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## Article

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RESEARCH

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# Transfer of know-how based on learning outcomes for development of open innovation

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## Abstract

The Paper focuses on the inbound know-how transfer for the development of open innovation as an approach to business management. It can be a challenging task for useful and meaningful transfer of external know-how to create value, thus the addressed research questions are: What constitutes a successful know-how transfer? How to measure performance of know-how transfer? How transfer of know-how should be done? Qualitative research methods – participatory action research within a specific case and application of existing theories as well as focus groups' discussions were applied to create the study and obtain triangulation. The paper applied both inductive and deductive reasoning. The research shows that learning outcomes based approach can be used for successful know-how transfer. Performance of know-how transfer is affected by accuracy of the stated aim (learning outcomes), applied teaching, learning and assessment methods and both internal and external environment characteristics of the stakeholders involved in the process. Both the know-how transfer performance measurements and the developed six step process model are presented in the paper. Implications and recommendations for future research are given.

**Keywords:** Open innovation, Technology, Knowledge, Know-how transfer, Performance, Learning outcomes, Constructive alignment, Action research

## Introduction

Development of science and technologies (technology push), changing market needs (market pull) and demand as well as increasing competition significantly affect the environment conditions for business management. Thereby, posing challenges to assurance of business competitiveness and foster growth. Focusing on the value creation is argued in the business management, for example, by Drucker (1954, 1999); Porter (1985); Albrecht (1992); Amit and Zott (2001); Webster (2002); Kotler (2003); Chesbrough (2003); Kumar (2004); Kaplan and Norton (2004); Porter and Kramer (2007); Kotler et al. (2010); Teece (2010); Osterwalder et al. (2014); and Kotler and Armstrong (2014). Thus, value creation should be considered the main aim of business, especially nowadays. Hence appropriate implementation of value creation will result in a profit. The process of value creation can be done independently, but it requires links to an external environment in order to be innovative. Growing importance of cooperation and networking for innovation development has been emphasized, for example (e.g.), by Rothwell (1992); Von Hippel (2005); Chesbrough and Bogers (2014);

Nieminen and Lehtoranta (2015). Furthermore, development of electronic environment has extremely broadened opportunities for networking and collaboration compared to the situation few decades ago. Various forms of open systems can take place in business. For the Paper's purpose the open innovation concept introduced by Chesbrough (2003) is used as the context. Chesbrough (2003) explains the ways how to capture value from technology and argues the possibility to create more value from external sources. Laursen and Salter (2006) argue that firms which are more open to external sources or search channels are more likely to have a higher level of innovative performance. They state that openness to the external sources allows firms to draw in ideas from outsiders to deepen the pool of technological opportunities available (Laursen and Salter, 2006). Open innovation motivates managers to explore entirely new ways of innovating with partner organizations and individual experts (Von Krogh, 2011). Nevertheless, external sources need to be managed carefully (Laursen and Salter, 2006). The concept of open innovation has been used widely since its introduction, although the ideas behind it have been discussed before, for example, see Open Systems Model introduced by Quinn and Rohrbaugh (1983), which arose between 1951 – 1975 (LaChapelle, 2008). Thus, the concept of open innovation is not without criticism (see e.g. Trott and Hartman, 2009; Groen and Linton, 2010; Altmann and Li, 2011). However, it appears to be one of the most influential widely used concepts that has emerged recently.

Importance of readiness to adopt new ideas and change has been emphasized (see e.g. Weiner, 2009; Combe, 2014). It should be considered that the institutional learning is much more difficult than the individual learning and the ability to learn faster than your competitors may even be the only sustainable competitive advantage (De Geus, 1988). Despite the end of Moore's law (Waldrop, 2016; Bright, 2016; *Technology Quarterly*, 2016; Simonite, 2016) the amount and availability of data, information and knowledge nowadays is growing faster than ever (see e.g. *Big Data Universe Beginning to Explode*, 2012; Schilling, 2013; *Big Data, for better or worse* 2013; Gunelius, 2014; Turner et al., 2014), thus knowledge management issues matter more than ever before. Considering that, our memory has some limits (Miller, 1956; Cowan, 2010; Woollaston, 2016), the interest in what we are able to do instead of what we know is rising. Furthermore, Spady (1994) argues that having learners do important things with what they know is a major step beyond knowing itself. According to *Capturing The Value* (2015) organizations which have formal knowledge transfer processes perform better. However, useful and meaningful transfer of the external know-how to create value can be a challenging task because the current practice of know-how transfer often is still rather content oriented and not towards the outcomes. Thus, outcomes-based approach is considered to be tested in this Paper. The aim of the research is to develop a know-how transfer framework. It leads to the research questions: What constitutes a successful know-how transfer? How to measure performance of know-how transfer? How transfer of know-how should be done? In order to confirm the research problem, the first of two focus group discussions with the experts involved in the process of know-how transfer was conducted in December, 2015.

