RIGA TECHNICAL UNIVERSITY

Ginta ŠTĀLE

INFORMATION TECHNOLOGY ECOSYSTEM MODEL FOR SUPPORT OF CONTINUING EDUCATION

Summary of Doctoral Thesis

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„ E-Learning Technologies and Management”

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I hereby confirm having written this doctoral thesis which I have submitted for obtaining a doctoral degree in engineering sciences from Riga Technical University. The doctoral thesis has not been submitted to any other university for a degree in engineering.

Ginta Štāle …….(Signature)

Date: ……

The Doctoral thesis is written in Latvian, it consists of the introduction, 3 chapters, conclusions, a list of literature, 11 appendices, 68 pictures, 18 tables, a total of 182 pages. There are 327 titles in the bibliography.

CONTENTS

INTRODUCTION

Information technologies and their application account for a significant part of people's lives in a knowledge society. [Maier R., 2010]. The role of continuing education in an individual's professional and private life is strengthened by innovations in the sphere of technologies, changes in the work style in organizations, and by an increasing role of technologies in everyday life [Qiong W., Biao M, 2010]. Provision of continuing education is becoming more significant due to ever increasing necessity for personal growth and competence development. [Hansman C.A., Mott V.W., 2010, Cheung K.S.u.c., 2009; Hernandez-Leo D., 2010]. Continuing education is an important activity for one's active involvement in social environment and enhancing of competitiveness. [Kasworm C.E., u.c., 2010]. A wide spectrum of technologies is available for education in the world. [Tchounikine P., 2011], including continuing education. [Stale G., 2008].

Knowledge flows are "invisible", but very essential for achievement of success for an individual or an organization [Leistner F., 2010]. Application of information technologies in continuing education facilitates knowledge flow and makes its contents accessible regardless of the individual's location and time. [Nissen M.E., 2006]. Each of the applied technologies in continuing education provides for a particular service or helps to find a solution for a specific problem. The various application of technologies ensures a potential for acquisition of diverse learning contents; on the other hand, it may impede the learning process due to underestimation of its use in the particular situation. [Chang, V., Guelt, C., 2007]. Application of ecosystem theories in the development of an information technology model offers a possibility to evaluate and predict the impact of technologies on the implementation of continuing education processes and the required time for an individual to achieve the desired competencies [Adomavicius G., et. al, 2008; Stale G., et al., 2010; Stale G., 2009].

The sphere of continuing education differs from other spheres in education in a way that it is implemented outside formal education and situations where individuals learn [Hansman C.A., Mott V.W., 2010]. The individuals' previous education levels may differ, as well as their work and life experience. These factors should be taken into account providing the contents of continuing education with adequate technologies. This is successfully done in specific continuing education courses for enhancement of professional competencies (e.g., courses on the latest Microsoft software in the Baltic Computer Academy with face to face meetings). However`, more and more people

choose to enhance their competencies with the use of distance learning and using the available technologies [Hansman C.A., Moto V.W., 2010].

Considering all the above, the author has come to the conclusion that it is necessary to develop a model which provides assessment of the applied technologies for the particular situation in continuing education and offers a way of developing competencies relevant for the given individual in the shortest possible timeframe, simultaneously developing the contents of continuing education and fruitful cooperation of its participants. Ecosystem approach in the given situation makes it possible to characterise and evaluate changes in the competencies of the participant of the educational process, and interaction of technologies, and to reflect this interaction in a graphical way. This approach was chosen with an aim to integrate the digital ecosystem theory and its principles of operation for identification of potential directions of technology development. Digital ecosystem operation principles include technology as interaction of elements, self-organization and adaption, which provides for knowledge creation and dissemination in a company, community or any other organization [Uden L., Damiani E., 2007]. This doctoral thesis focuses mainly on interaction principles. It is based upon conclusions of a group of scientists who ascert that from the point of view of the ecosystem technology interaction and development models are important, and it is an essential area of research in the era of rapidly changing technologies [Adomavicius G., u.c., 2008].

The introduction of the doctoral thesis gives characteristics of the problem situation, its justification, topicality of the theme, the aim and objectives of the doctoral thesis, as well as the scientific outcomes and their practical application and evaluation.

Problem Situation and Justification of the Research

The current rapid economic changes and development of information technologies create a necessity for a continuing educational process [Stale G., 2009]. For the provision of continuing education process various technologies are being developed and offered to its participants, however, what is missing is a continuing education process model which would reflect provision of application of learning context relevant technologies and methodology for defining the requirements for a new information system.

Significance of such research has been emphasised by several researchers who put a focus on the following aspects of the problem situation:

- a wide spectrum of offers in computer technologies provides for their application in solving everyday situations, which in its turn creates a demand for technology integration and cooperation in a single system [Adomavicius G., et al., 2008], [Quinones M., et al., 2008], [Adomavicius G., et al., 2007];
- alongside application of versatile use of technologies in organizations (including continuing education) it is necessary to create a model of technology ecosystem for identifying the factors that affect this system, as well as a technology for analysis of potential impact of the technologies [Adomavicius G., et al., 2008];
- rapid changes in social and work environment create a necessity for continuing education, however, the tight schedules do not allow for a longer absence from work, thus creating a demand for an overall system where an individual could work and study simultaneously [Leong P., Miao Ch., 2008];
- the increasing requirement for continuing education creates a necessity for improvement of accessibility and efficiency of e-study environment [Chang V., Guelt C., 2007], which in its turn creates a necessity for application of a holistic approach to the study process, for an adaptive system and user-friendlier and cheaper solutions [Guelt C., et al., 2005];
- the fast development of industry, economics and business environment facilitates changes in the cultural and social environment, and create a demand for a continuing education process relevant to the technological changes [Gadus, J., et al., 1999];
- web technology application development, more widespread business environment and systems in the internet create both a demand and a supply of solutions for integrated continuing education and business information systems [Maier R., 2010].

Topicality of the theme

Currently different continuing education courses have been developed not only in Latvia, but in the whole world. Every educational institution offers its own training management system, including teaching materials, different lectures and interactive multimedia learning materials.

The author of this doctoral thesis has elaborated an IT ecosystem model for continuing education providing assessment of relevance of an IT solution for the particular situation; it also presents the way of learning for acquisition of the desired competencies in the shortest time possible. The model helps to select systemic IT solutions which facilitate contents development in continuing education and fruitful cooperation of its participants. The technology ecosystem approach provides planning their interaction and development possibilities.[Adomavicius G., u.c., 2008].

Topicality of the theme is emphasised in the following documents:

- "Memorandum of Lifelong Learning" issued by European Commission on 30 October, 2000, in Brussels [A Memorandum of Lifelong Learning, 2000];
- Communication from the Commission of the European Communities "Making a European Area of Lifelong Learning" [Making a European Area of Lifelong Learning, 2001];
- The Lisbon European Council conclusions pointing out that continuing learning is an important precondition for transition to knowledge based economy and society [Markkula M., Sinko M., 2012];
- The National Development Plan of the Republic of Latvia stating the necessity to enhance accessibility of continuing education by creating diversified cooperation between the education providers and seekers [National Development Plan, 2012];
- The European Community Sixth Framework Programme Project *Ten Competences* conclusions and outcomes pointing at the analysis of IT application as an essential component part in competency development in continuing education [Hernandez-Leo D., 2010].

Research Questions

How do information technologies (IT) affect knowledge flow in continuing education processes? In what way could appropriate IT use affects knowledge flow in continuing education processes and enhancement of competencies of an individual? How to characterise the most appropriate learning path in the given context?

Research Object

The object of research of this doctoral thesis is information technology ecosystem for continuing education.

Goals and Objectives of the Doctoral Thesis

The **goal** of the doctoral thesis is to characterise the increase in knowledge flow and participants' competences in the use of technology-related continuing education situations while elaborating an IT ecosystem model and software prototype for the support of continuing educational process.

To reach the goal of the doctoral thesis, the following **objectives** were set:

- to explore and develop theoretical models for continuing education IT ecosystem on the basis of other researchers' findings in this problem sphere;
- to explore knowledge flow in IT ecosystem and its forecast in the context of time dimension;
- to develop an IT ecosystem model for the support of continuing education process;
- to develop software requirements for the implementation support of continuing education IT ecosystem model;
- to develop software architecture and prototype for assessment of competence increase, analysis and forecast in continuing educational IT ecosystem;
- to evaluate continuing education IT ecosystem model and the developed software prototype.

The following **theses** are put forward for the defence of the doctoral Paper:

- the main components of continuing education IT ecosystem are: the student's portfolio, knowledge contents and knowledge flow, technologies both of the continuing education service provider and the receiver, as well as methods of their interaction, adaption and self-organization;
- knowledge flow and its intensity in continuing education IT ecosystem is determined by technology characteristics and the student's portfolio formed by previous competence and meta-competence levels;
- learning paths in continuing education IT ecosystem are determined by the set learning goals, knowledge flow and its intensity, as well as the number of learning objects and their overlapping;
- the application of the continuing education IT ecosystem makes it possible to evaluate the acquisition time of the competence and to develop

information technology solutions which encourage learning activities and facilitate completion of the course and reaching the learning goals.

Scientific Novelty, Its Practical Application and Outcome Evaluation

1. Theoretical and practical aspects of IT ecosystem model development for continuing education enhancement have been explored.
2. A continuing educational IT ecosystem model has been developed; it reflects the impact of applied technologies on knowledge flow. The developed model makes it possible to predict to what extent the applied technologies support enhancement of an individual's competences.
3. The developed software prototype in the IT ecosystem makes it possible to predict the acquisition time of the competences. The business process support module helps to identify the necessity of enhancing competences in a company and gives advice for their development.
4. The outcomes of this work are envisaged for practical application in continuing education contents evaluation, continuing learning process implementation, and for development of new contents for continuing education.

Previous evaluation of the outcomes of this work has been carried out in the following international conferences and seminars:

1. Stale G., Majors I. The Application of EM for Knowledge Flow Analysis and the Development of an Educational IT Ecosystem. Practical Aspect of Enterprise Modeling (PoEM 2012). Germany, Rostock, 7-8 November, 2012.
2. Stale G., Cakula S., Kapenieks A. Application of a Modelling Method for Knowledge Flow Analysis in an Educational IT Ecosystem. Virtual and Augmented Reality in Education (VARE 2011), Valmiera, Latvia, 18 February, 2011.
3. Stale G., Cakula S. Application of Enterprise Modeling Method for Continuing Education Design and Development. WSEAS International Conference on Visualization, Imaging and Simulation (VIS '10), Portugal, Faro, 03-05 November, 2010.
4. Stale G., Majors I. Application of Enterprise Modeling and Knowledge Management for Educational Information Technology in SMEs. 10th

International Conference on Knowledge, Culture and Change in Organization, Canada, 26-29 July, 2010.

5. Stale G. IT Ecosystem Based Model for Ubiquitous Continuing Education. 13th East-European Conference on Advances in Databases and Information Systems, Doctoral Consortium. Latvija, Riga, 07-10 November, 2009.
6. Stale G., Majors I. Applying Knowledge Management Methods and Enterprise Modelling Methods to the IT "ecosystem" for Continuing Education in SME's. Third IEEE International Conference on Digital Ecosystem and Technologies. Turkey, Istambul, 31 May-3June, 2009.
7. Stale G. Promoting Continuing Education Development by Applying IT Supported Ecosystem. 7th International JTEFS/BBCC Conference on Sustainable Development, Culture, Education. Latvia, Daugavpils, 5-8 May, 2009.
8. Stale G., Urpena I. Multi-perspective Knowledge Overlapping Analysis in the Continuing Education. 5th International Conference on Intellectual Capital, Knowledge Management & Organization Learning. United States of America, New York, 15-16 October, 2008.
9. Stale G. IT Ecosystem for the Continuing Education. International Conference Interactive Computer Aided Learning. Austria, Villach, 24-26 September, 2008.
10. Štāle G., Majors I., Meiers A. Knowledge Management and Continuing Education for Strengthening Company Capacity. International seminar "Contents and Knowledge – Convenient and Interactive Applications", Latvia, Ventspils, 26-27 October, 2008.
11. Tomsons Dz., Štāle G., Kirikova M. Application of a Service Oriented Paradigm as a Solution for the Development and Delivery of a Continuing Education Course. Riga Technical University international conference, IT section. Latvia, Riga, 10 October, 2007.
12. Stale G., Kirikova M. and Tomsons Dz. Implementing of modelling methods and game approach in continuing education design. Riga Technical University international conference, IT section. Latvia, Riga, 12-13 October, 2006.
13. Stale G., Kirikova M., Application of Knowledge Management Methods for Acquiring Project Management Skills. The First International

Conference on Research Challenges in Information Science. Marocco, Quarzazate, 23-26 April, 2007.

