution according to criteria function (minimum of \( z \)).
2.5. Cutting of activities on knowledge base

This is the main part of our model. We have different limitations in real business when we are searching for a new “actual” knowledge e.g. the process changed because of new market demands and the management has no budget to cover employment of new employees (a situation in a recession when we must develop new products with fewer employees).

In such case, we re-organize employees on process activities. The problem occurs, because we have only a few wide educated employees and a lot of specialists. From the knowledge view wide educated employees are never “bottle necks”, but from capacity view they are always (e.g. everybody calls best programmer for instructions). Our answer is: when there is a lack of knowledge, re-organize it. The theory goes like this:

1. Find knowledge in the work position required knowledge list that a specific employee is unable to perform and remove it.
2. Consequently, remove the process activity or a part of it. When we split it, the process KPI is getting worse.
3. Removed activity or part of it is given to an employee that covers it successfully from the knowledge aspect. Work position specification has been changed (or we created a new work position).
4. Consequently, the knowledge is re-organized better (best minimum of $z$ optimization function) and the process is feasible.

By using this principle, we will achieve better actual knowledge allocation by cutting as-is activity on two parts. Of course, we will slow down the process too by doing that because of additional one work position break (As-Is process KPI: 0 work position breaks / 1 activity = 0. To-Be process KPI: 1 work position break / 2 activities = 0.5. The KPI goes up, that means that the process is getting slower). But the result is reverse engineered process with better alignment of required knowledge (To-Be process):

The comparison of To-Be required knowledge of process and existent actual knowledge of employees $E_1, E_2$ shows us, that we achieved an optimal allocation. We could simply allocate both employees on as-is activity also, but then we have the problem that both must be available at the same time.

3. An example of using proposed model

Let’s assume we have three employees that must be allocated in three work positions in such way that we have reached minimal total absolute gap of knowledge (positive and negative). The input data of employees are in Table 1.

<table>
<thead>
<tr>
<th>Knowledge list</th>
<th>$E_1$</th>
<th>$E_2$</th>
<th>$E_3$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge 1</td>
<td>0</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Knowledge 2</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>Knowledge 3</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Knowledge 4</td>
<td>1</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

We can see that e.g. employee $E_1$ has no knowledge. 1. The input data of work positions are in Table 2.
Table 2. Required knowledge

<table>
<thead>
<tr>
<th>Knowledge list</th>
<th>Knowledge strength by work position</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$W_1$</td>
</tr>
<tr>
<td>Knowledge 1</td>
<td>0</td>
</tr>
<tr>
<td>Knowledge 2</td>
<td>4</td>
</tr>
<tr>
<td>Knowledge 3</td>
<td>2</td>
</tr>
<tr>
<td>Knowledge 4</td>
<td>1</td>
</tr>
</tbody>
</table>

We can see that e.g. work position $W_1$ requires no knowledge 1. We must calculate $e_{E,i}$ (comparison of employee specific knowledge strength on the required work position knowledge strength) and $c_{ij}$ for this optimization function (Table 3).

Table 3. Comparison of actual and required knowledge

<table>
<thead>
<tr>
<th>Work position $(i)$</th>
<th>Employees $(i)$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$e_{E1}$</td>
</tr>
<tr>
<td>$W_1$</td>
<td></td>
</tr>
<tr>
<td>Knowledge 1</td>
<td></td>
</tr>
<tr>
<td>Knowledge 2</td>
<td></td>
</tr>
<tr>
<td>Knowledge 3</td>
<td></td>
</tr>
<tr>
<td>Knowledge 4</td>
<td></td>
</tr>
<tr>
<td>$c_{ij}$</td>
<td>0.3</td>
</tr>
<tr>
<td>$W_2$</td>
<td></td>
</tr>
<tr>
<td>Knowledge 1</td>
<td></td>
</tr>
<tr>
<td>Knowledge 2</td>
<td></td>
</tr>
<tr>
<td>Knowledge 3</td>
<td></td>
</tr>
<tr>
<td>Knowledge 4</td>
<td></td>
</tr>
<tr>
<td>$c_{ij}$</td>
<td>1.8</td>
</tr>
<tr>
<td>$W_3$</td>
<td></td>
</tr>
<tr>
<td>Knowledge 1</td>
<td></td>
</tr>
<tr>
<td>Knowledge 2</td>
<td></td>
</tr>
<tr>
<td>Knowledge 3</td>
<td></td>
</tr>
<tr>
<td>Knowledge 4</td>
<td></td>
</tr>
<tr>
<td>$c_{ij}$</td>
<td>2</td>
</tr>
</tbody>
</table>

The symbol “/” means that this knowledge for that work position is not important and therefore is excluded from comparison.