## **Literature review**

### **Technology transfer and open innovation**

Technology transfer is emphasized as an important driver in innovation and the creation of sustainable growth (Allen and O'Shea, 2014). It is a special and difficult type of

communication process (Rogers et al., 2001) and has been approved as an important task within different fields of research as well as in regulation and policy planning documents (Dubickis and Gaile-Sarkane, 2017). Technology Transfer is seen as an adoption of innovation made by another organization (Rogers, 1962 cited in Sazali and Raduan, 2011), an application of technology to a new use or user (Gee, 1981 cited in Sazali and Raduan, 2011) and also defined as the transfer of a technology, technique, or knowledge that has been developed in one organization and then transferred to another where it is adopted and used (Melkers et al., 1993 cited in Phillips, 2002). Dubickis and Gaile-Sarkane (2015) identify Technology Transfer as a process of change both – Outbound Technology Transfer and Inbound Technology Transfer. Clarifying the notion of open innovation, Chesbrough and Bogers (2014) conclude that open innovation ought to be conceptualized as a distributed innovation process that involves purposively managed knowledge flows across the organizational boundary and define the main types of open innovation – Outside-In (inbound), Inside-Out (outbound), combined Coupled type and the associated mechanisms, including pecuniary and non-pecuniary flows. Know-how as one of the forms of technologies to be captured within open innovation is mentioned (Chesbrough and Di Minin, 2014; Vanhaverbeke and Chesbrough, 2014), but not discussed explicitly. This could be due to the fact that the essence of the concept is assumed to be more or less clear to the reader. Following the meaning of the words in the concept, essentially it can be supposed that the concept of know-how characterizes a certain level of knowledge about the way how something should be done or a particular competence in other words. However, apprehension and comprehension of the concept might differ with different groups of stakeholders and the society.

#### **Learning process and application of learning outcomes approach to know-how transfer**

Researchers have distinguished many systems of learning theories into behaviorism, humanism, cognitivism and constructivism based on historical development in changes of understanding (Schunk, 2012 cited in History of Learning Theories, 2014). Although, these theories explain how individuals learn and they are often applied in the field of education, the concept of learning organization has been emerging rather recently in the field of management and organizations. Daft (2010) indicates that challenges in today's environment are leading to changes in organization design and management practices - many managers are redesigning companies towards the learning organization, which is characterized by a horizontal structure, empowered employees, shared information, collaborative strategy and an adaptive culture. By extrapolating different conceptualizations, Seidle (2013) defines organizational learning as the generation of new knowledge or insight that facilitates either new behaviors (actual or potential) or the improvement of existing ones. Cameron and Green (2009) emphasize that learning is not just an acquisition of knowledge, but the application of it through doing something different. Several forms of organizational learning have been described in the literature – for example, Seidle (2013) distinguishes three specific forms:

- 1) experiential learning, which occurs when organizations obtain new knowledge through direct experience with a given practice or technology (processes of trial-and-error and experimentation);
- 2) vicarious learning – organizations learn by making inferences or attributions related to activities observed in other firms;

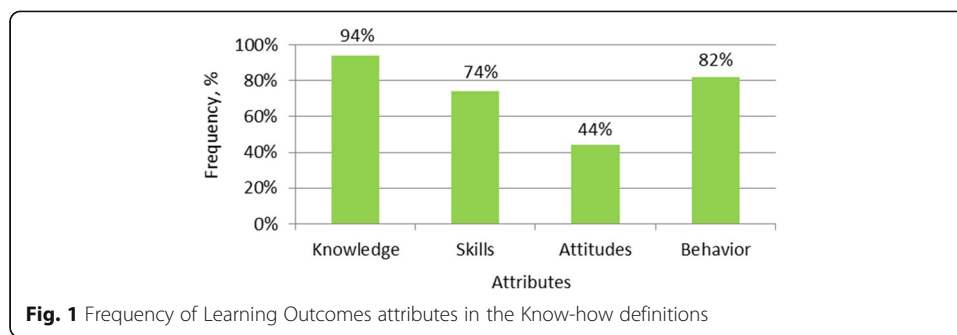
- 3) inter-organizational learning occurs when formal collaborations with other firms – strategic alliances, joint ventures, and other contractual partnerships – draw new knowledge into firm boundaries.

Whereas the learning process itself can be characterized for example by the Experiential Learning Model (Kolb, 1976) and Shewhart Cycle for Learning and Improvement – the PDSA Cycle (Deming, 1993), which both suggest that learning is an iterative process.