14. Stale G. Social and Motivating Knowledge Society Solutions for E-inclusion of the Disabled. IST 4 Balt Workshop "Towards a Knowledge Society". Latvia, Riga, 7 April, 2006.
15. Stale G., Kapenieks A., Slaidins I. A New Approach of E-Learning Solutions for Empowerment of People in Regional Development Context. The 6th Baltic Studies Conference *Europe The Baltic Way in Europe. Revolution and Evolution*. Latvia, Valmiera, 1.-19 June, 2005.

Publications. Research results have been published in 23 scientific articles which have been written individually by the author during the elaboration of the thesis, and in cooperation with co-authors.

1. Kapenieks A., Zuga B., Stale G., et al. Internet, Television and Mobile Technologies for Innovative E-Learning. Proceedings of the International Scientific Conference on Society, Integration and Education. Society, Intergration, Education, 2012, Vol.1, pp. 303 – 311. [Thomson Reuters database].
2. Stale G., Majors I. The Application of EM for Knowledge Flow Analysis and the Development of an Educational IT Ecosystem. Proceedings of the Conference Practical Aspect of Enterprise Modeling (PoEM 2012). Germany, Rostock, pp. 11. [DBLP Bibliography Server]
3. Kapenieks A., Zuga B., Stale G., Jirgensons M. E-Ecosystem driven e-learning vs technology driven e-learning. Proceedings of the 4th International Conference on Computer Supported Education CSEDU 2012, Vol. 2 , pp. 436-439 [Scopus database]
4. Stale G., Cakula S., Kapenieks A. Application of a Modelling Method for Knowledge Flow Analysis in an Educational IT Ecosystem. Virtual and Augmented Reality in Education (VARE 2011), Valmiera, Latvia, 2011, pp. 92 – 97. ISBN 978-9984-633-18-3
5. Stale G., Cakula S. Application of Enterprise Modeling Method for Continuing Education Design and Development. WSEAS International Conference on Visualization, Imaging and Simulation (VIS '10), Faro, 2010. pp.86 – 92. ISBN 978-960-474-246-2 [Scopus database, ACM Digital Library]

6. Stale G., Majors I. Application of Enterprise Modeling and Knowledge Management for Educational Information Technology in SMEs. Proceedings of the 10th International Conference on Knowledge, Culture and Change in Organization", Canada, 26-29 July, 2010, ISSN 1447-9524
7. Stale G. IT Ecosystem Based Model for Ubiquitous Continuing Education. Proceedings of 13th East-European Conference on Advances in Databases and Information Systems, Doctoral Consortium, 2009.
8. Stale G., Majors I. Applying Knowledge Management Methods and Enterprise Modelling Methods to the IT "ecosystem" for Continuing Education in SME's. Proceedings of Third IEEE International Conference on Digital Ecosystem and Technologies, 2009. June, Turkey, Istanbul. – Istanbul: IEEE, 2009, pp. 161 - 166. [IEEE Xplore Digital Lirbary, Scopus database]
9. Stale G. Madsen P.P. Behaviour and Context Awareness in an Educational IT Ecosystem. Published in the Annual Proceedings of Vidzeme University College „ICTE in Regional Development". Valmiera, 2009. – Valmiera: Vidzeme University College, 2009. [EBCSO database]
10. Stale G., Urpena I. Multi-perspective Knowledge Overlapping Analysis in the Continuing Education. Proceedings of the 5th International Conference on Intellectual Capital, Knowledge Management & Organization Learning, 2008. October, USA, New York. – New York: ICL, 2008, pp.479 – 484.
11. Stale G. IT "Ecosystem" for the Continuing Education. Proceedings of the International Conference Interactive Computer Aided Learning, 2008. September, Austria, Villach. – Villach: Kassel University Press, 2008, pp.1-6.
12. Štāle G., Majors I., Meiers A. Zināšanu pārvaldība un tālākizglītība uzņēmuma kapacitātes stiprināšanai. Starptautiskas konferences rakstu krājums. Saturs un Zināšanas – Ērti un interaktīvi lietojumi, Ventspils, 2008. October, Latvia, Ventspils. – Ventspils: LiePA, 2008, pp. 8-26. ISBN 9948-648-74-5
13. Gulbis R., Kapenieks A., Kudiņš J., Štāle G., Žuga B. SMS Applications for M-Learning Support. Saturs un zināšanas - ērti un interaktīvi lietojumi. Starptautiskās konferences materiālu krājums. - Ventspils, Latvia: Ventspils augstskola informācijas tehnoloģiju fakultāte, 2008. - pp 117-122.

14. Tomsons Dz., Štāle G., Kirikova M., Application of a Service Oriented Paradigm as a Solution for the Development and Delivery of a Continuing Education Course. Rīgas Tehniskās universitātes zinātnisko rakstu krājums, Rīga, September, Latvia, Rīga. – Rīga: RTU, 2008, pp. 9-16.
15. Kapenieks A., Zuga B., Gulbis R., Stale G., Strazds A. Innovative eLearning to promote sustainable development in Latvia. Proceedings of The International Conference on Technology Communication and Education (i-TCE 2008), Gulf University for Science & Technology, Kuwait, April 7-9, 2008, pp. 408-411.
16. Zuga B., Slaidiņš I., Ozoliņa A., Štāle G., Kapenieks A., Jirgensons M. Towards a T-Learning Content and Usability Testing Environment. Annual Proceedings of Vidzeme University College „ICTE in Regional Development", 2008, pp. 1- 9. [EBSCO Datu bāzē]
17. Majors I., Stale G. Incorporating Knowledge Management Principles into Continuing Education Programs to Strengthen SMME Development in Latvia's Regions. Annual Proceedings of Vidzeme University College „ICTE in Regional Development", 2007. Latvia, Valmiera. – Valmiera: Vidzeme University College, 2007, pp 78-82. [EBSCO Database]
18. Strazds A., Kapenieks A., Zuga B., Stale G. Measuring the responsiveness of e-learning materials to varying learning styles using EDUSA method. Conference on Interactive computer aided learning, 2007. September, Austria, Villach. – Villach: Kassel University Press, 2007, CD-ROM, ISBN: 978-3-89958-279-6.
19. Stale G., Kirikova M. and Tomsons Dz. Implementing of modelling methods and game approach in continuing education design. Scientific Proceedings of Riga Technical University, 2007. September, Latvia, Riga. Riga: RTU Computer Science, S. 5, Vol. 30, pp. 66-75, ISSN 1407-7493.
20. Stale G., Kirikova M., Application of Knowledge Management Methods for Acquiring Project Management Skills. Proceedings of the IEEE First International Conference on Research Challenges in Information Science, C Rolland, O.Pastor, J-L. Carero (Eds.), 2007. April, Morocco, Quarzazate. – Quarzazate: IEEE, 2007, pp. 247-252.
21. Anohina A., Štāle G., Pozdņakovs D. Intelektuāla sistēma studentu zināšanu vērtēšanai. Rīgas Tehniskās universitātes zinātnisko rakstu

krājums, Rīga, 2006. Septembris, Latvija, Rīga. – Rīga: RTU, 2006, Lpp.132 – 143

22. Stale G. Kirikova M. Application of Modeling Methods in the Context of Continuing Education. Published in the Annual Proceedings of Vidzeme University College „ICTE in Regional Dvelopment". Valmiera, 2006. – Valmiera: Vidzeme University College, 2006. ISBN: 9984-633-03-9 [EBSCO Database]
23. Stale G., Kapenieks A., Slaidins I. A New Approach of E-Learning Solutions for Empowerment of People in Regional Development Context. Published in the Annual Proceedings of Vidzeme University College „ICTE in Regional Dvelopment". Valmiera, Vidzeme University College, 2005, pp.132 - 136.

Structure of the Doctoral Thesis

The Doctoral Thesis consists of an introduction, three chapters, conclusions, bibliography and 11 appendices. The body of the thesis comprises 160 pages, 68 pictures, 18 tables. The bibliography includes 322 titles of information sources.

The introduction gives overall characteristics of the problem situation and the topicality of the theme and depicts research issues. The author gives a formulation of the research object, the goal and objectives, as well as theses for the defence. The introduction also explains the scientific novelty and practical application and evaluation of the outcomes.

Chapter 1 describes the essence of information technology ecosystem for the support of continuing education process. The concept of information technology ecosystem is analyzed from the aspect of its importance in the support of continuing education. The specific nature of continuing education is analyzed alongside an overview of IT solutions in continuing education and the concept of knowledge flow. The author has attempted to explain the concept of competence and meta-competence and their role in the analysis of language flow in the continuing education information technology ecosystem. This chapter also gives an overview of similar research works in the problem sphere of this Paper. The author has come to the conclusion that the spectrum of other researchers is wide, and each of the elaborated models or approaches characterises the situation and application of certain technologies in the continuing education; however none of them gives scientifically or methodologically grounded answers how the technologies may be used for enhancement of an individual's

particular competences. When evaluating knowledge flow in continuing education information technology ecosystem, the following aspects should be taken into account: characteristics of technologies, the student's portfolio consisting of previously acquired competences and meta-competences which depict the intensity of the knowledge flow in the continuing educational information technology ecosystem.

The aim of Chapter 2 is to analyse the component parts of the continuing education information technology ecosystem that provide knowledge flow and enhancement of competences in the continuing education process. The chapter focuses on analysis of methodologies for the development of a model of the continuing educational information technology ecosystem with the help of the chosen methodology. The author explains each of the model sections in detail; the evaluation of the model has been carried out in the expert group. The component parts and characteristics of the continuing education information technology ecosystem have been described in the chapter; it also includes a compilation of results of knowledge flow analyses and evaluation of changes in competences and meta-competences in the continuing educational information technology ecosystem. The chapter describes the prototype of the developed knowledge flow analysis and the obtained experimental outcomes. Technology support and the obtained competence development results in continuing education projects are presented in this chapter. At the end of the chapter the author concludes that knowledge flow in IT ecosystem depends on the synergy of several factors; they are: each person's meta-competences, relevant application of technologies for the development of knowledge flow; and the contents of knowledge.

Chapter 3 describes the developed conceptual model for the support of the continuing educational information technology ecosystem. The author analyses methodologies for elaboration of the conceptual model supporting continuing educational information technology ecosystem operation. A model of continuing educational information technology ecosystem has been developed together with an algorithm and the respective software prototype for the knowledge flow and competence enhancement support in the continuing education IT ecosystem. Analysis of different continuing education situations is given in this chapter, mainly from the point of view of knowledge flow and coverage. The chapter shows an individual's potential competence development graphs which characterise different continuing education situations. The main functionality of the developed research software prototype together with evaluation results in the target group is described in this chapter. At the end the author concludes that the developed prototype provides for

selection of a faster and a more precise competence enhancement way according to the continuing education situation and the student's portfolio.

At the end of the Paper the author summarises the results and conclusions of the doctoral thesis and gives an outline for future research directions and possibilities.

