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KNOWLEDGE MANAGEMENT IN SOFTWARE DEVELOPING ORGANIZATIONS; A NEW PARADIGM

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ABSTRACT

Software Developing Organisations (SDOs) usually do not have designed, documented, implemented and maintained Knowledge Management Systems (KMSs) in spite of the fact that they develop a product, i.e. software, which is entirely made up of knowledge. Thus far, science has not developed any instruments of cognition of this sphere of reality. Studies should be undertaken which will allow to indicate such instruments. A model solution in that respect may consist in treating the Quality Management System as a framework for the KMS. The article presents a 7-stage model facilitating creation of a Knowledge Management System in Software Developing Organisations which apply Quality Management Systems.

Keywords: Software developing organisation, knowledge management, quality management systems

INTRODUCTION

Numerous scholars point out to the fact that the present stage of the civilisation development can be described by the term "information society". The development of the information society is principally determined by the use of information and knowledge in combination with different communication and information techniques. It seems that software developing organisations (SDOs), which provide a specific product, i.e. software, are of fundamental importance for the information society. An assumption has been made in the article that a software developing organisation is the one which participates in all – or only selected ones – stages of the software life. An SDO is frequently treated as an almost perfect example of a knowledge-based organisation since the results of its activities, i.e. software and related services, are products based solely on knowledge. Hence, the conclusion arises that it is necessary to create and apply a knowledge management system (KMS) in such an organisation.

It follows from even a cursory analysis that although SDOs generate products entirely based on knowledge, they have not designed, documented, and implemented a KMS and do not maintain such a system. This observation is confirmed by the literature – very scarce – on the subject. Thus far, science has not developed any instruments of cognition of this sphere of reality. This article presents an outline of an approach to creation of KMSs in SDOs, however with taking into consideration quality management systems. It is an effect of the author's many-years' experience as a designer, programmer, implementation organiser and project manager in SDOs, as well as of his experience gained from designing, documenting and implementing quality management systems (QMSs) for Polish and foreign companies fulfilling the requirements of the proposed definition of the SDO.

THE FUNCTIONALISTIC PARADIGM AND THE FORMS IT ASSUMES

If we assume after T. S. Kuhn [11] that a paradigm is generally acknowledged scientific achievements which after some time provide the community of researchers with model problems and solutions, then it seems that new paradigms are needed which will be instruments of cognition of a certain aspect of reality. They should assume the form of convictions, attitudes and believes shared by scholars practising the relevant scientific discipline.

A model problem in SDOs is a lack of designed, documented, implemented and maintained QMSs. A proposed model solution to the problem can consist in making the QMS, as conformable with the series 9000 ISO standards, a matrix (framework) for the KMS [4, 7].

The outlined approach presented in the paper is an attempt to prepare a research aimed at employing the attainment of quality management system to construction of knowledge management systems in software developing organizations. The research in all likelihood has the uniqueness value which can be proved by the presented below studies in the broadly conceived subject area of knowledge management and knowledge management systems. Some of them have been described in short below. They refer to the information technology branch in the scope of e.g. software development in an organisation, application of information technologies in the course of implementation of virtual projects, relations between raising knowledge by the employee, sharing knowledge with the group, raising the effectiveness of the organisation's operations.

The examples given are not an exhaustive presentation of all the works undertaken in this area. The description is not complete; its aim is only to demonstrate how diverse studies are undertaken and brought to an end, for instance through making public their results. The author has been interested in the investigations and their results – available in literature – as conducted recently, i.e. in 2009 and later. The below survey of the studies conducted is a proof that the research undertook by the author is in no case a continuation of those studies.

Thus A. M. Subramianian has identified the factors affecting the use of knowledge management systems [13]. He classified them as technological, individual, organisational, and social ones. The research was done on software companies providing services to minimum 500 customers each. They offer their software to finance, administration, telecommunication, production, and health protection sectors. A special questionnaire was prepared. It contained 31 questions which were answered by 180 respondents.