Ang and Joseph (1996) believe that Learning outcomes are the consequences of the Organizational Learning and Learning Organization. Kennedy (2009) outcome-based approach traces back to the work of the behavioral objectives movement of the 1960s and 1970s in the United States. He states that one of the advocates of this type of teaching was Robert Mager who proposed the idea of writing very specific statements about observable outcomes (Kennedy, 2009). Whereas Spady (1994) argues that outcome-based systems go back at least 500 years to the craft guilds of the Middle Ages in Europe. As contemporary examples of outcome-based models Spady (1994) mentions technical training programs in the military, flight schools, ski schools, professional licensure of doctors, lawyers, cosmetologists and any other area of learning where clearly defined competence and performance are essential to carrying out a role effectively. Standardization of production including the field of education in order to become more productive might be the hindering factor to a development of application of learning outcomes based approach (Spady 1994). Though, where it has been implemented, outcome based education has had a significant and beneficial impact (Harden, 2002). Learning outcomes help to tell learners what is expected of them more precisely, make it clear what learners can hope to gain, know where learners stand and accordingly ensure that appropriate teaching and assessment strategies matched to the intended learning outcomes are applied (Jenkins and Unwin, 2001). Adam (2004) argues that learning outcomes highlight the relationship between teaching, learning and assessment as well as promote the reflection on assessment and the development of assessment criteria, and more effective and varied assessment. These three method groups – teaching, learning and assessment in the literature are called Constructive alignment (Biggs, 2003). Considering definitions by Spady (1994), Baume (2009) and a survey of literature (Kennedy, 2009) Learning outcomes are here defined as the statements of what knowledge, skills and attitudes the know-how receiver is able to demonstrate in behavior after the know-how transfer process is completed successfully.

Content analysis was performed with predefined categories (Carley, 1993; Ezzy, 2002; Bryman and Bell, 2015) of know-how concept to identify the theoretical applicability of Learning Outcomes based approach to a know-how transfer. Definitions of know-how concept were collected from 49 various sources. Analysis was done by both authors independently to ensure validity of the findings. The assigned codes were discussed and finally the agreed results were presented through consensus. Such attributes of Learning Outcomes as knowledge, skills, attitudes and behavior were applied as the coding categories. The collected and with predefined categories analyzed know-how definitions are listed in Table 1 (see Appendix). Frequency of the attributes of Learning Outcomes in the know-how concept is given (Fig. 1).

The analysis reveals that not all attributes of learning outcomes are equally presented in the know-how definitions. It may be due to the simplicity of some definitions as well as historical development of the concept. A rather large number of definitions does not include the aspect of attitude, however 44% do, thus it is considered to apply Learning



Outcomes approach to know-how transfer and for the statements of the know-how transfer aim consider such attributes as knowledge, skills, attitudes and behavior.

### Performance of know-how transfer

Questions which have become increasingly important during the last decades are measurement, indicators and statistics of innovation activity on the macro level, but there is no single truth about innovation indicators and there is room for various different and sometimes even conflicting ways of understanding and measuring of innovation (Nieminen and Lehtoranta, 2015). In general, the innovation measurements are equally important both on the level of an organization and the state or region policy planning. The need for the distinction between different process effectiveness measurements is emphasized (e.g. Pennings and Goodman, 1976; Ostroff and Schmit, 1993; Marley, 2000; Flay et al., 2005). However, a brief survey of the articles with “know-how transfer” in the title reveals that existing body of scientific knowledge about effectiveness measurements is relatively pure. There are articles that discuss effectiveness issues (e.g. Teece, 1981; Jensen and Szulanski, 2007), but do not provide equations to measure the performance of the transfer process.

### Methods

The research problem outlined in the Paper is performance of know-how transfer and how the process of know-how transfer can be improved. The focus in the Paper is on the Outside-In (inbound) perspective on know-how transfer. Considering research questions, which seeks to explore, explain and understood phenomena, the Paper applies qualitative research methods. As know-how transfer is a teaching and learning process and the interest is not only in studying a particular problem but also in creating solutions, an action research approach (Lewin, 1946) is used to perform a particular case study from January until April, 2016 in the manufacturing company which practices know-how transfer. This kind of research design enables co-researchers to step back cognitively from familiar routines, forms of interaction, and power relationships in order to fundamentally question and rethink established interpretations of situations and strategies (Bergold and Thomas, 2012). Bergold and Thomas (2012) assume that in the best case, both science and practice benefit from the action research process. Particular research design has been found as useful for testing whether a specific theory and model actually apply to a phenomenon in the real world (Iacono et al., 2011; Smith, 2016). Synthesizing ideas of McNiff et al. (1996) and McNiff and Whitehead (2011) twelve steps action research model is provided. It includes activities as follows:



- 1) To review current practice,
- 2) identify an aspect we want to investigate,
- 3) imagine a way forward,
- 4) try it out, and
- 5) take stock of what happens.
- 6) To modify what we are doing in the light of what we have found, and
- 7) continue with the action in this new way,
- 8) monitor what we do,
- 9) review and evaluate the modified action,
- 10) evaluate the validity of the claims to knowledge,
- 11) develop new practices in the light of the evaluation (McNiff and Whitehead, 2011), and
- 12) continue until we are satisfied with that aspect of our work (McNiff et al., 1996).

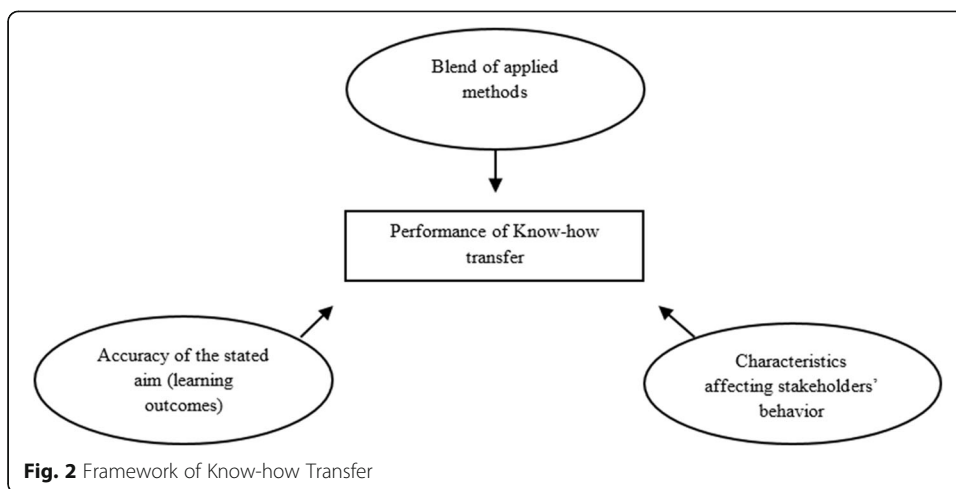
Fals-Borda's (1995) guidelines for field research and scientific reporting within participatory action research and three basic aspects – participation, action and research (Chevalier and Buckles, 2013) as well as ethical principles (Winter, 1996; O'Brien, 1998) were considered during the research. Interviews and participant-observation (Yin, 2012) as data collection methods that are suitable for the organization's environment within action research case were applied. Existing theories were applied to the findings (Birks and Mills, 2015) for the framework generation. At the end of the project, the second focus group discussion was conducted to validate the results (see Table 2 in Appendix) and to obtain the triangulation. Detail research protocol is not presented according to the agreement with the company studied in the Paper. As the Paper applies qualitative research methods, it should be considered that, generalizability of the findings is limited and results are subject to further research.

## **Results and discussion**

### **Framework of know-how transfer based on learning outcomes**

Current practice of know-how transfer in the company where action research was carried out is rather content and topics oriented and not towards a possible specifically defined attainable result. Accordingly, Learning outcomes approach was chosen to be tested, it allows to define the attainable results to improve the know-how transfer process. Therefore, understanding of stakeholders was essentially promoted but it became clear that understanding can differ essentially depending on both personal and environmental characteristics. The transfer methods (activities for both parties) were divided during the process to attain each specified result because the attainable results may be on various complexity levels. According to the observations and intervention within action research case study it is argued here that performance of the know-how transfer process is affected by variables as follows – accuracy of the stated aim (learning outcomes), applied methods and stakeholders' behavior (see Fig. 2).

Formulation and implementation should be separated and both affect the successful attainment of the result (Mintzberg, 2000). People must know what, how and why to implement (Fifield, 2007). For the statements of know-how transfer learning outcomes taxonomies presented by Bloom et al. (1956), Simpson (1972), Krathwohl et al. (1964) or some of revised versions (O'Neill and Murphy, 2010) are suggested. Constructive



alignment (Biggs, 2003) approach is suggested. It considers three groups of methods, which for the purposes of the Paper are applied as follows:

- 1) teaching methods, which in this case refer to what actions apply transferor,
- 2) learning methods – actions which are applied by transferee, and
- 3) assessment methods – actions applied to fix whether transfer has been done successfully.