The Paper has X appendices: Appendix 1 – Definitions of concepts used in the doctoral thesis; Appendix 2 – Enterprise Knowledge Development (EKD) total model; Appendix 3 – List of European Structural Fund Projects where EKD methodology is used for the support of continuing education process; Appendix 4 – Expert survey page for evaluation of continuing education IT ecosystem; Appendix 5 – Summary of expert answers of the evaluation of continuing education IT ecosystem; Appendix 6 – Respondents' answers regarding potential duration of courses: Appendix 7 – Evaluation of meta-competences and comparison to the number of course graduates; Appendix 8 – A questionnaire for continuing education course graduates; Appendix 9 – Description of competence and business process analysis software prototype; Appendix 10 – List of pictures placed in the doctoral thesis; Appendix 11 – List of tables used in the doctoral thesis.

1. INFORMATION TECHNOLOGY ECOSYSTEM FOR SUPPORT OF KNOWLEDGE FLOW IN THE PROCESS OF CONTINUING EDUCATION

The chapter consists of 52 pages, 6 tables, and 20 pictures.

In our modern and ever-changing world knowledge has become one of the preconditions for an individual's work and social life [Chin L. K., Chang E., 2009], [Maier R., 2010]. Not only the success and self-sufficiency of an organization, but also those of an individual depend on their ability to develop and use the surrounding environment for creation and application of knowledge [Maier R., 2010], and to enhance their competences for acquisition of new knowledge and provision of knowledge flow [Bo G., Luccini A.M., Dicerto M., 2006]. The use of information technologies has become an integral part of the educational process [Chin L. K., Chang E., 2009], [Maier R., 2010]. The wide spectrum of available information technologies, versatile methods and learning contents provide for far-reaching continuing education possibilities to every individual. Consequently, it creates a need for a model of mutual interaction of information technologies to promote continuing education. It would help to forecast the acquisition time of the learning contents and enhancement of competences in compliance with the application of the technologies and the student's e-

portfolio [Stale G., Kirikova M., 2007; Stale G., Majors I., 2009; Stale G., Cakula S., Kapenieks A., 2011].

The chapter of the doctor's thesis consists of 5 parts and conclusions at the end of the chapter. The first part focuses on analyzing information technologies for the support of continuing education process and gives examples of application of technologies. In the second part the author examines the concept of eco-system in continuing education and reviews the research of other authors on this theme. The third sub-chapter gives a conceptual definition of continuing education and in conclusion the author presents a definition of the continuing education process in the context of this doctoral thesis. Further, the fourth sub-chapter is devoted to analysis of the concept of knowledge flow in the context of continuing education. Finally, the fifth part focuses on analysis of research outcomes of other authors and conclusions of provision of information technology eco-system's knowledge flow and enhancement of competences in the process of continuing education. In the conclusion the author presents the outcomes, draws up conclusions and proposals used in further chapters.

1.1. Information Technologies in the Process of Continuing Education

Information technologies are becoming an integral part of the educational process [Tchounikine P., 2011]. They provide for initiation of new activities [Bian L., 2009; Buzan T., 2007], their implementation [Chang, V., Guelt, C., 2007], and assessment of students' knowledge [Anohina A., 2007; Anohina A., et al., 2006].

Information technologies planned for continuing education in the context of IT eco-system are **defined** as *hardware, software and service package used by people for the provision of the process of continuing education both from the service provider and the service receiver.*

Thus, knowledge flow is provided in the IT ecosystem of continuing education with the help of technologies [Nissen M.E., 2006; Stale G., Cakula S., Kapenieks A., 2011]. There are three kinds of technologies which are used for the provision of knowledge flow and the continuing education service [Davenport T.H., Prusak L., 2000]:

- **service provider's technologies** – technologies necessary for the development of learning contents, for instance, Camtasia [Richards L.G., 2010], which is a tool for creation of different multimedia materials;

- **service receiver's technologies** – they provide accessibility to the contents of continuing education, for instance, mobile technologies [Sharples M., et al., 2007], which are becoming increasingly popular;
- **technologies for the supply/ maintenance of the contents of continuing education** – technologies providing accessibility of the contents of continuing education, for instance, Moodle learning management system [Tsai T., et al., 2010], [Kumar S., 2011], as well as physical supply of contents through different types of communication channels.

Within the framework of this doctoral thesis the author has researched the continuing education IT ecosystem part related to the types of technologies providing the learning contents which are available to the service receiver (the internet, mobile technologies and television).

1.2. Concept of Information Technologies Ecosystem in the Context of Continuing Education

Traditionally the concept of ecosystem is used in the context of nature research. However, this concept has a broader meaning [Jorgensen S.E., 1992] in scientific publications. This fact has been proved by the many-sided results of Jorgensen's research, both in the context of nature research and in the context of information technologies [Jorgensen S.E., Muller F., 2000; Jorgensen S.E., 1992].

Within the framework of this paper the IT ecosystem approach is used to research, evaluate and depict graphically the interaction of the participants of the educational process and the technologies with an aim to explain and demonstrate the impact of different technologies and their parameters upon the processes of continuing education, and to develop a method for evaluation of continuing education information systems.

The IT ecosystem is a complex adaptive system consisting of autonomous systems, interacting with one another, as their qualities, interactivity and adaptability change in the course of time [Rausch A., a.o., 2012]..

1.3. The Concept of Continuing Education in the Context of the IT Ecosystem

The concept of continuing education is frequently defined differently. Ambiguous interpretation of the concept is found in foreign authors' works and in the Latvian authors' publications, as well as in laws and regulations of the Republic of Latvia.

While working on the development of the model of information technology ecosystem it is important to define the concept of continuing education very precisely, as it will be used in the further research. The correlation of common concepts and the research field of the doctoral thesis is shown in Picture 1.2. This paper focuses on possibilities of continuing education for continuing professional development and interest education.

Continuing education is an active learning process of adults in an informal way using multiple options regarding time, contents and learning methods according to the set goal or the problem to be solved, learning style and available technologies. [Stale G., Cakula S., 2010].

1.4. Enhancement of Knowledge Flow and Competences in IT Ecosystem of Continuing Education

Analysis of knowledge flow plays an essential role in implementation of continuing education processes. [Selwyn N., et al., 2005; Zhuge H., et al., 2006]. This concept is widely used in scientific literature. [Michailova S., Mustaffa Z., 2011], [Huggins R., Johnston A., 2010], [Fan I., Lee R., 2009], [Nonaka I., et al., 2008], [Nissen M.K., 2006], [Uden L., Damiani E., 2007], [Zhuge H., 2006]. However, the interpretation of the concept is ambiguous, and each author treats it differently.

Zhuge has given the most precise definition of knowledge flow from the knowledge management and learning perspective [Zhuge H., 2006]. According to his definition, knowledge flow is knowledge transfer or movement between knowledge "nodes" [Zhuge H., 2006]. A knowledge "node" may be a team player, knowledge portal, knowledge basis, or knowledge intensive process [Zhuge H., 2006]. *In the context of continuing education IT ecosystem knowledge flow is defined as knowledge transfer between knowledge "nodes" which in the framework of this Paper occurs between technologies of the continuing education provider and the receiver.*

Knowledge flow has three characteristic features [Zhuge H., 2006]:

- direction which defines the sender and the receiver or the knowledge "node";
- contents containing the necessary knowledge;
- disseminator or medium transferring knowledge.

The aim of provision of knowledge flow (in the context of this Paper) is enhancement of an individual's competences and meta-competences. A competence in general comprises knowledge, skills attitudes, values, experience and ability to solve the problem or the given situation. [Karampiperis P., 2006]. Meta-competences are

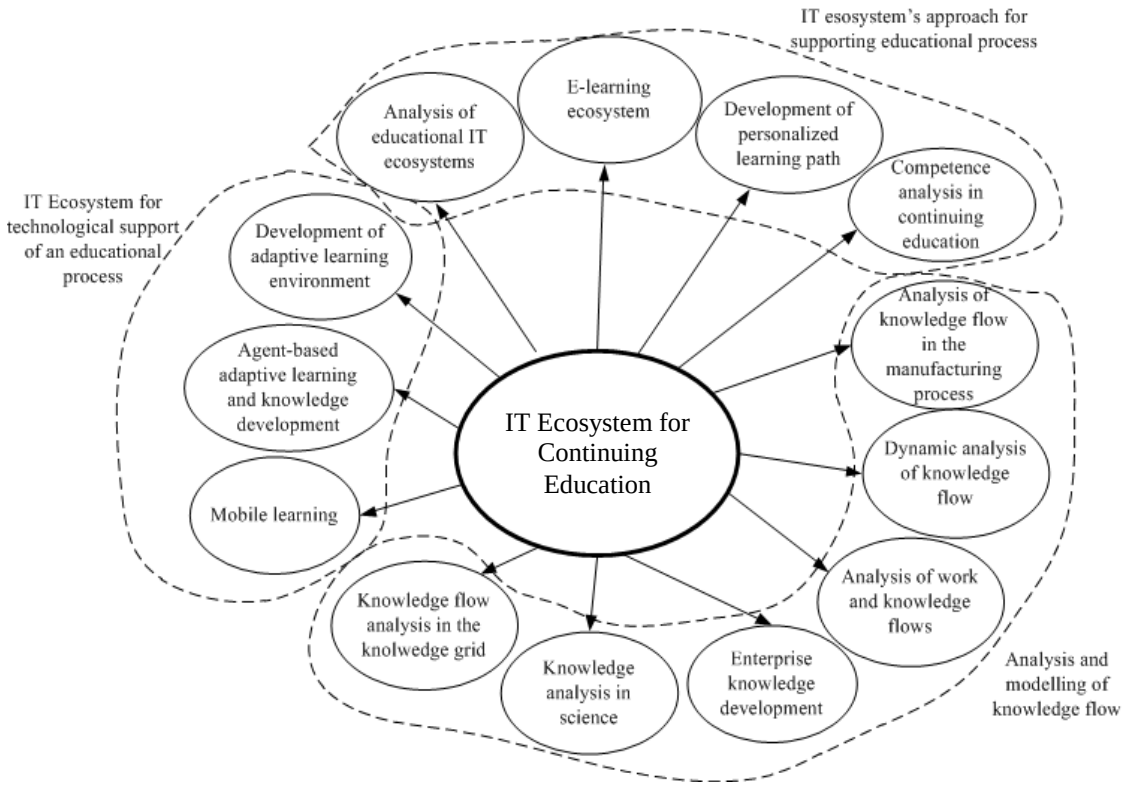
essential for the development of competences and are part of the total competence framework [Song E., et al., 2011; Koper R., Specht M., 2006; Broek C., et al., 2010]. The aggregate of meta-competences and competences forms a person's portfolio which, according to the opinion of scientists should be compiled and documented in a certain framework [Adomavicius G., Tuzhilin A., 2005; Berlanga A. J., et al., 2008; Romero M.C., et al., 2012].

1.5. Overview of Continuing Education IT Ecosystem in Research of Different Authors

Research directions found in scientific literature are given in Picture 1.1.

The author has identified three main research directions in the context of this Paper [Stale G., 2009]:

- IT ecosystem approach to improvement of the educational process which comprises the definition of elements of the educational process and reflection of interaction of the processes;
- IT ecosystem approach to the support of the educational process which provides application of natural ecosystem principles in analysis and development of educational IT;
- analysis and modelling of knowledge flow both at the university and in a production company.



Picture 1.1. Research directions in scientific literature for support of IT ecosystem in continuing education [adapted and supplemented from Stale G., 2009]

1.6. Summary and Conclusions on Support of IT Ecosystem' Knowledge Flow in the Process of Continuing Education

This chapter of the Paper offers analysis of concepts of information technology ecosystem and knowledge flow, as well as a theoretical overview in the context of continuing education.

The chapter presents **the accomplished** work by the author:

- analysis and interpretation of the concept of continuous education and development of its definition in the context of this Paper to define it more precisely;
- characteristics of the concept of information technology ecosystem in continuing education with an overview of the results of research in this sphere by other authors;
- characteristics of the knowledge flow concept in continuing education; development of a theoretical framework for its evaluation in the context of this Paper;

- description of concepts of competences and meta-competences in continuing education.

