Proceedings of the 2015 Winter Simulation Conference
L. Yilmaz, W. K. V. Chan, I. Moon, T. M. K. Roeder, C. Macal, and M. D. Rossetti, eds.

SIMULATION OF KNOWLEDGE TRANSFORMATION IN PURCHASING PROCESS

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ABSTRACT

This paper presents an approach for modelling the transformation of knowledge in the procurement process and the findings obtained from simulating that process. The knowledge transformation is from tacit knowledge into explicit knowledge for the purchasing process of a chemical company. The simulation model considers the information flow from the identification of the need for a purchase to the placing of an order with a supplier. The model utilizes results from the authors' previous work that identifies the factors which influence knowledge transformation.

1 INTRODUCTION

This paper presents results from modelling and simulating knowledge transformation in the purchasing process and provides findings on the factors that affect transforming tacit knowledge into explicit knowledge.

The main contribution of this paper is a methodology for modeling the transformation of knowledge in the procurement process. The methodology uses knowledge as a resource and introduces a new category of object, referred to as a knowledge flowitem. The research questions being addressed are: (1) is it possible to simulate the change of knowledge from tacit to explicit and (2) what factors affect the transformation of the knowledge?

These questions result from the notion of knowledge being a resource is very elusive.

Moreover, in the purchasing process knowledge appears in different forms. Explicit knowledge comes from internal and external sources, such as the quality requirements for the object being purchased, information about suppliers, production and sales plans, catalogues of materials available in the market and available at exhibitions, price lists, offers, advertising brochures (Skowronek and Sarjusz-Wolski 2012).

Tacit knowledge of employees responsible for procurement includes practical skills (e.g., proficiency, professionalism), theoretical knowledge, talents, work experience, intellectual agility, innovation, ability to imitate, entrepreneurship, ability for changes, motivation, desire for action, personality predispositions to determined behaviours, commitment to the process, ethics, manager leadership (Bartnicki and Strużyna 2001). The transformation of knowledge, i.e. the process of converting non-systematized tacit knowledge of an employee into systematized explicit knowledge is based on the work of Nonaka and Takeuchi (2000) and Werner, Hadaś, and Pawlewski (2012).

The paper is structured as follows. Section 2 provides a brief literature review of knowledge transformation in purchasing process. Section 3 defines the knowledge flowitem, describes the process using IDEF0 methodology, and provides the mathematical formulation of knowledge transformation. Section 4 summaries the results of the verification of the simulation model of the knowledge transformation in the procurement process. Section 5 provides a brief discussion and conclusions.

2 RELATED WORK

2.1 Tacit Knowledge and Explicit Knowledge

Distinguishing knowledge as explicit or tacit (alias silent or secret) originates with the Hungarian philosopher M. Polanyi. According to Polanyi, a certain kind of knowledge is incessantly collected by people mainly as a result of experience. However, it is very difficult to articulate and record. Therefore, it is named silent (tacit, implicit) knowledge (Polanyi 1967). On the other hand, explicit knowledge (formal, articulated) can easily be presented by means of speech, documents, schemes, symbols, textbooks, instructions, etc.

Tacit knowledge is understood as the knowledge of the individual employee in enterprise data, resulting from their professional experience, intuition, and know-how. While secret knowledge is difficult to articulate, transfer, and copy, it is the source of competitive advantage (Stankiewicz 2006). Therefore, tacit knowledge is the focus of attention of scientists who seek methods and techniques for moving this knowledge to computer systems in order to further its use. These notions are the motivations for the authors to develop and conduct simulations of the knowledge transformation process.

In enterprises the tacit or secret knowledge is derived from employee competences and experiences. It is personal, often intuitive, difficult to manage, and remains unavailable to other employees until it is formalized and transformed into explicit knowledge. Tacit knowledge is individual, context-specific, hard to formalize and communicate, and requires specific learning skills (Boiral 2002).

Explicit knowledge is suitable for transferring by means of a formal and structured language; i.e., it is possible to express it in the form of words and numbers. It takes the form of documents, instructions, procedures, regulations, or orders. Nonaka,Toyama, and Konno (2001) classify explicit and tacit knowledge into four groups of knowledge assets:

- experimental knowledge assets - result from shared experiences, individual's education, personal skills and know-how, as well as energy, passion, mutual confidence, help, and sense of security;
- routine knowledge assets - practical actions, including the ability to perform certain operations, as well as the organizational behaviours and elements of organizational culture;
- conceptual knowledge assets – formal and specified knowledge, expressed in the form of ideas, images, symbols, language (e.g. specific projects, patterns, models);
- systemic knowledge assets - formalized in the form of documents, specifications, instructions, databases, patents, etc. Such knowledge is easily transferred.