The third variable within the developed framework is the stakeholders’ behavior. Kurt Lewin (1936) equation of behavior is adopted to explain characteristics affecting stakeholders involved in the process of know-how transfer. He argues that behavior is a function of the person and environment (Lewin, 1936).

To illustrate the results of action research performed, following equations are developed:

$$KH = f(K, S, A),$$

where

- KH – Know-how to be transferred (the aim stated),
- K – Demonstration of knowledge in behavior,
- S – Demonstration of skills in behavior,
- A – Demonstration of attitudes in behavior.

$$KHT = f(q_1K, q_2S, q_3A),$$

where

- KHT – Know-how transferred (the result achieved),
- K – Demonstration of knowledge in behavior,
- S – Demonstration of skills in behavior,
- A – Demonstration of attitudes in behavior,
- $q_n$  – Coefficient of the achieved outcome.

$$M = f(T, L, A),$$

where

- M – A blend of applied methods,



- T – Applied teaching methods,
- L – Applied learning methods,
- A – Applied assessment methods.

$$STC = \sum_{i=1}^n (P_i, E_i),$$

where

STC – A sum of characteristics affecting stakeholders’ behavior,

P – Internal environment characteristics,

E – External environment characteristics.

The equations explaining variables which affect the success of the know-how transfer enable to perform the analysis and look for compensating elements if some of them are not strong enough. For example, the applied methods can and should be adapted considering the characteristics of the stakeholders involved in the process. Prior knowledge should be provided in case of lack of them etc.

### Know-how transfer performance measurements

There are various performance measurement concepts in the literature. At the same time it is stated that misuse of different performance measurement notions are the cause for confusion (Tones and Tilford, 1994; Pfefer and Salancik, 2003; Roy, 2003; Hutcherson, 2014; Hockey, 2013), because they are not only used interchangeably but there are also different perspectives on each of them and, accordingly – definition. Therefore, complex approach to effectiveness measurements is applied in the Paper – effectiveness, efficiency and efficacy measurements are considered and specific definitions are adopted for the purposes of the Paper. Here the efficacy is defined as either power or capacity to produce the desired effect (Efficacy, n.d.), and as a result the following equation is designed:

$$Efficacy = \frac{\sum_{i=1}^n (P_i, E_i, T, L, A)}{f(K, S, A)}$$

It is suggested here to measure efficacy primarily before the start of know-how transfer project, because it is important to refuse the project on time if there is no capacity or the set objectives have to be reviewed. Also this equation can be complemented with the assumptions of Expectancy theory (Vroom, 1964) that is based on the idea that people believe there are relationships between the effort they put forth at work, the performance they achieve from that effort, and the rewards they receive from their effort and performance (Lunenburg, 2011). Whereas during or afterwards the project it can be useful to consider rational use of resources. The efficiency for the Paper’s purposes is defined as the ratio of the effective or useful output to the total input in any system (Efficiency, n.d.). The equation describing the efficiency of know-how transfer is given as follows:

$$Efficiency = \frac{f(q_1K, q_2S, q_3A)}{\sum_{i=1}^n f(P_i, E_i, T, L, A)}$$

With the aim to understand how the effectiveness of know-how transfer could be measured, effectiveness for the purposes of the Paper is defined as the degree to which objectives are achieved and the extent to which targeted problems are solved (Effectiveness, n.d.). The equation of effectiveness of know-how transfer can be defined as follows:

$$\textit{Effectiveness} = \frac{f(q_1K, q_2S, q_3A)}{f(K, S, A)}$$

It is suggested here that for know-how transfer to be found successful, the process must meet the standards for all the performance measurements provided in the Paper – efficacy, efficiency and effectiveness.

#### **Know-how transfer process model**

For the purposes of practical application of the framework developed during the action research, the know-how transfer six step process model based on Shewhart Cycle for Learning and Improvement – the PDSA Cycle (Deming, 1993) is designed:

- 1) Learning outcomes of the know-how transfer process should be stated as precisely as possible. Statements of the knowledge, skills and attitudes to be acquired must be distinguished and formulated considering the aspect of demonstration in behavior.
- 2) Appropriate teaching, learning and assessments methods have to be selected for each defined outcome statement, considering both internal environment characteristics (for example, prior knowledge, experience, motivation, values, beliefs, expectations, age and other abilities) and external environment characteristics (for example, organizational culture, structure, mission, aims and resources) of the stakeholders involved in the process.
- 3) Stakeholders involved in the process have to be familiarized with the learning outcomes and the selected teaching, learning and assessment methods.
- 4) Transfer of know-how should be implemented by applying the selected methods.
- 5) The success of the process should be monitored. Learning outcomes and/or the applied methods should be reviewed if necessary.
- 6) The process of transfer should be continued and final assessment should be applied to fix whether learning outcomes are achieved.