The author has accomplished:

- to formulate the definition of information technologies in the context of continuing education;
- to develop a definition of continuing education providing such an education which in the context of this research is an active learning process of adult people in an informal by using multiple options regarding time, contents and learning methods according to the set goal or the problem to be solved, learning style and available technologies;
- to define the relevance of using information technologies in different situations in continuing education;
- to develop a theoretical model of knowledge flow in continuing education;
- to identify types of meta-competences for evaluation of continuing education IT ecosystem;
- to compile an overview of literature regarding results of other authors' research works on continuing education IT ecosystem.

The main **conclusions** are as follows:

- analysis of concepts in the framework of this chapter depicts the broad research field in the problem sphere of this Paper which in its turn prescribes the need for clarification of the definitions;
- the research spectrum of other authors is broad and each of the developed models or approaches characterises a situation in continuing education and application of a certain technology, but none of them gives scientifically and methodologically grounded answers how to use the technology for enhancement of an individual's specific competences;
- from the review of literature one may come to the conclusion that the use of technologies in continuing education models is limited to introduction of continuing education traditional experience in information technologies, however, there is no model which would provide for assessment of the effectiveness of the given technology in the particular situation of the continuing education and would create a possibility to define new requirements for improvement of a new or the existing technology;
- authors have researched and reflected in their works particular types of technologies and their application in different continuing education

situations, however, there are no models which would include technology interaction and overall application;

- the authors who have researched the use of some specific types of technology for different continuing education situations, point out the importance of an overall IT ecosystem for continuing education;
- other authors have not done research nor reflected models that would directly demonstrate differences between the conventional continuing education and continuing education in IT ecosystem;
- different technologies have been analyzed and research has been done in the sphere of application of different technologies, however, continuing education models in IT ecosystem are not known.

2. IT ECOSYSTEM FOR CONTINUING EDUCATION

The chapter contains 69 pages, 11 tables and 34 pictures.

On the basis of the defined concepts in the previous chapter and the review of other researchers' works, the aim of this chapter is to analyze components of continuing education IT ecosystem which provide for knowledge flow and competence enhancement in the continuing education process. This chapter consists of 5 sub-chapters; there are conclusions at the end of the chapter. The first sub-chapter describes a general continuous education IT ecosystem model which has been developed on the basis of outcomes of the completed research within the framework of the previous chapter and the results of a research project. The second part is devoted to analysis of the main components of the IT ecosystem, knowledge processes and flows in the continuing education IT ecosystem. The achieved outcomes are based upon research done in the target group. The third part is devoted to the analysis of technology and methodology support to the continuing education IT ecosystem on the basis of outcomes achieved in continuing education projects. In the fourth sub-chapter the author analyses knowledge flow and competence enhancement in continuing education IT ecosystem. In the fifth part we see a summary of preconditions for the development of a continuing education IT ecosystem to support the continuing education process. The summary and conclusions regarding the completed research are given at the end of the chapter.

2.1. Common Model for the Continuing Education IT Ecosystem

The aim of the common model for the continuing education IT ecosystem is to present support to continuing education process both from the part of the service provider and the service receiver.

To develop the model the author has used her research results from the literature analysis and also previously presented scientific publications. For further development of the model the author has compiled and thoroughly analysed the outcomes and conclusions of activities of an expert group at Riga Technical University Distance Study Centre and the European Regional Development Fund co-financed research project Nr.2010/0222/2DP/ 2.1.1.1.0/10/ APIA/VIAA/150 „E-Technologies in Innovative Knowledge Source and Flow Systems (ETM)".

The overview of the modelling outcome is given in Picture 2.1, its full-size Picture is given in the Appendix 2.

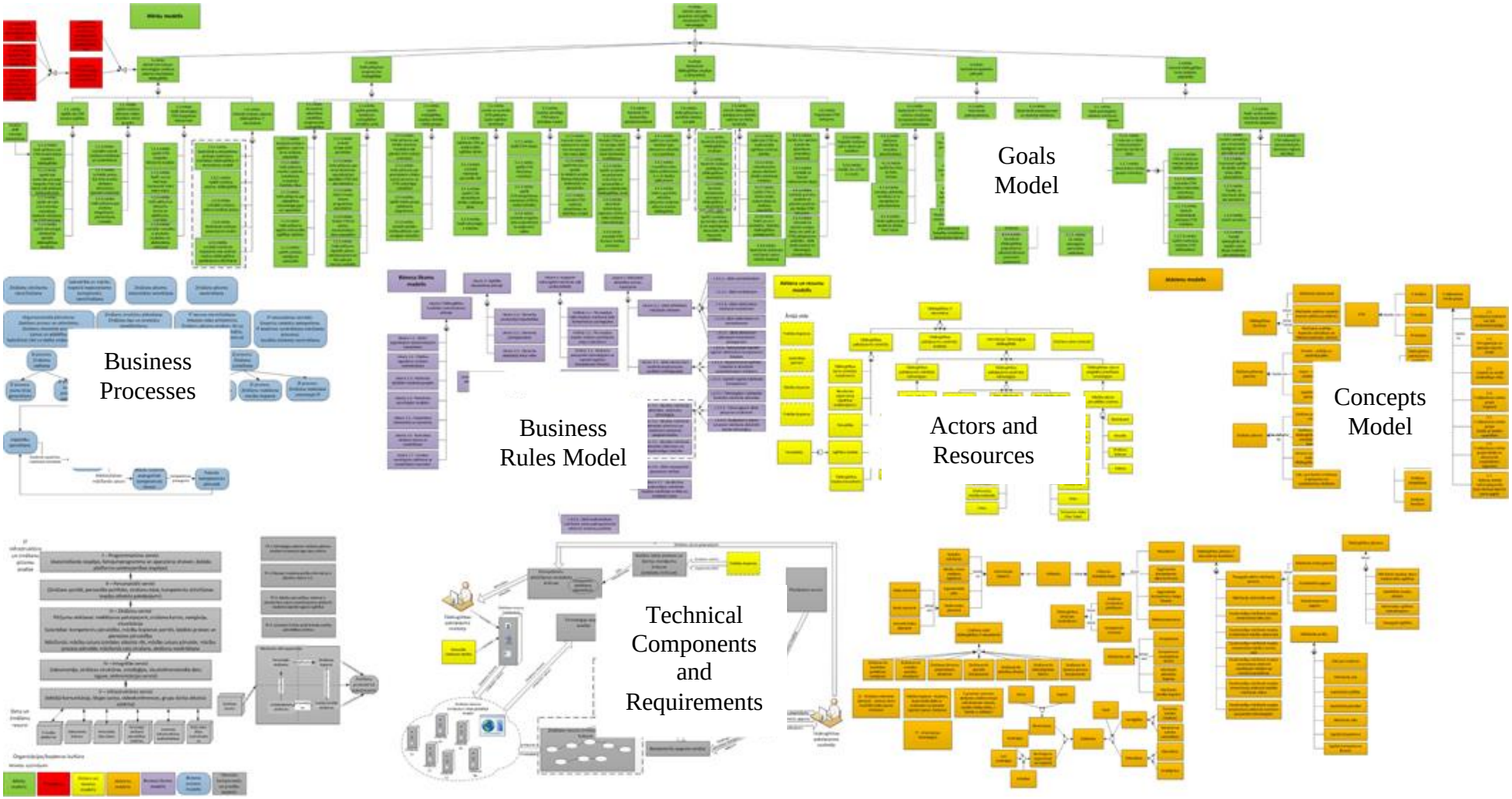
The general model of EKD methodology consists of 6 inter-related models [Bubenko J. A., et al., 2006]:

- a goals' model which in the general case reflects the company goals and problems in reaching the goals and implementing business processes;
- a business law model which in the general case describes laws that have to be complied with for reaching the set goals and/ or implementing business processes;
- a concept model which explains concepts used in other models;
- a business process model which in the general case describes processes to be implemented for reaching the goals;
- an actor and resource model which in the general case includes the necessary human resources and material-technical resources for implementing business processes;
- a model of technical components and requirements which in the general case describes software and hardware provision for business process implementation and reaching the set goals.

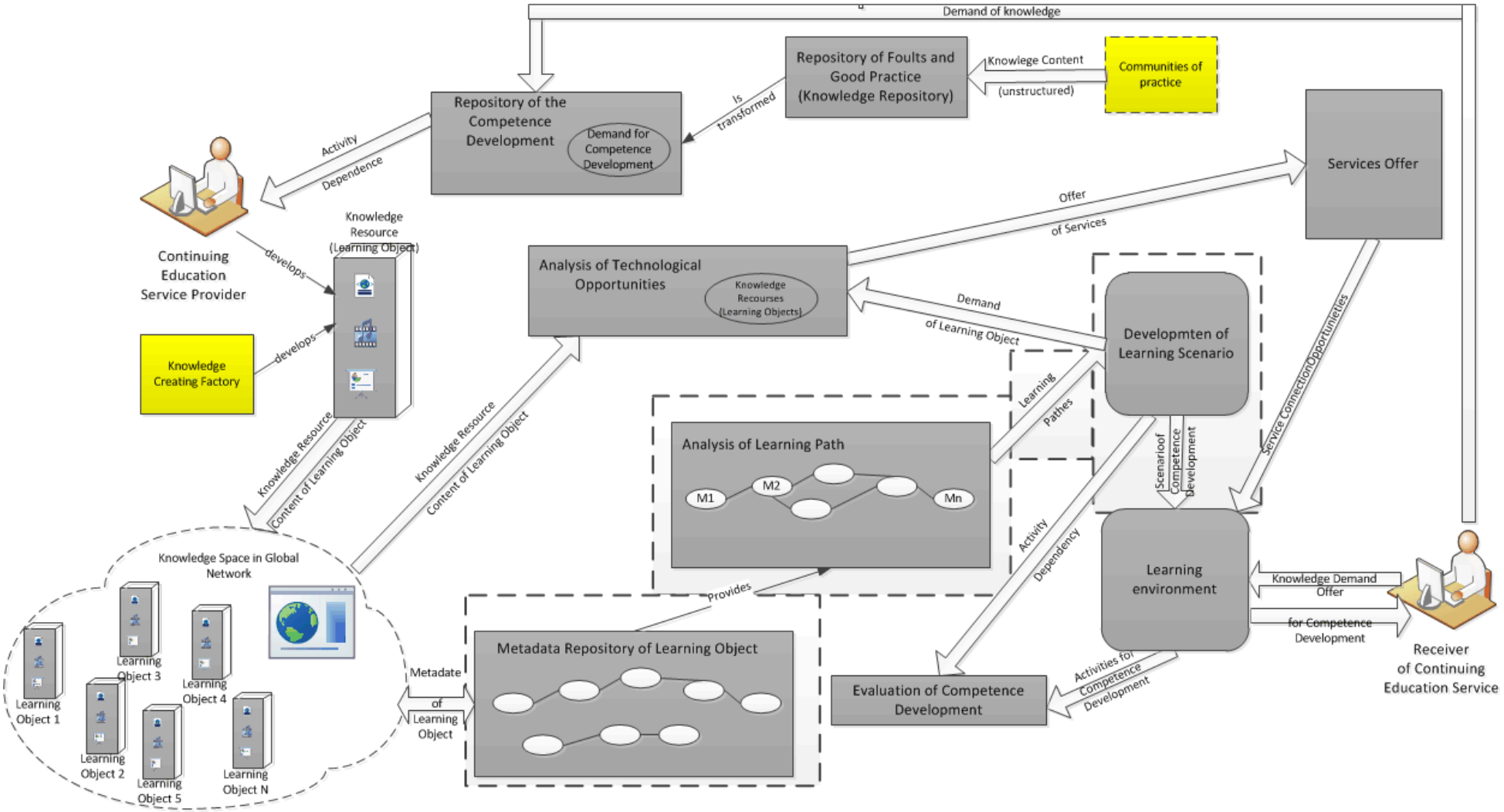
The model of technical components and requirements is given in Picture 2.2. The model demonstrates operation of the IT ecosystem facilitating achievement of the chief goal. This paper analyzes in detail and reflects the continuing education IT ecosystem part which concerns the student.