These assets are created, developed and consequently transformed into the spiral SECI (Socialization, Externalization, Combination, Internalization) process (Andreeva and Ikhilchik 2009) that is shown in Figure 1.

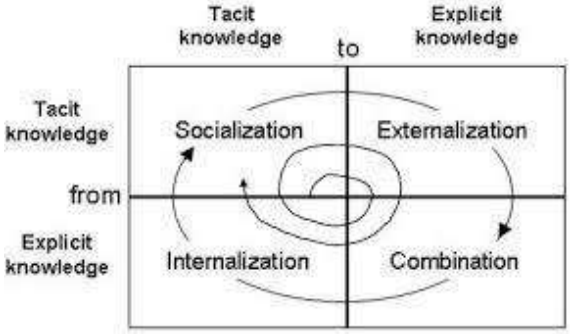

Figure 1: SECI model.

2.2 Tacit Knowledge and Explicit Knowledge in the purchasing process

The procurement process is a basic logistics process. It has significant influence on the financial performance of every enterprise. Enterprises, regardless of the core business, purchase materials, components, sub-assemblies, and services from a market; these purchases are required for conducting basic business activities (Skowronek and Sarjusz-Wolski 2012). Procurement is a process that involves the following decisions:

- make or buy, producing a product in-house or purchasing it from an external supplier,
- volume of purchases based on material requirements planning and inventory control,
- date of purchases, based on production needs and inventory control,
- place of purchases, selection of sources of the goods or services (Skowronek and Sarjusz-Wolski 2012).

The procurement process is an information process. It comprises activities concerned with acquiring, collecting, and transforming information, defining material needs (type of materials, quantity, quality, delivery date, etc.), and sources of purchases (Skowronek and Sarjusz-Wolski 2012). For the purchasing process, the following are sources of explicit knowledge:

- current prices,
- quality requirements,
- information about suppliers,
- production plans and sales plans of finished goods,
- level of consumption and inventory policies,
- standard versus special parts,
- catalogues of materials available in the market, price lists, guides, offers, advertising brochures, etc. (Skowronek and Sarjusz-Wolski 2012).

In addition to explicit knowledge, the procurement process includes tacit knowledge from employees executing the purchases, in the form of:

- competences: practical skills (proficiency, professionalism), theoretical knowledge, talents, experience, work experience,
- intellectual agility: innovation, ability to imitate, entrepreneurship, ability for changes,
- motivation: desire for action, personality predispositions to determined behaviours, commitment to the process, ethics, manager leadership (Bartnicki and Stróżyna 2001).

In the opinion of the authors, modelling the flow of explicit knowledge in the procurement process is not a problem, since it mostly involves physical objects; however, modelling and simulation of the flow of tacit knowledge is a challenge.

3 MODELLING OF KNOWLEDGE TRANSFORMATION IN PURCHASING PROCESS

3.1 Modelling of the purchasing process

In order to simulate knowledge transformation, the authors first modelled the purchasing process using the IDEF0 methodology. (Lucas et al. 2005). IDEF0 is a simple graphical methodology used in systems analysis to define processes and enable effective communication between the analyst and the customer. (Grover and Kettinger 2000) The IDEF0 process card consists of the rows of activities and the following information on each activity, shown as columns in the card:

- ID –activity identification
- Name– activity name

- I – input – the name and id of items that trigger the activity -
- O – output – the name and id of item which is the result of performing the activity
- M – mechanism – systems, people, equipment used to perform the activity
- ID s. – identification number of the successor activity
- ID p. – identification number of the preceding activity
- T – Time – duration of the activity, expressed with the fixed value or the range.

Based on observing the purchasing process for raw materials, the authors developed a process card for the simulated process, a portion of which is shown in Table 1. The full purchasing process consists of 17 activities.

Table1: Process card of knowledge transformation in the purchasing process.