#### **Conclusions**

The research results show that learning outcomes based approach can be used for successful know-how transfer. The study suggests that framework developed in the Paper is applicable for know-how transfer within an open innovation concept. The study suggests that performance of know-how transfer is affected by accuracy of the stated aim (learning outcomes), the applied teaching, learning and assessment methods and both internal and external characteristics of the stakeholders involved in the process. The process model of know-how transfer developed in the Paper is verified within an action research case study and can be applied by practitioners. Performance measurements presented in the Paper give an insight to different perspectives which should be taken into account. Companies can use the process model to conduct a successful know-how transfer process and create value within open innovation. The findings complement the literature that advocates the action research as an effective approach to solve real-life business problems, particularly – know-how transfer. Further research may consider the relationships between different levels of knowledge, skills, attitudes and teaching, learning, assessment methods to be applied. Further analysis of the internal and external characteristics affecting behavior of the stakeholders within know-how transfer should be considered.

**Appendix**

**Table 1** Content analysis of Know-how definitions

Definition and source	Attributes			
	Knowledge	Skills	Attitudes	Behavior
<p>"The accumulated practical skill or expertise which allows one to do something smoothly and efficiently." Source: Von Hippel, E. (1987). Cooperation between rivals: Informal know-how trading. <i>Research Policy</i>, 16(6), 291–302.</p>		x	x	x
<p>"Description of knowing how to do something; description of what defines current practice inside a firm." Source: Kogut, B., Zander, U. (1992). Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology. <i>Organization Science</i>, 3(3), 383–397.</p>	x			x
<p>"A commercially viable integration of proficient technique gained by practicing the work process of an expert and contextual knowledge gained by observing and questioning other workers." Source: Wolek, F.W., Klinger, J.W. (1998). Apprenticeship and the transfer of technical know-how. <i>The Journal of Technology Transfer</i>, 23(3), 51–57.</p>	x	x		x
<p>"Specific professional and technological information which is commercially valuable and usually an industrial secret." (Translated by authors) Source: Baldunciks, J. (1999). <i>Svešvārdu vārdnīca</i>. Rīga: Jumava.</p>	x	x	x	
<p>"Knowledge or proficiency based high technology skill, specific knowledge co-existing with practical skills and their use including natural invention skill and scientifically proficient imagination." (Translated by authors) Source: Beljickis, I., Blūma, D., Kokže, T., Markus, D., Skujina, V., Šalme, A. (2000). Pedāg oģijas terminu skaidrojošā vārdnīca : aptuveni 1500 terminu latviešu, angļu, vācu un krievu valodā. Rīga: Zvaigzne ABC.</p>	x	x	x	x
<p>"Scientific technological, commercial, organizational etc. knowledge, information which specifically favors the user in business... in the form of trade secrets, non-patented technological processes, selective not generally known production or trade information... is international business deal object, a product that can be bought or sold." (Translated by authors) Source: Zināitība (2000). Ekonomikas skaidrojošā vārdnīca. <a href="http://termini.iza.lv/term.php?term=zinaitiba&amp;lang=L.V">http://termini.iza.lv/term.php?term=zinaitiba&amp;lang=L.V</a>. Accessed 14 May 2016.</p>	x	x	x	
<p>"Any professional skill based specific information including otherwise unavailable (undisclosed, confidential) information." (Translated by authors) Source: Zināitība (2002). Nacionālais Apgāds. <a href="http://www.letonika.lv/resursi/rtu.lv/groups/default.aspx?cid=30981&amp;r=1&amp;id=30981&amp;q=zin%C4%81%C4%AB&amp;h=5126">http://www.letonika.lv/resursi/rtu.lv/groups/default.aspx?cid=30981&amp;r=1&amp;id=30981&amp;q=zin%C4%81%C4%AB&amp;h=5126</a>. Accessed 14 May 2016.</p>	x	x	x	
<p>Organizational practices. Source: Jensen, R., and Szulanski, G. (2004). Stickiness and the Adaptation of Organizational Practices in Cross-Border Knowledge Transfers. <i>Journal of International Business Studies</i>, 35, 508–523.</p>				x
<p>"Contains trade secret specific information thus providing secrecy." (Translated by authors)</p>	x			