The developed software prototype includes the following modules shown in Picture 2.2:

- basis of knowledge resource metadata;
- a module of possible learning paths analysis;
- development of possible learning scenarios providing integration of learning contents for further service provision in the learning environment.



Picture 2.1. Common model of continuing education IT ecosystem



Picture 2.2. Model of technical components and requirements of continuing education IT ecosystem [adapted from Stale G., Kirikova M., 2007]

The author has chosen to attract experts for evaluation of the common continuing education IT ecosystem. The experts were invited from Latvia and abroad. The foreign experts were offered the model in translation. The experts were selected using criteria elaborated by Dz. Albrehta [Albrehta Dz., 1998], in addition, the following aspects were taken into account:

- experience in various continuing education and information systems development projects;
- international experience in the sphere of continuous education (course development and use of different technologies in development of course materials);
- publications in development and introduction of continuous education systems;
- practical experience in application of various modelling methods (especially enterprise modelling methods and the use of EKD approach);
- publications in application of modelling methods for evaluation of educational processes (especially continuing education processes).

For the analysis of the common model for the continuing education IT ecosystem the following experts were attracted:

- Dr. oec. Ingūna Jurgelāne – Vidzeme University for Applied Sciences, Lifelong Education Centre Manager,
- Dr. ing.sc. Renāte Strazdiņa - Renāte Strazdiņa, Ernst & Young Baltic Management, Consultation Department Director;
- Dr. Per P. Madsen – Alborg University Associate Professor;
- Mg. sc. educ. Lāsma Ulmane-Ozoliņa – Liepāja University, Lifelong Education Department expert.

The total evaluation of the developed model is positive. All the experts have acknowledged that the selected methodology is adequate for the development of the continuing education IT ecosystem model. Amendments were proposed for the following models:

- The goals model should also indicate problems regarding financing continuing education in Latvia; it would also need more active attraction of the State and municipal institutions;
- business law model should be supplemented with a student support systems' law to ensure that continuing education can be interesting, relevant and

adequate for independent studies; it is impossible to do without a student support system as it is one of the key elements in e-, m-, and t- learning;

- business process model should be more explicit with the system's total work and IT support;
- the actors' model needs more clarification regarding technologies for development of teaching materials: web 2.0 tools could be added, like blogs or emuars, podcasts, viki, a.o.; the student community should be included in the service receiver part as it would make a good resource for finding out the needs and development of materials, but especially for enhancement of the students' competences; it is also an element of student support and knowledge transfer;
- the concept model should include a target group with people who have dropped out of the labour market, for instance, parents with young children, or due to long-term illness; it should also define the student support system's concept;
- the model of technical components and requirements needs a more detailed definition of software requirements.

The above mentioned suggestions will be taken into account in the next stage of the model development.

2.2. Components of the Continuing Education IT Ecosystem

In the context of the doctoral thesis the author has defined the following continuing education IT ecosystem **components:**

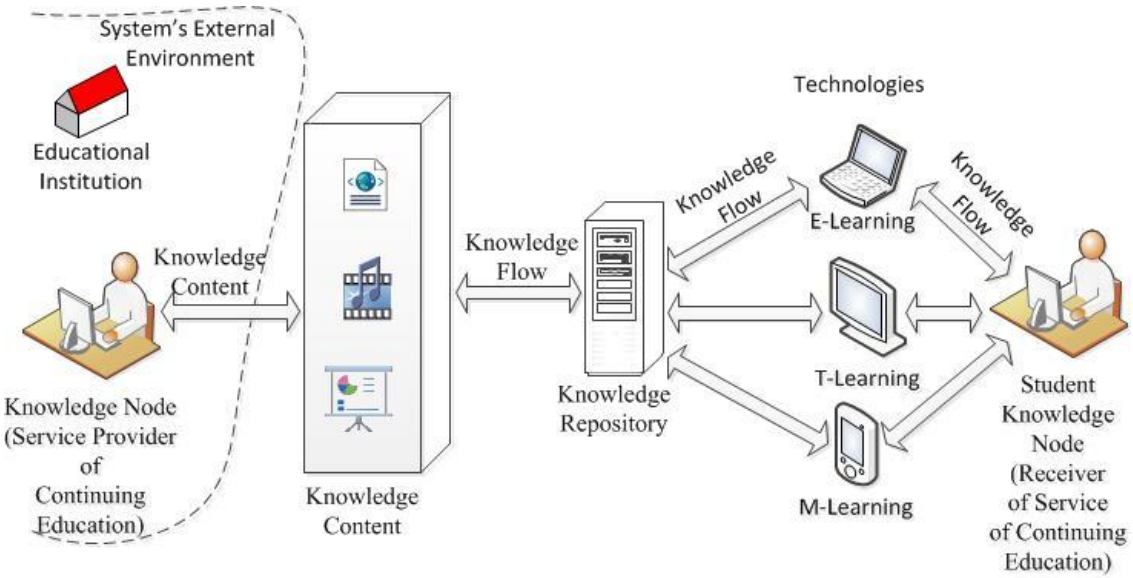
- knowledge flow nodes, or **participants of the continuing education process** who are both knowledge producers (developers of the contents of the continuing education) and knowledge receivers (students acquiring the particular knowledge contents and developing their meta-competences and competences)
- **knowledge** which is the contents of continuing education and that by the previous definition of the concept is an information aggregate compiled and presented in such a way that it provides for an active learning process and within the framework of this paper is named as learning object;
- **knowledge flows** providing knowledge transfer from the place where it is accumulated, to the knowledge receiver, or in this case, the student;

- **technologies** for provision and support of knowledge flows;
- **external environment of the system** from which knowledge flows into the system (usually higher education institutions, universities or other establishments providing the knowledge contents, but it may also be individual contents providers).

Picture 2.3 shows the components of the continuing education IT ecosystem.

The doctoral thesis deals with the part of the ecosystem referring to knowledge consumers, flows and their support technologies.

While doing research on interaction of the component parts of the continuing education IT ecosystem the author has used both qualitative and quantitative research methods. The chief goal of the research was to clarify the interaction and regularities of elements of the continuing education IT ecosystem which should be taken into consideration while developing courses in continuing education and planning the application of technologies in them. To reach this goal the author of this Paper has evaluated course outcomes. The chosen courses for researching the above mentioned relationships were implemented at Riga Technical University Distance Study Centre during the period of 2004- 2008.



Picture 2.3 Components of the Continuing Education IT Ecosystem

The research was implemented in two stages. The first stage started with a survey of experts to identify the characteristics of the main components and correlations that were tested later. In the next stage the author tested the proposed hypothesis and identified correlation in a wider group of respondents.

The target group of this research are participants of continuing education process who are involved in continuing education courses. According to the data of the Central

Statistics Bureau in 2007 as many as 312 thousand people were involved in the informal education [Central Statistics Bureau, 2013], which is the actual size of the population of my research. When research is done among the population increasing 100000 elements, then with 94% significance for the corresponding sample size the number should be 278 [Mārtinsone K., 2011].

This research in total embraced and evaluated seven courses with 282 participants. This number is sufficient for the allowable sampling error. The course participants' survey gave an opportunity to go into detail regarding the aspects of the course development, involvement of participants and the use of technologies and study support methods.

In the first stage of the research the following borderlines of the system were identified:

Borderline 1: the system provides for 100% of knowledge contents for the development of a competence.

Borderline 2: the system does not provide knowledge contents for the development of a competence, and the individual acquires knowledge on his/her own without any organized learning contents ("learning objects").

For the evaluation of these borderlines the author interviewed the experts to verify the initial hypothesis. The qualitative research method was used for this stage.

The author has identified the following initial research issues: does an individual develop a competence faster when using specially organized learning contents ("learning object") than without it and how much faster?

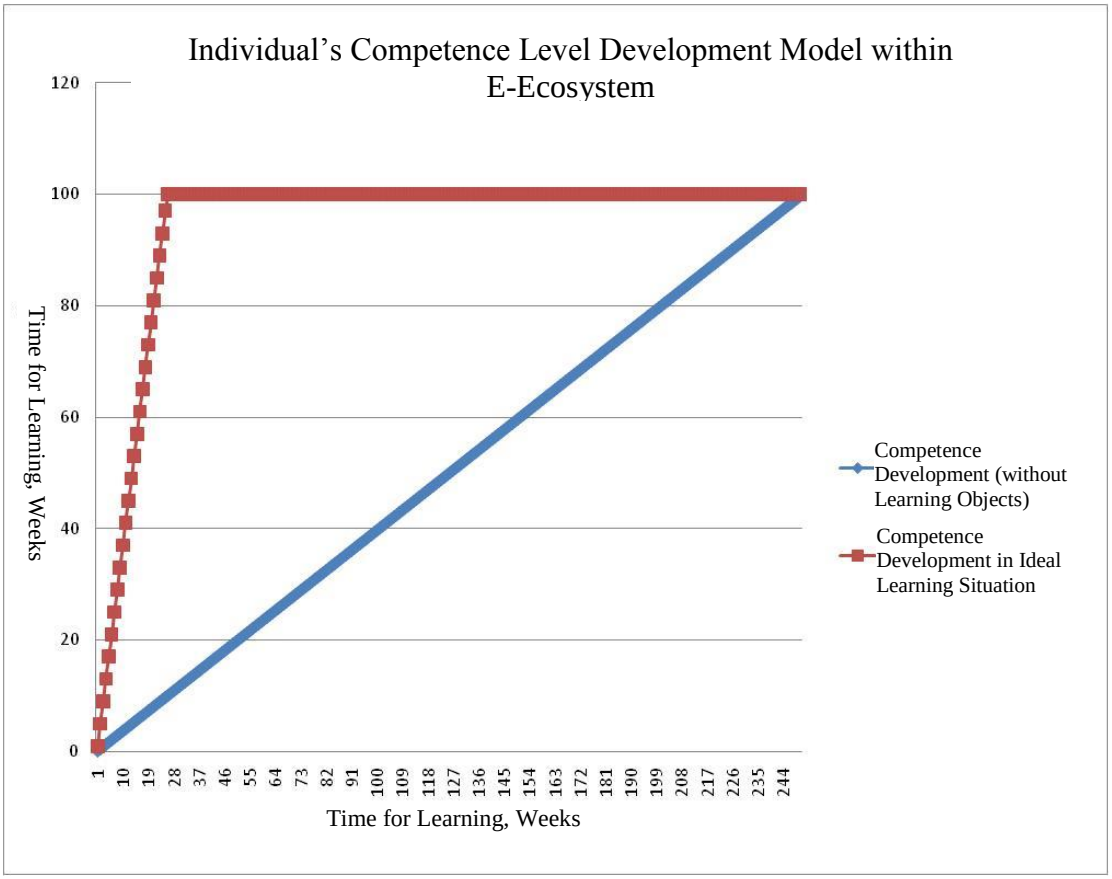
To answer the research question and define the hypothesis for further quantitative research the author used individual interviews as a qualitative research method.

Initially 20 experts were interviewed, their opinions were compiled. The number of respondents is sufficient corresponding to the qualitative research survey sampling requirements [DePaulo P., 2000]. Respondents were selected from various courses; the students were asked to define how long time according to their opinion would be necessary for developing competences if such courses were not available. The course participants were selected from different groups to cover as wide answer spectrum as possible.

In total, when assessing the testing of borderline cases, the author considered the respondents' views who had not developed knowledge and competences related to the course. In the course of further research it was taken into account that the students' work with the course materials was divided equally during the whole course and the

competence level was evenly enhanced accordingly. Picture 2.5 shows the competence enhancement development model proposed in the hypothesis; it reflects correlation between the learning time (typically a two- credit course lasts for two weeks) and the respective level of competence in %.