ID	**Name**	**I**	**O**	**ID s**	**ID p**	**Duration (min)**		**Employee**
						from	**to**	
A1.1	Check information about the supplier and the offer	The need to purchase raw materials – **JW0**	Offer from the supplier not being shortlisted – **JW3**	A1.4	**x**	30	480	The employee of the Logistics Department
		The need to select suppliers of raw materials based on offers – **JW1**	Offer from the supplier being shortlisted – **JW4**	A1.2	x			
		Offer for the raw material from the supplier **JW1**			x			
			Noninspection of data about supplier and offer - **JW2_1_Lim**	STOP 12	x			
A1.2	Complete the sheet of choice up for the supplier, to check or to correct	Offer from the supplier included in the list – **JW4**	Correctly filled up sheet of choice of the supplier – **JW7**	A1.3	A1.1	5		The employee of the Logistics Department
		Incorrectly filled up sheet of choice of the supplier – **JW13**	Incorrectly filled up or uncorrected sheet of choice of the supplier - **JW7_1_Lim**	STOP 12	A1.8			

Based on Table 1 the inputs and outputs of activities of the purchasing process define the flow of knowledge flowitems. These activities are defined in graphical form in Figure 2.

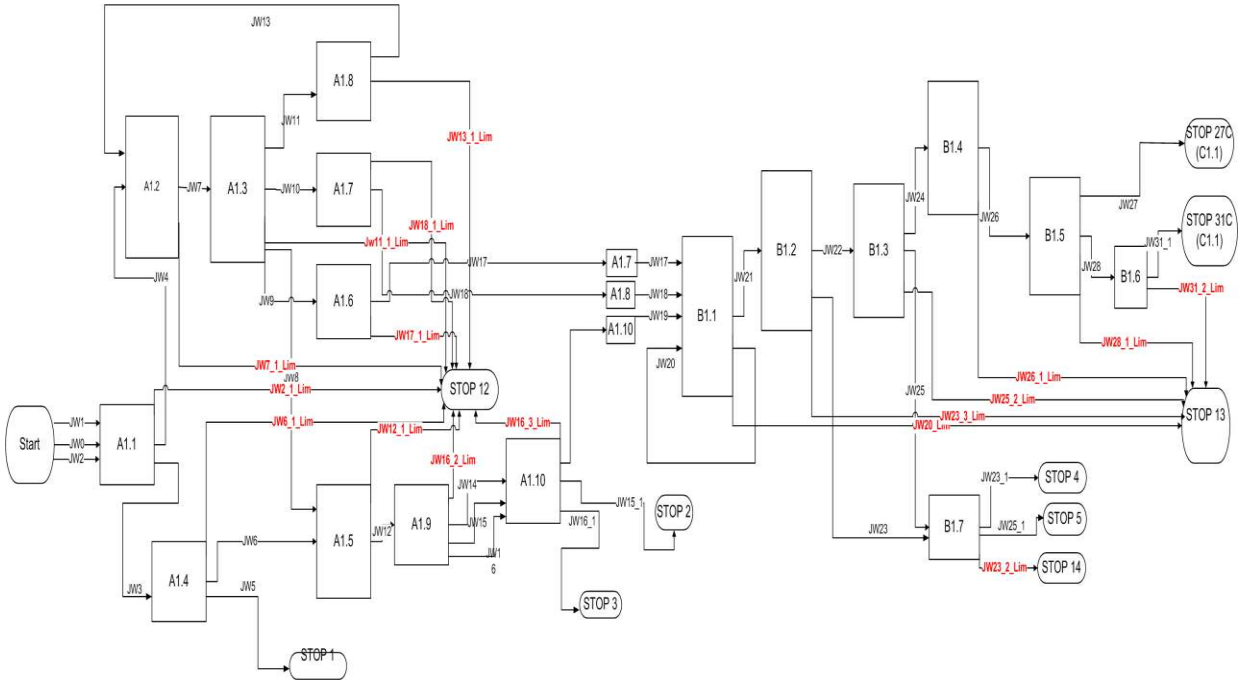

Figure 2: Model of knowledge flow in the selected part of purchasing process.