P. Arora, D. Owens, D. Khazanchi are concerned with developing a (software) tool that facilitates knowledge management in organisations participating in implementation of virtual projects [1]. The projects are understood as undertakings which are effected by geographically disseminated members of the team. They apply information technologies in their work by means of which they communicate. The tool is aimed at transferring and sharing knowledge in virtual projects in an efficient and cost-effective manner. It is enabled – as the authors suggests – through creating database patterns. Theoretical foundations of the tool are based – according to the authors – on the theory developed previously by other researchers (Kazanchi and Zigurs, the years 2005-2008). The researchers identified the cases in which the said tool may be applied in the course of implementation of virtual projects. The tool is a prototype which needs verification. A questionnaire was published which included 42 questions. The answer to the questions will allow to adjust the virtual projects to the capabilities of the IT tool.

Krishnaveni and Raja have commenced their research with a knowledge management life cycle [10]. The elements of the cycle are processes. There are seven such processes (e.g. knowledge organisation, knowledge archiving, etc.). Descriptive elements (descriptors), in the number of 51, were indicated for each of the life cycle elements. The authors carried out studies – with the application of statistical models – indicating the effect of the knowledge management life cycle model on the benefits achieved in respect of knowledge by companies of the information technology sector. Respondents, in the number of 59, allowed to collect a proper sample for research.

Batra has developed research forms on the basis of various sources (articles, periodicals, the Internet, etc.) [2]. The respondents were 50 employees of the IT company NCR – with a considerable professional experience, representing the executive level. Hypotheses were made and their statistical verification was carried out. The hypotheses concerned without limitation:

- the determination of the mutual impact between knowledge management processes (the knowledge management life cycle according to Leibowitz was adopted) and the individual increase of knowledge of the organisation employee with a simultaneous support of the organisation effectiveness,
- the impact of the constructed knowledge management processes for people working in a connection network on product (service) innovations delivered to customers.

L. Z. Cantu with a team has constructed and then validated a model of generation and transfer of knowledge in an organisation [3]. The model investigates the relations between three dimensions, namely: knowledge generation, knowledge transfer, and secret knowledge extension (occurrence areas). The specified dimensions are provided with more details through stating proper components (constructs). Thus knowledge generations have such components as: organisational culture, management style, personnel motivation, learning opportunity. The research was participated by thirty companies of the information technology sector from the Barcelona region. The average length of time of the companies in the market is 3, 4 years. The respondents were 105 employees of those companies. The research was conducted by means of questionnaires and the results were presented with the use of statistical models.

E. Revilla has selected for the research 80 products under development. The impact of individual categories of the information technology description (differentiation, assimilation, exploitation, exploration) on the knowledge base of the products developed was examined. It follows from the research that information technology solutions supplement more the developed product knowledge base in respect of their exploitation than in respect of development of knowledge on the products [14].

N. Mundra with collaborators has undertaken a research concerning the participation of knowledge management in realisation of a more effective organisation management strategy. A questionnaire with 12 questions was addressed to 15 companies of the information technology sector, including so well known as: Siemens, HP, Accenture. The questionnaire with inquiries was drawn up on the basis of original sources (direct observation, talks with proper persons, etc.), as well as secondary ones (Intranet, the company's official documents, discussions, etc.) [12].

Paradigms have been classified. For, instance, according to G. Burrell and G. Morgan, the paradigm dominating in social sciences is called functionalistic [9]. According to K. Kostera, scientific research should lead to conclusions of the type: implications for practice and implications for future studies. They can assume the following form:

- proposing guidelines on how to solve practical problems of management,
- creating and developing a language for management,
- providing practitioners with comparative models enabling a self-analysis and a self-assessment,
- generating generalising knowledge which should be construed as significant and credible,
- striving for elimination of uncertainty in the world of organisation.

In view of the limited dimensions of the article, we will describe only the first of the above mentioned forms.

PROPOSING GUIDELINES ON HOW TO SOLVE PRACTICAL PROBLEMS OF MANAGEMENT

The methodology is oriented to undertaking activities which transform the QMS (quality management system) into a frame of the KMS. Suppositions that such activities are possible have appeared in the literature on the subject [4, 7]. The methodology is presented in Figure 1.