**Table 1** Content analysis of Know-how definitions (*Continued*)

<p>• the working of a source of mineral deposits, or the carrying out of any agricultural, forestry or fishing operations.” Source: Know-how. (2016). HMRC internal manual. <a href="http://www.hmrc.gov.uk/manuals/camanual/ca70010.htm">http://www.hmrc.gov.uk/manuals/camanual/ca70010.htm</a>. Accessed 14 May 2016.</p>	X				X
<p>“Knowledge of how to do something; expertise.” Source: Know-how. (2016). WordReference Random House Learner’s Dictionary of American English. <a href="http://www.wordreference.com/definition/know-how">http://www.wordreference.com/definition/know-how</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“Knowledge of how to do something; faculty or skill for a particular activity; expertise” Source: Know-how. (2016). WordReference Random House Unabridged Dictionary of American English. <a href="http://www.wordreference.com/definition/know-how">http://www.wordreference.com/definition/know-how</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“Ingenuity, aptitude, or skill; knack; commercial and saleable knowledge of how to do a particular thing; experience” Source: Know-how. (n.d.). Collins English Dictionary - Complete &amp; Unabridged 10th Edition. <a href="http://www.dictionary.com/browse/know-how">http://www.dictionary.com/browse/know-how</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“Knowledge of how to do something; faculty or skill for a particular activity; expertise.” Source: Know-how. (n.d.). Dictionary.com Unabridged. <a href="http://www.dictionary.com/browse/know-how">http://www.dictionary.com/browse/know-how</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“The knowledge and skill to be able to (do something correctly).” Source: Know-how. (n.d.). English Wiktionary. <a href="http://www.yourdictionary.com/know-how">http://www.yourdictionary.com/know-how</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“Proficiency or skill at a particular thing, knowledge of how to do something, expertise.” Source: Knowhow. (n.d.). EUdict. <a href="http://www.eudict.com/?lang=en2eng&amp;word=proficiency%20or%20skill%20at%20a%20particular%20thing,%20knowledge%20of%20how%20to%20do%20something,%20expertise">http://www.eudict.com/?lang=en2eng&amp;word=proficiency%20or%20skill%20at%20a%20particular%20thing,%20knowledge%20of%20how%20to%20do%20something,%20expertise</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“Practical ability, knowledge and skill in a technical area.” Source: Know-how. (n.d.). Financial Times. <a href="http://lexicon.ft.com/Term?term=know-how">http://lexicon.ft.com/Term?term=know-how</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“Knowledge, practical ability, or skill to do something.” Source: Know-how. (n.d.). Longman Dictionary of Contemporary English. <a href="http://www.ldoceonline.com/dictionary/know-how">http://www.ldoceonline.com/dictionary/know-how</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“Knowledge that is needed to do something, usually something practical.” Source: Know-how. (n.d.). Macmillan Dictionary. <a href="http://www.macmillandictionary.com/dictionary/british/know-how">http://www.macmillandictionary.com/dictionary/british/know-how</a>. Accessed 14 May 2016.</p>	X			X	X
<p>“Knowledge of how to do something well.” Source: Know-how. (n.d.). Merriam-Webster. <a href="http://learnersdictionary.com/definition/know%E2%80%93how">http://learnersdictionary.com/definition/know%E2%80%93how</a>. Accessed 14 May 2016.</p>	X			X	X