Picture 2.5 shows two curves depicting two borderlines in competence development in the continuing education IT ecosystem. The competence development (without learning objects) denotes that an individual is training competences without a specially designed learning material (m learning object). The curve for the system with an ideal learning object denotes competence increase with an organized learning material (learning object).

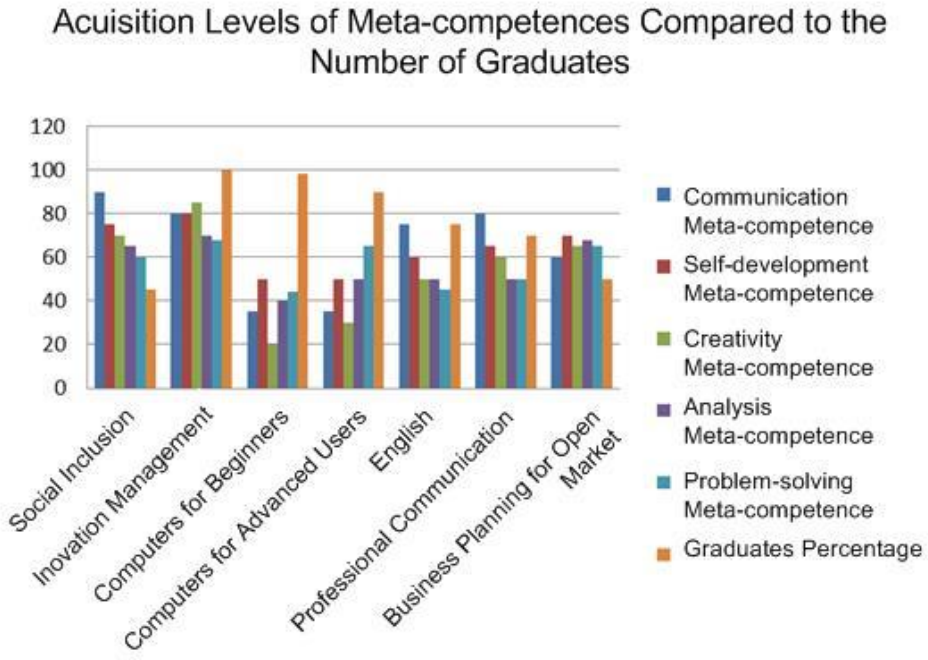


Picture 2.5. An individual's competence level development model (borderlines)

The next step was to verify the given correlations and proposed hypothesis. Seven courses were selected in which the component correlations were evaluated. Initially the author established what meta-competence level was reached in each course, as well as the number of students who had successfully completed the course. The attainable meta-competence level was defined after interviewing course tutors who had taken the course both as tutors and as students. This approach was chosen to objectively evaluate meta-competences in the course. Initially the author found out

each tutor's individual evaluation and after that by mutual agreement the total meta-competence level of each course was defined. The individual evaluations of the course and the total evaluation are depicted in Appendix 7, and graphically the correlations are shown in Picture 2.6.

Picture 2.6 shows a trend that with the increase of meta-competence level to be attained the number of course graduates becomes smaller. Innovation management course is an exception as its organization form is different from other courses. This course is organized with face-to-face sessions, and students study together in a group. These correlations are analyzed in more detail in the quantitative research described further in this sub-chapter. The quantitative research was carried out by a survey of graduates after successful completion of the course. The questionnaire is presented in Appendix 7 of this paper. The students of the following courses were surveyed.



Picture 2.6. Acquisition levels of meta-competences compared to the number of graduates

Comparing the outcomes of the qualitative and quantitative research cases the author has come to the conclusion that it is necessary to create an environment for evaluation of competence development and elaboration of the most relevant learning path in the continuing education IT ecosystem. To implement this goal the author developed a software prototype for carrying out such research.

The author's research and previous work experience in the sphere of continuing education gives the ground to conclude that currently there is a wide range of offers

regarding continuous education, and it takes time and knowledge of the wide range of offers for the person to choose a course [Stale G., 2009]. On the other hand, contents developers of the continuing education constantly create new contents without serious consideration of whether the total offer reaches the common goals of continuing education. [Caffarella R., Merriam B.Sh., 2000]. In the nature ecosystem there exists a self-regulating mechanism which ensures improvement of links among the elements, it is followed by a change in the structure of the system and appearance and disappearance of particular elements in the system [Jorgensen S.E., Straskraba M., 2000]. To implement this, it is essential to evaluate the continuing education IT system identifying links between its elements.

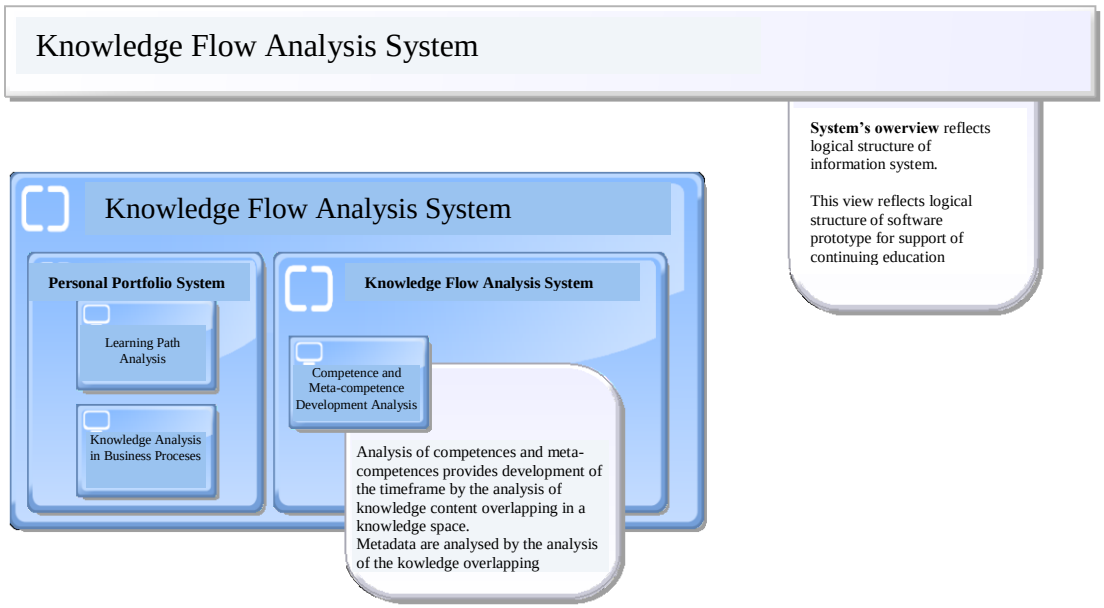
This research focuses in more detail on competence changes in the space of knowledge contents („learning objects") with an aim to evaluate the continuing education IT ecosystem and provide the users the best relevant learning path. To implement this task a special kind of software prototype was developed.

The total structure of the system of analysis of knowledge flows is given in Picture 2.7. The picture depicts two modules that differ from each other with their functionality:

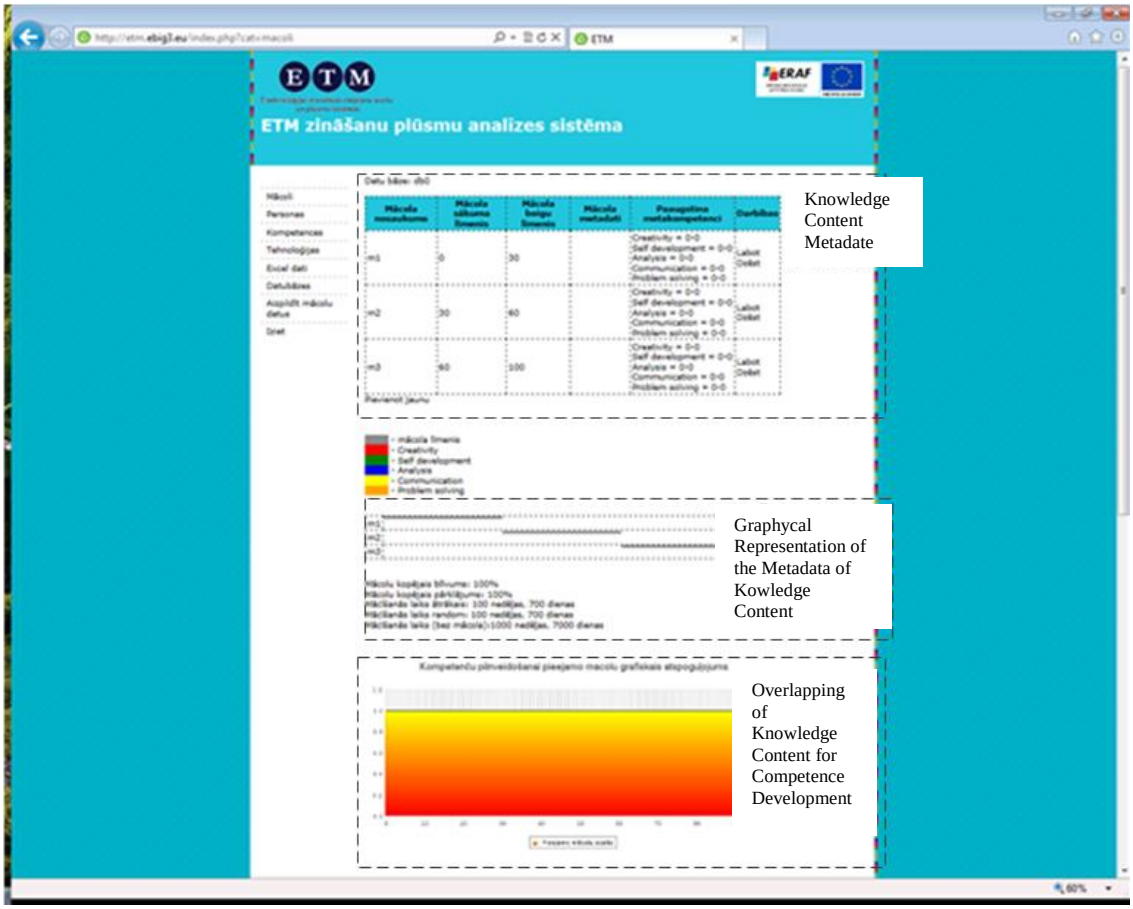
- a knowledge flow analysis system which includes a module of competence and meta-competence acquisition analysis;
- a personal portfolio system which includes analysis of the learning path and knowledge analysis in business processes giving an additional opportunity to use the system in companies for continuing education and competence development of the employees.

The prototype of experimental software is given in Picture 2.8. The Picture depicts the first three functionalities:

- reflection of knowledge contents ("learning object") metadata that are earlier downloaded into the system or specially downloaded into a specific package;
- graphic representation of the knowledge contents metadata; it gives a graphic picture of attainable competence range of knowledge contents (learning objects);
- a graph of knowledge contents overlapping shows a possible existence of the knowledge contents (learning object) in the total system.