The article presents an outline approach to creating a KMS in the SDO, however with regard to the QMS. It is a result of the author's many years' experience as a designer, programmer, implementation organizer and project manager in SDOs. Another field of his experience is works related to designing, documenting and implementing quality management systems (QMS) for Polish and foreign companies fulfilling the requirements of the SDO definition as quoted above.

The requirements that the above outline approach should meet may be reduced to the following elements:

a) it refers to the idea of quality management systems (QMS) as reflected in ISO international standards since these standard are most frequently the base for designing, documenting, implementing and maintaining quality management systems. The QMS is defined as a management system (a system for setting policies and objectives as well as achieving the objectives) intended for running an organization (a group of people and infrastructure with responsibilities, authorities and relations assigned) and supervising it with regard to quality,
b) it links the QMS, through ISO standards, with standard specifications in the form of all types of guidelines related to the SDO;
c) it makes it possible to localise knowledge in the SDO;
d) it makes it possible to specify elements of the KMS with the purpose of analysing them,
e) it makes it possible to analyse elements of the KMS which should contribute to the improvement of the KMS, and this in turn affects the QMS (a delivery of efficient software that meets customers' requirements).

It follows from the requirements which should be complied with by the outline approach to the KMS formation that the approach is closely related to the QMS. The above thesis can also be met in publications on the subject in the form of the suggestion that the QMS may be susceptible to the KMS, i.e. it can be a carrier for such a system.

The proposed approach to the KMS formation for the SDO is composed of five stages (see Figure 1). The stages are specified below (along with their characteristics):

Stage 1: Classification of QMS processes

A starting point for the proposed approach is a classification of QMS processes. They have been divided as follows:

a) main processes – they apply to product (here: software) realization and reflect the product life cycle as starting from software (product) related requirements specification through requirements reviewing, product realization planning, purchases, production and service delivery and follow up activities,
b) auxiliary processes – they support proper functioning of management processes, main processes and auxiliary processes,
c) management processes – they can be reduced to decisions constituting the QMS as taken by the top management. They can include documentation related requirements and management responsibility which in

turns includes management commitment, customer-oriented approach, quality policy, planning, responsibility, authorities, communication, management review,

d) improvement processes – they include continuous improvement, and preventive corrective activities.

Stage 2: Development of assumptions of a semantic model for presentation of requirements of ISO 9001:2000 and recommendations of ISO/IEC 90003:2004 (hereinafter called "model")
The ISO 9001:2000 standard is too general to render the QMS specificity for the SDO. The standard presents the requirements that should be met by an organization (here: SDO) so that the QMS might comply with standard requirements. The above standard has been expanded through provision of detailed recommendations. The recommendations are included in ISO/IEC 90003:2004 (Software engineering – Guidelines for the application of ISO 9001:2000 to computer software). The semantic model should facilitate application of both the above standards through defining the meaning of contents of specific elements of the standards. They have been divided into the following groups:

a) postulates, i.e. demands or requirements, and
b) questions, i.e. issues that should be additionally considered and, if possible, resolved.

Both the postulates and the questions can be attributed with different meanings of the attached contents (extensions) as provided by the ISO 9001:2000 standard and the ISO/IEC 90003:2004 recommendations. Those extensions may refer to:

a) the proposed method of realization,
b) specification of the scope,
c) additional notes as regards the realization method,
d) examples,
e) references to other sections of ISO 9001:2000,
f) references to other standards.

For individual sections of the ISO 9001:2000 standard and the related recommendations, the above extensions may occur in different numbers (e.g. several methods of specifying the scope, several examples, etc.) and with different intensity (e.g. only examples are given, or a number of realization methods, or some additional notes, or references to a standard other than ISO 9001:2000 are also provided). All the relations in the semantic model as described above are shown in Figure 2.