**Table 1** Content analysis of Know-how definitions (Continued)

"Knowledge of how to do something well; knowledge of how to do something smoothly and efficiently; knowledge of how to get things done." Source: Know-how. (n.d.). Merriam-Webster. <a href="http://www.merriam-webster.com/dictionary/know%E2%80%993how">http://www.merriam-webster.com/dictionary/know%E2%80%993how</a> . Accessed 14 May 2016.	X	X	X	X
"Knowledge of how to get things done." Source: Know-how. (n.d.). Merriam-Webster. <a href="http://www.wordcentral.com/cgi-bin/student?book=Student&amp;va=know-how">http://www.wordcentral.com/cgi-bin/student?book=Student&amp;va=know-how</a> . Accessed 14 May 2016.	X			X
"Knowledge gained by actually doing or living through something." Source: Know-how. (n.d.). Merriam-Webster. <a href="http://www.wordcentral.com/cgi-bin/thesaurus?book=Thesaurus&amp;va=know-how">http://www.wordcentral.com/cgi-bin/thesaurus?book=Thesaurus&amp;va=know-how</a> . Accessed 14 May 2016.	X			X
Knowledge of how to do something and experience in doing it." Source: Know-how. (n.d.). Oxford Advanced Learner's Dictionary. <a href="http://www.oxfordlearnersdictionaries.com/definition/english/know-how">http://www.oxfordlearnersdictionaries.com/definition/english/know-how</a> . Accessed 14 May 2016.	X	X	X	X
"Practical knowledge or skill; expertise." Source: Know-how. (n.d.). Oxford University Press. <a href="https://en.oxforddictionaries.com/definition/know-how">https://en.oxforddictionaries.com/definition/know-how</a> . Accessed 14 May 2016.	X	X	X	X
"The knowledge and skill required to do something correctly." Source: Know-how. (n.d.). The American Heritage® Dictionary of the English Language, 4th Ed. <a href="https://www.wordnik.com/words/know-how">https://www.wordnik.com/words/know-how</a> . Accessed 14 May 2016.	X	X	X	X
"Skill, technical skill; practical competence" Source: Know-how. (n.d.). The Dictionary of American Slang. <a href="http://www.dictionary.com/browse/know-how">http://www.dictionary.com/browse/know-how</a> . Accessed 14 May 2016.	X	X	X	X
"The (technical) knowledge and skill required to do something." Source: Know-how. (n.d.). Vocabulary.com. <a href="https://www.vocabulary.com/dictionary/know-how">https://www.vocabulary.com/dictionary/know-how</a> . Accessed 14 May 2016.	X	X	X	X
"The knowledge and skill to be able to (do something correctly)." Source: Know-how. (n.d.). Wiktionary. <a href="https://www.wordnik.com/words/know-how">https://www.wordnik.com/words/know-how</a> . Accessed 14 May 2016.	X	X	X	X
"The (technical) knowledge and skill required to do something." Source: Know-how. (n.d.). WordWeb Software. <a href="http://www.wordwebonline.com/en/KNOWHOW">http://www.wordwebonline.com/en/KNOWHOW</a> . Accessed 14 May 2016.	X	X	X	X
"The ability to achieve a practical end due to knowledge and/or skill. ... intangible property, the rights to which a person may buy or sell." Source: Know-how. (n.d.). Cornell University Law School. <a href="https://www.law.cornell.edu/wex/know-how">https://www.law.cornell.edu/wex/know-how</a> . Accessed 14 May 2016.	X	X	X	X



**Table 1** Content analysis of Know-how definitions (*Continued*)

<p>"Expert skill, information, or body of knowledge that (1) imparts an ability to cause a desired result; (2) is not readily available, and is (3) outside the public domain. Know how may include tangible material (such as blueprints, formulas, instructions, patterns, specifications, and trade-secrets) or intangibles (such as manufacturing practices, marketing concepts, quality control, and testing techniques) which are not common knowledge. In technology transfer agreements, know how is the most valuable factor and may have an indefinite enforceable life. Any industrial information and technique likely to assist in the manufacture or processing of goods or materials."                  Source: Know-How. (n.d.). WebFinance. <a href="http://www.businessdictionary.com/definition/know-how.html">http://www.businessdictionary.com/definition/know-how.html</a>. Accessed 14 May 2016.</p>	<p>X</p>	<p>X</p>	<p>X</p>	<p>X</p>	<p>X</p>	<p>X</p>	<p>...any form of technical information or assistance relating to the manufacture or placing into operation of the said products. ...any practical knowledge, techniques, and skill that are required to achieve some practical end. ...an intangible property in which rights may be bought and sold. ...the technical skill, which large groups of men acquire through extensively financed experimentation and cooperation. ...factual knowledge not capable of precise, separate description. ...when used in an accumulated form, after being acquired as the result of trial and error, gives to the one acquiring it an ability to produce something which otherwise would not have known how to produce with the same accuracy or precision found necessary for commercial success."                  Source: Know-How Law &amp; Legal Definition. (n.d.). USLegal. <a href="http://definitions.uslegal.com/k/know-how-intellectual-property-rights">http://definitions.uslegal.com/k/know-how-intellectual-property-rights</a>. Accessed 14 May 2016.</p>
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**Table 2** Validation of developed equations

Participant	KH	KHT	M	STC	Efficacy	Efficiency	Effectiveness
A	Valid	Valid	Valid	Valid	Valid	Valid	Valid
B	Not valid	Not valid	Valid	Valid	Not valid	Not valid	Not valid
C	Not valid	Not valid	Not valid	Not valid	Not valid	Not valid	Not valid
D	Valid	Valid	Valid	Valid	Valid	Valid	Valid
E	Valid	Valid	Valid	Valid	Valid	Valid	Valid
F	Valid	Valid	Valid	Valid	Valid	Valid	Valid
G	Valid	Valid	Valid	Valid	Valid	Valid	Valid
H	Valid	Not valid	Valid	Valid	Valid	Not valid	Not valid
I	Valid	Valid	Valid	Valid	Not valid	Valid	Valid
J	Valid	Valid	Valid	Valid	Valid	Valid	Valid

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**Authors' contributions**

Both authors read and approved the final manuscript.

**Competing interests**

The authors declare that they have no competing interests.

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