3.2 Modelling knowledge transformation in the purchasing process

The main idea of our concept is:

- Knowledge transformation can be modeled as the flow of knowledge flowitems.
- In production systems, flowitems represent product flows through workstations (processors) where value is added; i.e. after each operation a product is more valuable - in our concept we define the abstract object JWn which represents knowledge flowitem. The set of knowledge flowitems (Werner, Hadaś and Pawlewski 2012) form a set of enumerations (in mathematical formula):

$$JW \in \{JW1, JW2, JW3...., JWn\} \quad (1)$$

  where: $n \in N$.
- Every activity (operation) in the procurement process transforms a knowledge flowitem JWi into another knowledge flowitem JWn, both of which are from the set JW. For example, JW1 is transformed to JW5 during operation x.
- Through analysis of the real procurement process we defined all knowledge flowitems and build the set, in mathematical terms, as a set of enumerations. In our case example, we define 52 knowledge flowitems {JW1, …. , JW52} and identify where the knowledge flowitems are transformed – activity from process card – table 1.
- Through analysis of the procurement process we identify the influences in this process and we define the rules for operations. For example, JW1 is transformed by activity A5.1 to JW5 or to JW7 depends on the level of influences factors in this activity
- Based on the set of knowledge flowitems, the set of operations (activities), and the rules of flow, we model the process and observe how knowledge flows and how structure depends on influences.
- Influences on the flow are defined based on observations of the process, interviews, etc. The influences are defined in formal way, by algorithm, in order to consider the duration of influence. It means that after time the influences changes their impact power.

- The modelled procurement process has many exits, one of them is good (the procurement process finished correctly, with success it means that we obtain the proper knowledge flowitem at the end) and rest of the not good (process finished without success).
- Our task is to define the level of influences on the minimal level which guarantees the maximum number of knowledge flowitems in one "success" exit.

The description of part of the set of enumerations JW is presented in Table 2. The knowledge flowitems create the sequence of the activities in the purchasing process. In the Section 4.2 we provide an example description of the knowledge flowitems transformation.

Table 2: Knowledge flowitems flowing in purchasing process.

No	ID JW	Description
1	JW0	The need for the purchase of raw materials
2	JW1	The need for selection of the supplier of raw materials based on had offers
3	JW2	Offer for the raw material from the supplier
4	JW2_1_Lim	Noninspection of details about the supplier and the offer
5	JW3	Offer from the supplier not being shortlisted
6	JW4	Offer from the supplier being shortlisted

Based on the inputs and outputs of every activity in the purchasing process, the authors developed a questionnaire that was administered to the manufacturing company to identify the factors which influence knowledge transformation. Also, using a numerical scale, the authors obtained information about the level of these factors in knowledge transformation during the procurement process. Thirty-four factors were identified; a sampling of which is provided in Table 3.

Table 3: Factors affecting the purchasing process in terms of knowledge transformation.

The name of factor group	No	Sign	Element of the group of factors	Min value	Max value	Criterion of assessing the factor	Factor value in the enterprise
A Personal factor	1.	CA1	Level of the responsibility of the employee	1	6	**1** – none	4
						2 – allowing	
						3 - sufficient	
						4 – good	
						5 – very good	
						6 – perfect	
	5.	CA5	Professional experiences on the position of the employee	1	4	**1** from 0-5 years	3
						2 from 5 - 15 y.	
						3 from 15-25 y.	
						4 from 25-40 y.	
	6.	CA6	Occupational seniority	1	4	**1** from 0-5 years	3
						2 from 5 - 15 y.	
						3 from 15-25 y.	
						4 from25-40 y.	

4 SIMULATION OF KNOWLEDGE TRANSFORMATION IN THE PURCHASING PROCESS

4.1 Scope of the Simulation

The simulation model of the purchasing process with knowledge transformation was built using the discrete-event simulation and optimization software FlexSim (Beaverstock et al. 2011). The simulation model considers 17 activities, e.g. A.1.1 "Check the information on the supplier," B.1.6 "Order the means of transport," etc.

For the purpose of the simulation, the frequency of occurrence of a need to purchase an item is two per day, or every four working hours. The length of the simulation is one calendar year, or 251 working days with each work day being eight hours.

4.2 Knowledge Transformation – Mathematic Formula

As mentioned in section 3.2 the goal of simulation experiment is to obtain on proper exit maximal number of knowledge flowitems. We can investigate the reaction of simulated process depends on the level of influencies. This level is closely related to values, which take the factors influencing the process of procurement in terms of knowledge transformation. A logical record is used for recording the above conditions in the form of the cascade-branch control structure: If-Then-Else-If. Logical records show which of the factors by which reached values will lead to the transformation of knowledge in the purchasing process, and by what values the knowledge transformation does not occur. In case of not complying with a condition, the knowledge transformation isn't occurring on what results in the interruption of the implementation process. Authors assumed that boundary conditions of factors of the influence which allow the transformation of knowledge correspond to the assessment of the level of these factors present in the enterprise (Table 3).