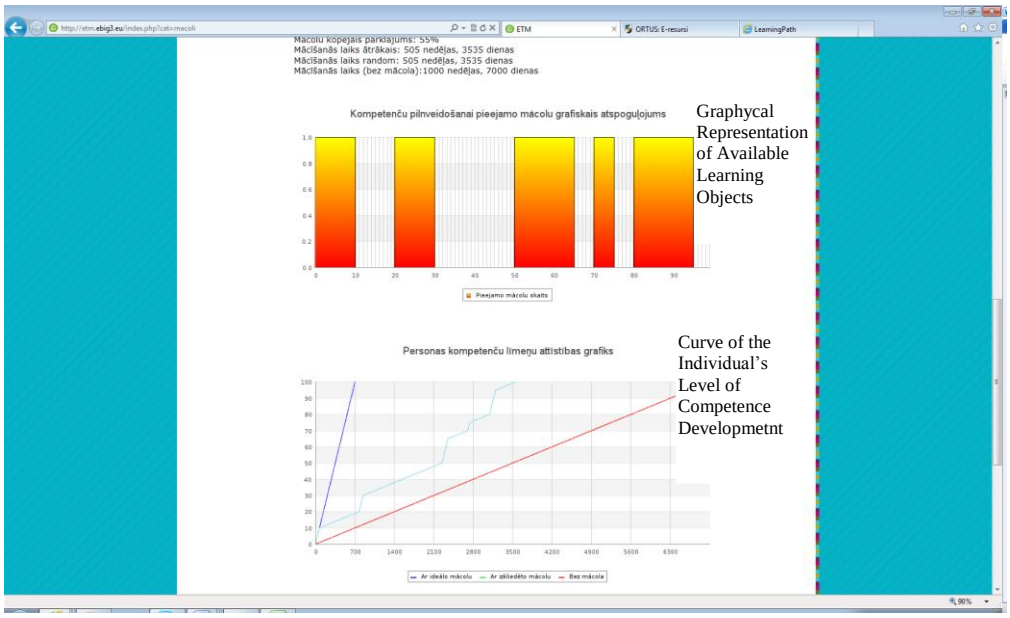


Picture 2.7. Architecture of experimental software



Picture 2.8. Prototype of experimental software – overview of knowledge contents (learning objects)

Charts in Picture 2.9 show analysis of knowledge contents („learning objects") metadata. The algorithm analyses the space of knowledge contents („learning objects"), investigates it and depending on whether in the given competence development situation such knowledge contents („learning objects") exist or not, it defines a definite timeframe quotient for the competence acquisition which has been set for ten previously done research cases. In case the knowledge contents („learning objects") exist, the competence development takes place in compliance with standards accepted in the education system of the Republic of Latvia, namely, one credit corresponds to one week (or 40 working hours) work.



Picture 2.9. Experimental software prototype – competence development curve (for a system with dissipated knowledge contents (learning objects)

2.3. Summary and Conclusions of Chapter II

In this part of the doctoral thesis the author analyses components of the continuing education IT ecosystem and reflects their correlation. Within the framework of the chapter the author has carried out a research on the impact of technologies on knowledge flows and an individual's competence development in the continuing education IT ecosystem.

The accomplishments in this chapter:

- theoretical literature study, compilation of elements in the continuing education IT ecosystem, identification of their parameters in the continuing education IT ecosystem;
- experts' survey on the role of technologies in meta-competence development in the process of continuing education IT ecosystem;
- research on the impact of technologies on the increase of knowledge flows and competences in the continuing education IT ecosystem;
- a detailed research regarding the impact of different types of technologies on competence development in the continuing education IT ecosystem.

The achieved outcomes in this chapter are the following:

- development of a component group for the continuing education IT ecosystem;
- compilation of conclusions regarding the intensity of the competence increase depending on the applied technologies for the provision of knowledge flows in the continuing education IT ecosystem;
- development and evaluation of a model for the continuing education IT ecosystem;
- development and evaluation of a prediction model for competence acquisition both within the situation in the continuing education IT ecosystem and outside it.

The main conclusions:

- knowledge flows in the IT ecosystem depend on the synergy of several factors which are: a person's meta-competences, relevant application of technologies for facilitation of knowledge flows, and the knowledge contents;
- knowledge flow in the ecosystem with an analysis of the knowledge flow system (in which the contents are offered adequately to the student's acquired meta-competences and competences) occurs ten times faster than without it;
- technological support for promotion of knowledge flows is very important, however, the research proved that the higher the education level of the student, the less technological support is necessary;
- the use of multimedia in the continuing education IT ecosystem plays an important role; this was proved by the research results: the more elements of

various multimedia are used for the promotion of the knowledge flow, the fewer face-to-face sessions in the classrooms are necessary;

- the knowledge flow in the continuing education IT ecosystem is more intensive in cases when the student's everyday work is connected with the topics of the knowledge flow;
- the intensity of knowledge flow depends on the level of meta-competences: the higher the level of all meta-competences, the less technological and methodological support is necessary for acquisition of competences.

3. CONCEPTUAL MODEL AND SOFTWARE PROTOTYPE FOR SUPPORT OF CONTINUING EDUCATION IT ECOSYSTEM

The chapter contains 19 pages, 1 table and 14 pictures.

To develop a conceptual model for support of the continuing education IT ecosystem, it was necessary to complete the following preparation described in this chapter: to compare various technologies, to select the most appropriate methodologies in accordance with the context of the situation, and to develop of a conceptual model for support of the continuing education IT ecosystem. The conceptual model reflects the main operational principles of the continuing education IT ecosystem. The developed model has been evaluated by expert interviews and by presenting it to an international audience, and in the target group. The first chapter analyzes methods of support for the continuing education IT ecosystem. The second part reflects the operational principles of the continuing education IT ecosystem. The third subchapter is a summary of evaluation of the continuing education IT ecosystem. At the end of Chapter III conclusions are given.

3.1. Conceptual Reflection of the Operation of the Support System's Principles for the Continuing Education IT Ecosystem

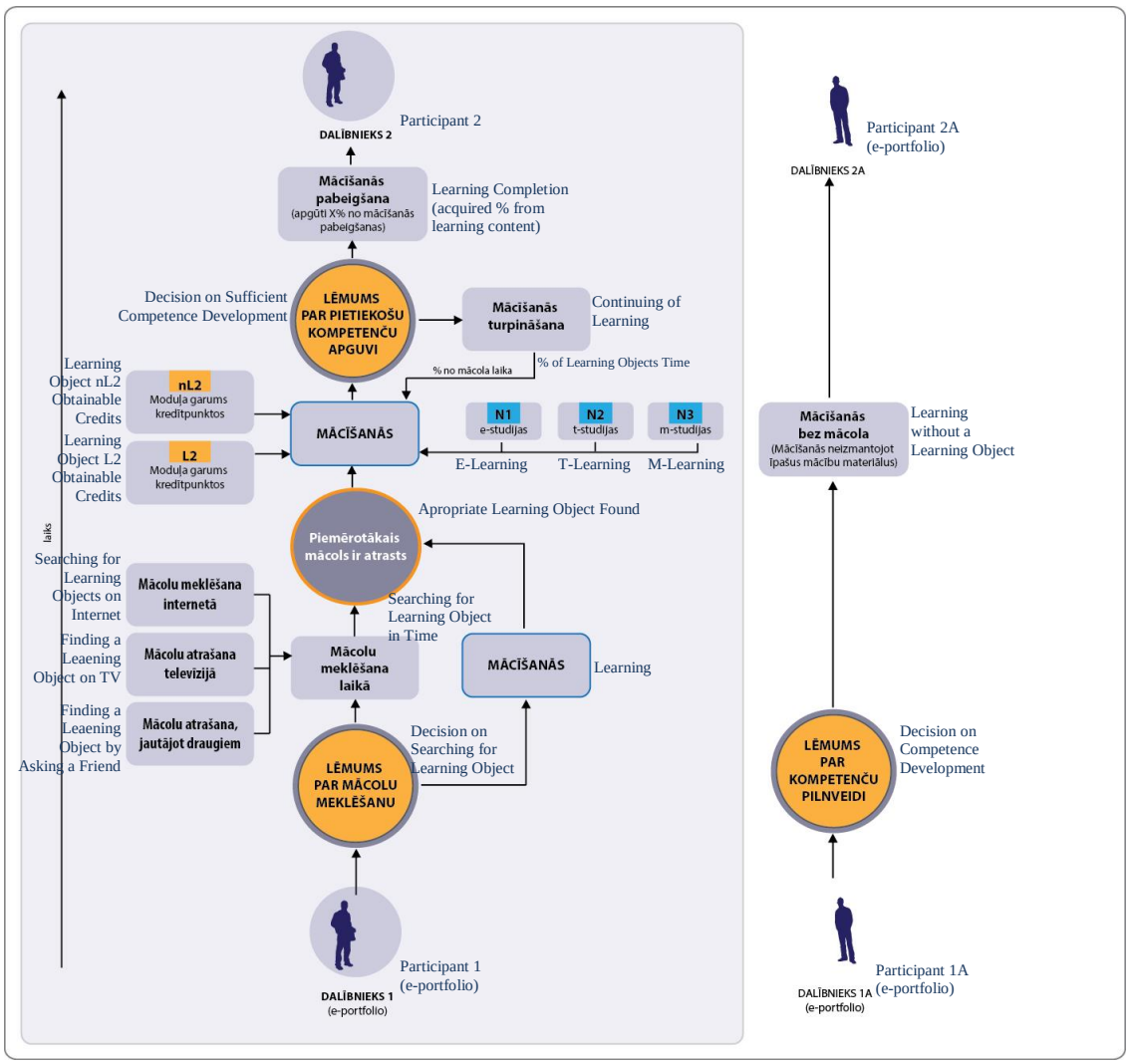
The conceptual model was developed in two stages. Initially the author researched the traditional systems' analysis and methods of reflection of conceptual operation. After their comparison the most appropriate method was selected for the development of the continuing education IT ecosystem.

Evaluating alternative variants of methodologies the author has come to the conclusion that for the analysis of conception for the continuing education IT ecosystem model the most appropriate approach would be a combination of two methods, namely, Zachman's architecture and socio-instrumental service modelling approach. Such an approach provides for meeting all the criteria and inclusion of all components of the continuing education IT ecosystem into the conceptual support model. This chapter presents a conceptual reflection of operation of the support system for the continuing education IT ecosystem using Zachman's architecture and socio-instrumental service modelling approach.

The operation principles of the continuing education IT ecosystem are shown in Picture 3.1. It shows the two main systems borderlines (described in more detail in Chapter II):

- a situation with no knowledge contents, and the individual acquires knowledge without a special learning material; in this case competence development is ten times slower than in cases when such a material exists;
- a situation with learning material (learning object) which indicates searching for further knowledge contents, finding the best 'learning object' and competence development in the system of the continuing education IT ecosystem.

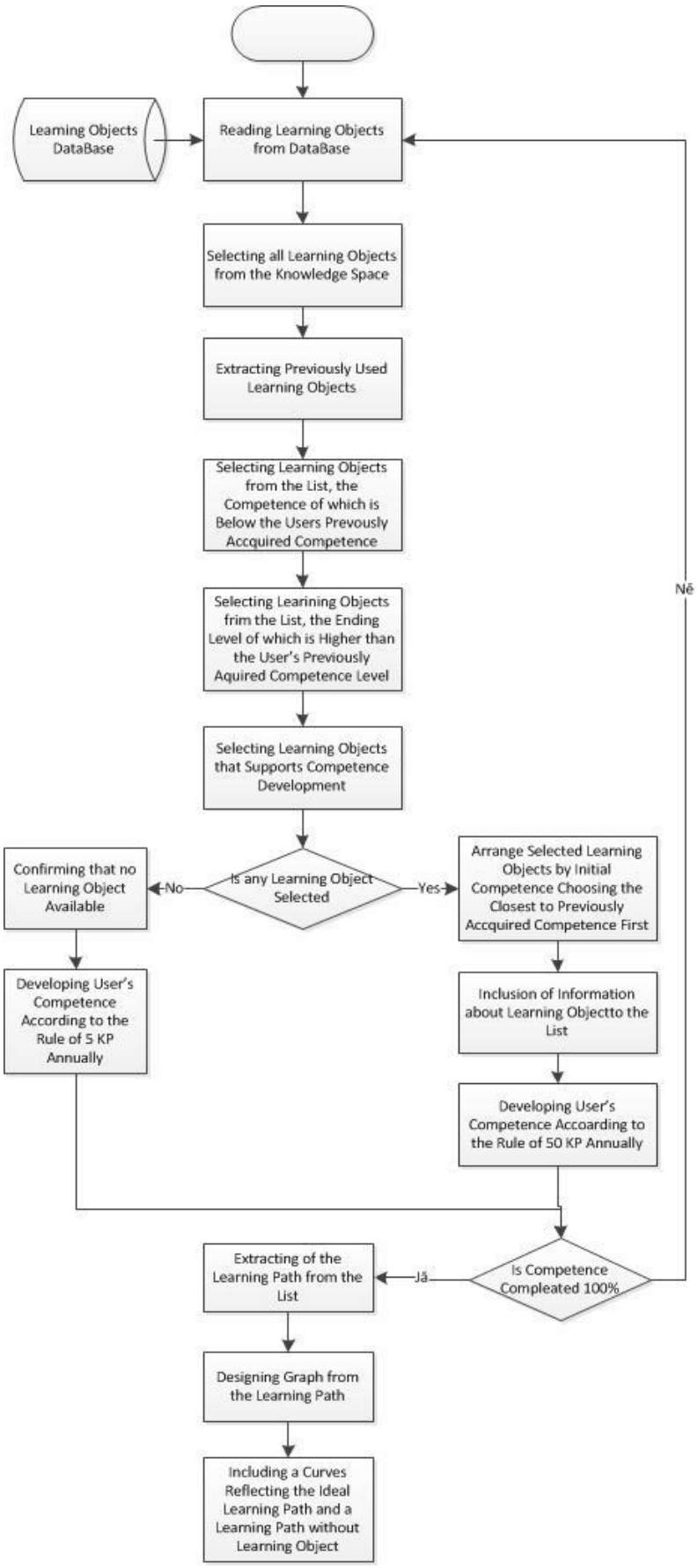
Picture 3.1 gives a scheme of operational principles of the continuing education IT ecosystem which shows that initially the student makes a decision of finding a learning object this is followed by searching for learning objects, during this stage the student learns by developing his/her meta-competences. In this case technologies may help in finding the learning object. When the respective learning object has been found, the real learning process starts, as the result of which competences are developed. In such a case the knowledge contents are offered in the form of e-learning, t-learning and m-learning. After the learning process is completed, it is evaluated and a decision is made whether to continue the competence development or to finish studies. At this moment the knowledge flow analysis system may be very useful as it indicates perspectives and possibilities of further competence development.