We can see that employee $E_i$ with its actual strength of knowledge2 = 3 is under required strength of knowledge2 of work position $W_i$ = 4 by 1 point ($3 - 4 = -1$). We can see also that the average absolute difference of all knowledge of employee $E_i$ on work position $W_j = 0.3$ points ($\text{abs sum } (-1, 0, 0) / 3$).

Now we can start with the specification of variables of optimization problem:
- $x_{1i} = E_i$ occupies $W_i$ $\forall i$
- $x_{2i} = E_i$ occupies $W_i$ $\forall i$
- $x_{3i} = E_i$ occupies $W_i$ $\forall i$
- $x_{4i} = E_i$ occupies $W_i$ $\forall i$
- $x_{5i} = E_i$ occupies $W_i$ $\forall i$
- $x_{6i} = E_i$ occupies $W_i$ $\forall i$
- $x_{7i} = E_i$ occupies $W_i$ $\forall i$
- $x_{8i} = E_i$ occupies $W_i$ $\forall i$

Optimization function:

$$Z_{\text{min}} = 0.3x_{1i} + 0.7x_{2i} + 1x_{3i} + 1.8x_{4i} + 0.5x_{5i} + 0.8x_{6i} + 2x_{7i} + 0x_{8i} + 1$$

Boundaries functions of this optimization problem:
- $E_1$ can occupies: $x_1 + x_4 + x_7 = 1$
- $E_2$ can occupies: $x_2 + x_5 + x_8 = 1$
- $E_3$ can occupies: $x_3 + x_6 + x_9 = 1$
- $W_1$ must be occupied: $x_1 + x_2 + x_3 = 1$
- $W_2$ must be occupied: $x_4 + x_5 + x_6 = 1$
- $W_3$ must be occupied: $x_7 + x_8 + x_9 = 1$

The solution of this optimization problem was made with WhatsBest tool (Figure 2).

Figure 2. Results

We can see that the optimal solution according to knowledge allocation is reached (the gap is still 1.1 points) when employee $E_1$ occupies work position $W_1$, $E_2$ occupies $W_3$ and $E_3$ occupies $W_2$.

Now we can make activity cutting (already explained in section 2.5) to find lower value of optimization function (with parallel calculation of process KPI for a control purposes that our process is still efficient enough).
4. Conclusion

By using this model we have an option to have feasible process even when best educated employees leave the company. We can substitute them with the knowledge of two or more employees simply by cutting process activities. This is especially important for large companies where an employee on a specific work position must perform many different process activities with different knowledge requirements and also in the companies where the fluctuation of employees is high.

Our mission in this research was not to find what value of process KPI is still appropriate. We simply defined, that the company must follow a best practice of process organization and according to that must define still appropriate process KPI values.

This model was tested in practice in three companies in Slovenia: Iskratel (high-tech company) in a department of information product development, InterEuropa (transport company) in a department of business informatics and MORS - Slovenian Ministry of defense in a department of human resource management [8, 9]. We built process repository in each company. It includes all company processes composed of activities with required knowledge and attached work positions, and definitions of all employees with actual (explicit and tacit) knowledge.

This is to small sample for a statistical evaluation of the model of course. But the companies feedback shows us that the best results are achieved when management performs a strategy of downsizing and we still want to maintain the same product or service quality. The companies can also better allocate and manage employees that are bottle necks from knowledge view. They can load capable employees only with appropriate work from knowledge view – only key activities or part of them (e.g. it is hard to be a “paper” manager if your knowledge is appropriate for product innovations).

We also know that the knowledge allocation is not enough because there are other things that matter in a relation of business process requirements and employees. Currently we are working on matching actual competences and process required competences - that means on all measureable work habits and personal skills used to achieve a work objective [6].

10. References