Stage 3: Presentation of individual QMS processes by means of a semantic model.
Using the model potentialities, individual QMS processes can be presented. More information on the subject can be found in some books [5].

Stage 4: Working out of maps of individual processes while taking into account the model assumptions
The legend to the Figure consists of markings of the icons applied. The process map presents in a one place a selected process in an abbreviated form, thus enabling the process analysis.

Stage 5: Working out of potential decisions as a method for knowledge localisation
The process map prepared for reviewing the design and development process, as complying with the requirements of ISO 9001:2000 and recommendations specified in ISO/IEC 90003:2004, will be used for linking the QMS with the KMS. Assuming that the key knowledge management processes include: knowledge localisation, knowledge procurement, knowledge development, knowledge sharing, knowledge dissemination, knowledge utilization, knowledge maintenance [13], the hypothesis can be proposed that it is possible to elaborate the localisation of knowledge in an SDO that applies the QMS – an example of a key knowledge management process – provided that potential decisions to be taken by the implementing team are previously defined [8].

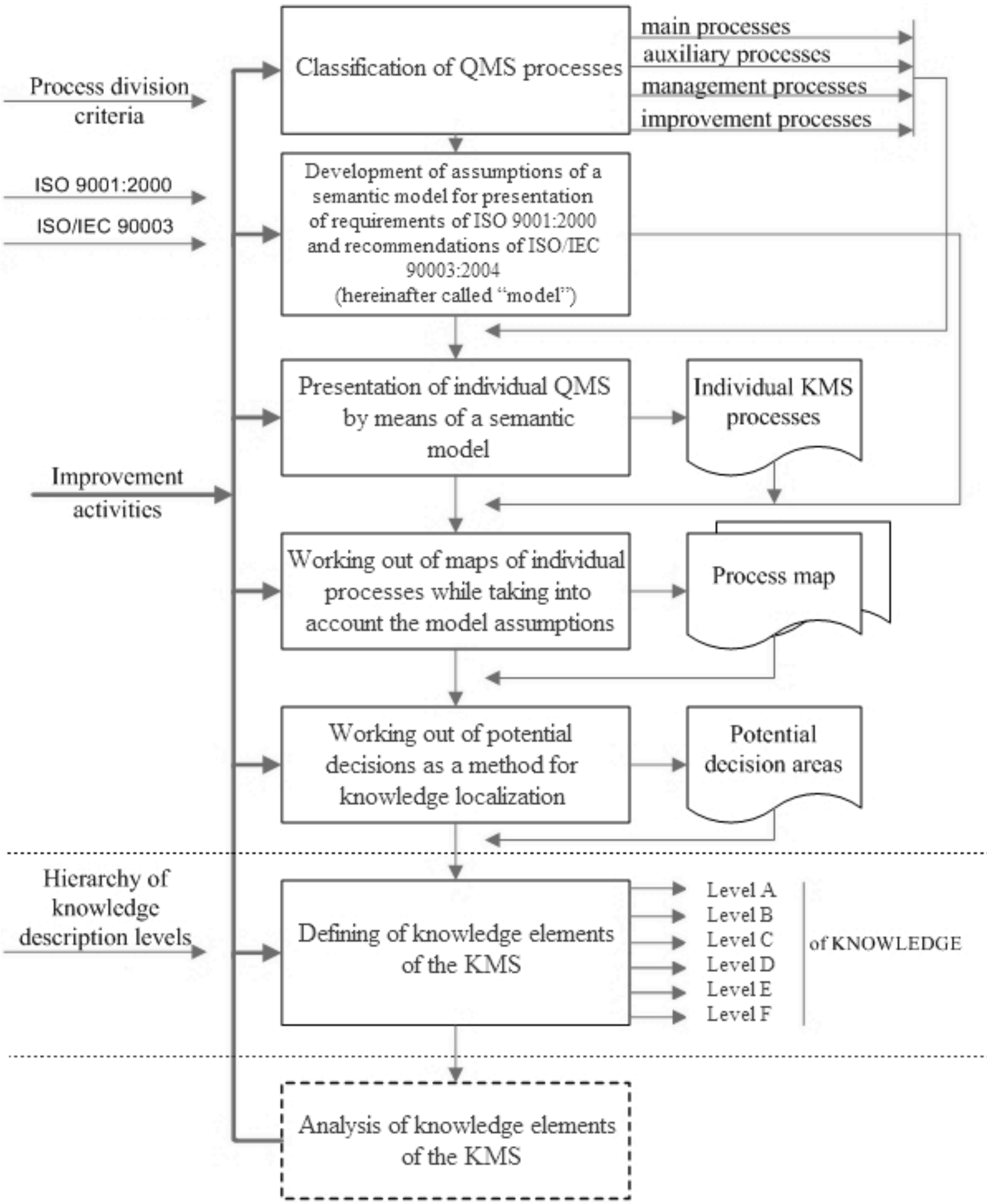

Figure 1. Elements taken onto account when specifying the method of constructing a KMS for SDOs that apply a QMSs

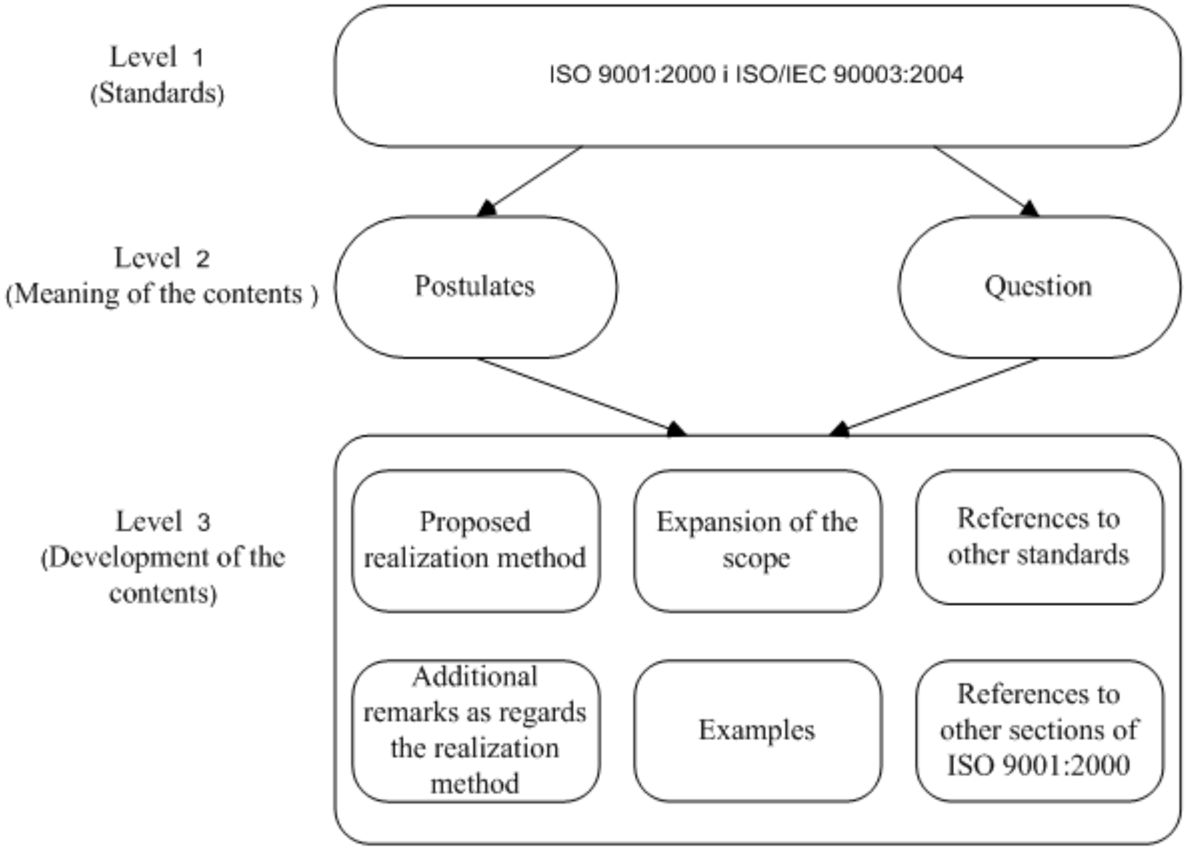

Figure 2. Relations between semantic model levels

Based on the standard structure, six levels of knowledge description have been indicated.
The structure of processes related to design and development includes the following elements:
Level A: Basic processes
Level B:

1) Planning of product realization – 7.1
2) Customer related processes – 7.2
3) Design and development – 7.3
4) Purchasing – 7.4
5) Production and service provision – 7.5

Level C (for 7.3):

1) Design and development planning – 7.3.1
2) Design and development inputs – 7.3.2
3) Design and development outputs – 7.3.3
4) Design and development review – 7.3.4
5) Design and development verification – 7.3.5
6) Design and development validation –7.3.6
7) Control of design and development validation –7.3.7

Level D (for 7.3.1):

1) Design and development planning – 7.3.1.1
2) Review, verification and validation – 7.3.1.2
3) Responsibilities and authorities – 7.3.1.3
4) Interfaces – 7.3.1.4

Level E (only 7.3.2 and 7.3.3): Potential decision areas (Table 1) for 7-3-2 (1 to 9) and for 7.3.3 (10 to 22)

Level F: Decisions taken

Table 1. Level E of the knowledge description hierarchy intended for the knowledge localisation in the SDO for level B (design and development – 7.3) and level C, i.e. design and development inputs (7.3.2) and design and development outputs (7.3.3).

No.	Model element	Potential decisions localizing knowledge in the SDO
1.	Postulate 1 (7.3.2)	1. Inputs relating to product requirements shall be determined and quality records maintained – in respect of functional and performance requirements
		2. Inputs relating to product requirements shall be determined and quality records maintained – in respect of applicable statutory and regulatory requirements
		3. Inputs relating to product requirements shall be determined and quality records maintained – information derived from previous similar designs
		4. Inputs relating to product requirements shall be determined and quality records maintained – other requirements essential for design and development
2.	Postulate 2 (7.3.2)	5. Design and development inputs shall be complete
		6. Design and development inputs shall be unambiguous
		7. Design and development inputs shall not be in conflict with each other
3.	Question 1 (7.3.2)	8. Determination of the system requirements allocated to software and specification of the interfaces between the system components for the purpose of software requirement analysis
4.	Question 2 (7.3.2)	9. Determination of design and development input (e.g. on the basis of functional, performance, quality, relevant safety and security requirements, system design constraints, derived through prototyping techniques, design change requests originating from previous phases in iterative development model, problems to be fixed, or requirements arising from acceptance criteria, etc.)
5.	Postulate 3 (7.3.3)	10. The outputs of design and development shall be provided in a form that enables verification against design and development input
		11. The outputs of design and development shall be approved prior to release
6.	Postulate 4 (7.3.3)	12. Design and development outputs shall meet the input requirements for design and development
		13. Design and development outputs shall provide appropriate information for purchasing production and for service provision
		14. Design and development outputs shall contain or reference product acceptance criteria
		15. Design and development outputs shall specify the characteristics of the product that are essential for its safe and proper use
7.	Question 4 (7.3.3)	16. Determination whether the outputs from the design and development process are defined and documented in accordance with the prescribed and chosen method
8.	Question 5	17. Determination whether the outputs from design and development are complete

	(7.3.3)	18. Determination whether the outputs from design and development are accurate and consistent with the requirements
9.	Question 6 (7.3.3)	19. Determination of the form of expressing design and development outputs, e.g. a text, a diagram, a symbolic modelling notation (e.g. data models, pseudo code or source code, etc.)
10.	Question 7 (7.3.3)	20. Determination whether design and development documentation has been worked out for the prototyping applied
11.	Question 8 (7.3.3)	21. Defining of acceptance criteria for design and development in order to demonstrate that the inputs to each design and development stage is correctly reflected in the outputs
12.	Question 9 (7.3.3)	22. Have the tools been validated for their specific intended use?