The description of one example of transformation (for activity A1.1) is described below:

Table 4: Record of knowledge transformation in Activity A1.1 Check information about the supplier and offer.

<table>
<tr><th>Activity ID</th><th>Name of the activity</th><th>I input</th><th>Formula of knowledge transf.</th><th>O output</th></tr>
<tr><td rowspan="3">A1.1</td><td rowspan="3">Check information about the supplier and offer</td><td>The need for purchase of raw materials – JW0</td><td rowspan="2">CA3>=4; CA5>=3; CA6>=3, CA13>=4; CH4>=3</td><td>The offer from a vendor is not on the list – JW3</td></tr>
<tr><td>The need for vendor selection of raw materials on the basis of the tenders – JW1</td><td rowspan="2">The offer from a vendor is on the list – JW4</td></tr>
<tr><td>Offer for raw material from the supplier – JW2</td><td></td><td>The data about suppliers and offer – JW2_1_Lim</td></tr>
</table>

The transformation is performed when all three (JW0 & JW1 & JW3) knowledge flowitems are together at the entry to activity A1.1. Algorithm of this transformation is presented below

```
IF  (CA3 >= 4 AND CA5 >= 3 AND CA6 >= 3 AND CA13 >= 4 AND CH4 >= ) AND
      (JNL == 0)
  THEN (CREATE(JW3))
       ELSE  IF  (CA3 >= 4 AND CA5 >= 3 AND CA6 >= 3 AND CA13 >=  AND
                           CH4 >= 3) AND (JNL == 1)
              THEN  (CREATE(JW4))
                                ELSE  (CREATE(JW2_1_Lim))
```

4.3 Simulation Experiments

Four simulation experiments (scenarios) were planned to see if the purchasing process in the simulation model is consistent with the assumptions of the scenario. The following describes the process followed for one scenario; the other three are similar.

The objective of the experiment is to verify the simulation model, by means of following scenario. Scenario 1 – Based on the levels of the factors of influence, the purchasing process is stopped - the offer from the supplier is rejected; it is non-compliant with the requirements. Graphically, the activity on the A1.1 path. - Stop 1 is shown in Figure 3. The level of the factors is provided in Table 5. The expected value of the JW determined on the exit is in Table 6.

The portion of the purchasing process on A1.1. path- Stop 1 includes activities: A1.1. – Check information about the supplier and the offer and A.1.4- Preliminary to give one's opinion on the offer.
In the presented process there are Stop elements:

- Stop 1 – offer rejected from the potential supplier since it does not fulfil the enterprise's quality requirements,
- Stop 12 – details about the supplier and offer not checked or no preliminary opinion on the offer.

In both cases, the interpretation is that a transformation of the knowledge did not happen in activities.

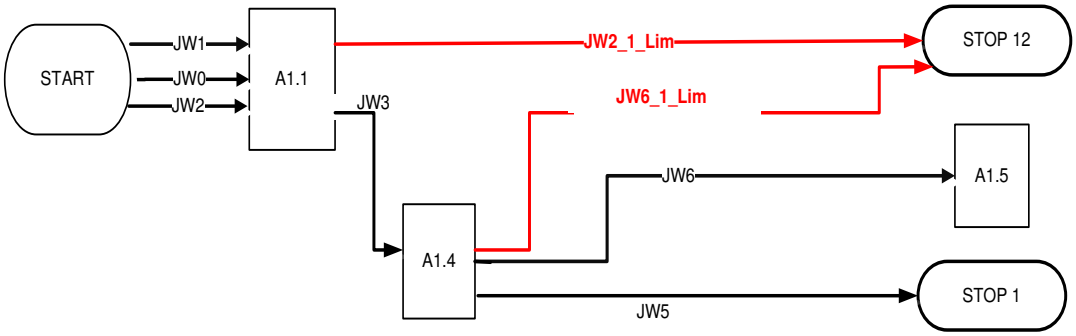

Figure 3: The execution of purchasing process at path: A1.1 – Stop 1.

Based on logical records of knowledge transformation the authors selected from formulas of knowledge transformation those which allow for the knowledge transformation in the path A1.1 – Stop 1:

$$C_{A1.1.-Stop\ 1} = \{CA3>=4;\ CA5>=3;\ CA6>=3,\ CA13>=4;\ CH4>2,\ CA1>=4;\ CA5>=3;\ CA6>=3;\ CA7>=3;CA10>=1;\ CD1>=4;\ CE1>1,CE2>=4;\ CG2>1;\ CG3>=4\} \quad (2)$$

On the basis of the selected set, the minimal value of each factor of influence (Table 5) is set in a path that enables knowledge transformation.

Table 5: Minimal values of factors of influence for path A1.1. – Stop 1.

No	Factor	Factor name	Min value of factor
	CA 1	Level of the responsibility of the employee	4
3	CA 3	Desire for sharing the knowledge by the employee	4
4	CA5	Professional experiences on the position of the employee	3
5	CA6	Occupational seniority	3
6	CA7	Occupational seniority in the Luvena SA	3
7	CA10	Position occupied by the employee	1
8	CA13	The ability to acquire knowledge from various sources by the employee	4
9	CB4	Speed of receiving information by the employee	2
10	CC1	Ability of the interaction between employees	4
11	CD1	Striving for competitive advantage by the enterprise	4
12	CE1	Market of suppliers of the enterprise	2
13	CE2	Availability of raw materials of the enterprise	4
14	CG2	Work standardization (procedures, instructions)	2
15	CG3	The degree of decision making by the employee	4

On the basis of the logical records of knowledge transformation, the expected number of JW on the output is defined from the analysis phase of the procurement process. The offer from the supplier of the raw materials is rejected since it does not meet the quality requirements. Such a situation occurs in the enterprise about 20% of the time. We simulated one year of work and during this time there were 502 purchase needs for raw materials and 104 offers were rejected – it was shawn graphically in figure 4.

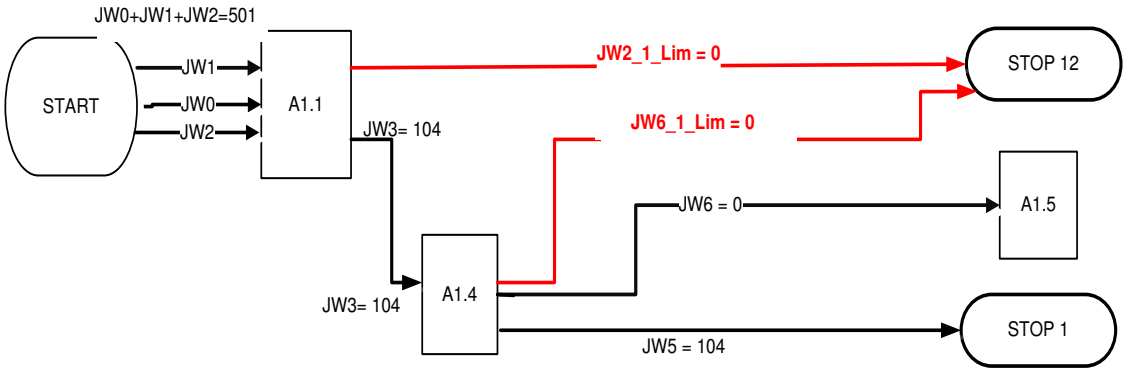

Figure 4: Results of simulation on path: A1.1 – Stop 1.

5 DISCUSSION AND CONCLUSION

This research demonstrates that knowledge transformation in the purchasing process can be modelled and simulated. The modelling is enabled by a newly defined object, a knowledge flowitem that considers information flow and not the more traditional document flow. The simulation model from one point of view shows the knowledge transformation during the one flow of process, and from second point of view shows the impact of influence in time in this case it is convincing hypothesis that process changing the form of the knowledge from tacit in explicit can be simulated. We want to notice that in this type of simulation we

observe how many knowledge flowitems left the system by which exit. We can control the system by changing the level of influencies so we have possibilities to find the minimal level of influencies which garantees the maximal exits with success in defined time – this definition of optimization task determines the direction of our further researches. In practice we want to evaluate the knowledge of employees. Which knowledge of employee is necessary to perform for example the procurement process to obtain proper business effects.

Findings of authors, are pointing, that methodology of modelling accepted by them, enables to build the credible model of the purchasing process in terms of knowledge transformation. Additional result of carried out research was to acquire the knowledge about factors of the influence on knowledge transformation in the procurement process.

Authors used these results for further research above the optimization of purchasing process in the aspect of the knowledge transformation.

ACKNOWLEDGMENTS

This research was performed under the project - 503213/11/140/DSPB/4129 Poznan University of Technology.

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