CONCLUSIONS

If we treat the lack of KMSs in SDOs as a research problem, any attempt to solve the problem requires defining a new paradigm. Reports in the literature on the subject are very scarce. The new paradigm should provide the community of learners, at the minimum, with a method of solving of the defined problem. It seems that such a paradigm should aim at creating a methodology of transition from a QMS (if implemented in the SDO) to a KMS. Such a model has been presented in the article. It also yields some additional research opportunities through defining the hierarchy of knowledge description levels.

It follows from the studies conducted by the author on processes of knowledge location and acquisition that the model is useful in SDOs.

REFERENCES

1. Arora, P., Owens, D., Khazanchi, D. (2010), "A pattern-based tool for knowledge management in virtual projects", *The IUP Journal of knowledge management*, Vol. 7 No. 3.
2. Batra, J. (2010), "Knowledge management: Emerging practices in IT Industry in NCR", The *IUP Journal of Knowledge Management,* Vol. 8 Nos. 1 & 2.
3. Cantú, L.Z., Criado, J.R., Criado, A.R. (2009), "Generation and transfer of knowledge in IT-related SMEs", *Journal of knowledge management*, Vol. 13 No. 5.
4. Cieśliński, W., Perechuda, K., Witkowski, K., Zarządzanie procesami-organizacja dyfuzji wiedzy w gospodarce cyfrowej *[Process Managing – Organizing Knowledge Diffusion in a Digital Economy]*, [in:] R. Knosala, [ed.], Komputerowe Zintegrowane Zarządzanie *[Integrated Computerised Management]*, Vol. 1, WNT, Warsaw 2005.
5. ISO 9000:2000, Quality management systems – Fundamentals and vocabulary, Brussels, 2000.
6. ISO/IEC 90003:2004, Software Engineering Guidelines for Application ISO 9001:2000 to Computer Software.
7. Jashapara, A. (2004), "Knowledge Management: as Integrated Approach", Pearson Education Limited. Polish version*: Zarządzanie wiedzą. Zintegrowane podejście*, PWE Warszawa 2006, p. 168.
8. Kisielnicki, J. (2003), "System pozyskiwania i zarządzania wiedzą we współczesnych organizacjach" *[Knowledge Acquisition and Management System in Contemporary Organizations]*, Zarządzanie wiedzą we współczesnych organizacjach *[Knowledge Management in Contemporary Organizations],* Oficyna Wydawnicza Wyższej Szkoły Handlu i Prawa im. R. Łazarskiego, Warszawa.
9. Kostera, K. (1996), Postmodernizm w zarządzaniu, PWE, Warszawa, p. 35-37.
10. Krishnaveni, R., Raja, S. (2009), "An empirical study on the impact of KM life cycle activities on the KM benefits of IT organizations", *The IUP journal of knowledge management,* Vol. 7 Nos. 3 & 4.
11. Kuhn, T.S (1962), *The structure of scientific revolutions, Chicago, University of Chicago; Toronto, University of Toronto 1962.*
12. Mundra, N., Karishma, G., Vashisth, R. (2011), "Achieving competitive advantage through knowledge management and innovation: Empirical evidences from the Indian IT sector", *The IUP journal of knowledge management*; Vol. 9 No. 2.

13. Probst, G., Raub, S., Romhardt, K. (2000), Managing Knowledge: Building Blocks for Success. John Wiley & Sons, London. Polish version: *Zarządzanie wiedzą w organizacji*, Oficyna Ekonomiczna, Kraków 2002.
14. Revilla E. (2009), "Information technology as knowledge management enabler in product development", *European journal of innovation management.* Vol. 12 No. 3.
15. Subramanian A.M., Soh P-H. (2009), "Contributing knowledge-to-knowledge repositories: dual role of inducement and opportunity factors", *Information Resources management Journal*, 22(1); 1-3.