Picture 3.1. Principles of operation of the continuing education IT ecosystem

3.2. Knowledge Flow Analysis Software Prototype for Support of the Continuing Education IT Ecosystem

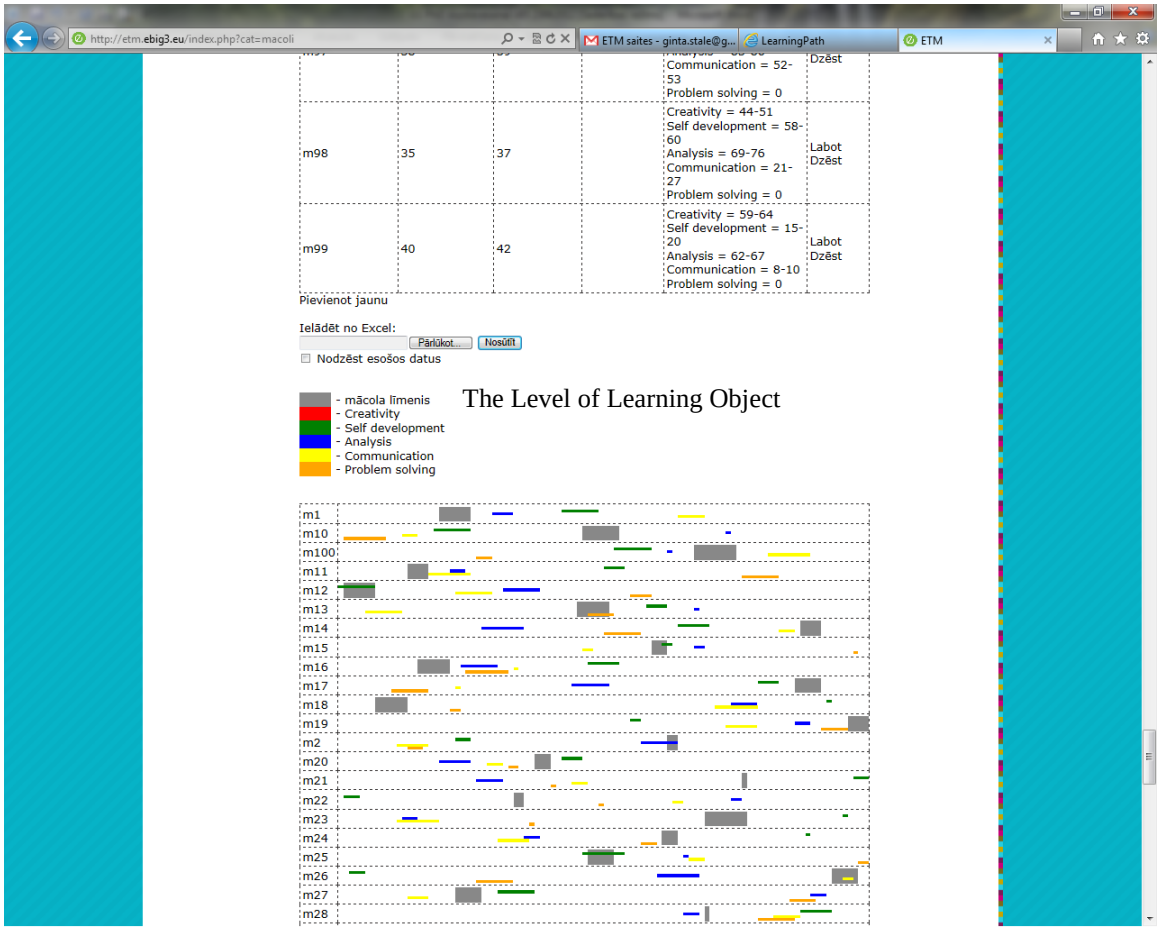
The system's main operation is shown in Picture 3.2, it depicts the way how the system evaluates possible learning paths by calculating possible learning time in the existing system and finding the most beneficial ways for the user for the development of competences and meta-competences.



Picture 3.2. Knowledge Flow Analysis Software Prototype for Support of the Continuing Education IT Ecosystem

Picture 3.2 depicts how initially metadata of the knowledge contents (‘learning object’) are read from the knowledge base. Further on the learning object metadata analysis is carried out according to competence levels, the program selects learning objects that develop the respective competences. The next step in the system is to arrange the ‘learning objects’ according to the initial competences and selecting the closest ‘learning object’ in compliance with the law which prescribes to offer the user a ‘learning object’, whose initial competence does not exceed 50% of the student’s competence in the respective sphere. Then the system prepares the output of all possible learning paths and finds the most beneficial path for the student.

Picture 3.3 shows a graphic reflection of the learning contents (‘learning objects’) overlapping field. It shows the range of learning object’s provided competences and meta-competences in relation to the metadata imported into the system.

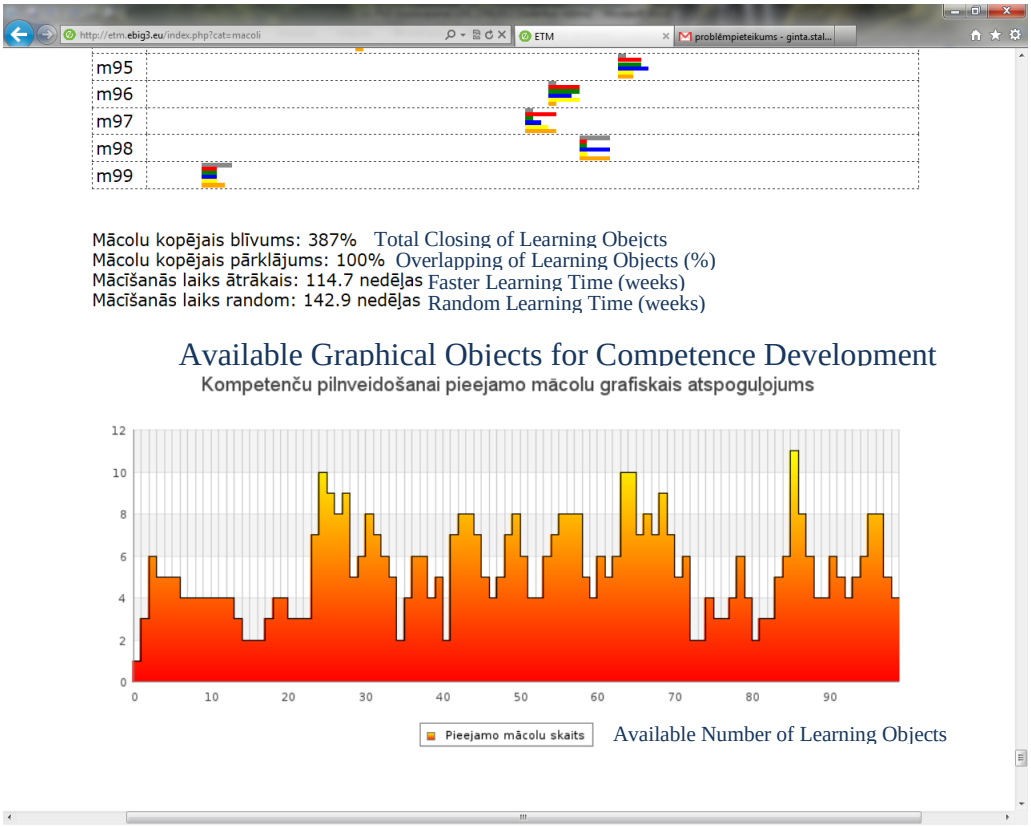


Picture 3.3. Graphic reflection of the knowledge overlapping field

Picture 3.4 shows a graph of knowledge density and overlapping presenting available learning objects for the development of the competences. The appropriate competence levels are saved in the metadata of each learning object. The given picture shows the available number of learning objects for the required competence level. Such

a graph makes it possible to have an overview of the learning objects' field and survey the missing learning objects in certain competence levels.

The developed software prototype was evaluated in a students' group at Vidzeme University of Applied Sciences in two stages. In the first stage it was demonstrated to a students' group to find out their opinions of usefulness of such a program, its functionality and understandability. After the presentation it was amended and supplemented.



Picture 3.4. Chart of knowledge density and overlapping

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3.3. Summary and Conclusions of the Development of Conceptual Model and Software

This chapter of the doctoral thesis is devoted to the analysis of methodologies of the development of the continuing education IT ecosystem, as the result Zachman's architecture approach has been chosen. The developed model includes two parts: the software part and the system's part.

The author has accomplished the following:

- has analyzed methodologies for the development of the continuing education IT ecosystem;

- has elaborated a model for promotion of knowledge flows in continuing education;
- the elaborated model has been evaluated in the experts group and in the target group;
- has used an in-depth interview method for the evaluation of the model; the outcome reflects the evaluation of the target group;
- has developed a software prototype for the analysis of knowledge flow in the continuing education IT ecosystem; the developed prototype has been tried in the target group and evaluated as adequate for the given purpose.

The main conclusions are the following:

- the developed continuing education IT ecosystem makes it possible to design adequate systems for promotion of knowledge flows;
- the effectiveness of knowledge flows and competence development support depends on evaluation of knowledge flows;
- the knowledge flow support prototype for the continuing education IT ecosystem should include competence analysis and offer learning paths for the participants of the continuing education process;
- the developed software prototype analyses the spectrum of students' competences and selects the most appropriate learning path;
- the developed prototype offers a possibility to select the most relevant competence development way for the student and do it more accurately and faster.

CONCLUSIONS

The following **goal** was set for the doctoral thesis: to develop an information technology ecosystem model for support of continuing education.

Implementing the set objectives the author achieved the following **theoretical outcomes**: the author

- researched and analyzed concepts related to continuing education IT ecosystem and defined new concepts in the context of this Paper;
- developed theoretical justification for provision of an IT ecosystem to support the continuing education from the perspective of the service receiver (further in the text: student);
- defined the concept of knowledge flow and developed a theoretical model for prediction of its timeframe from the aspect of the student in the context of the continuing education IT ecosystem;
- elaborated theoretical justification for the development of the IT ecosystem model to support continuing education form the student's aspect;
- summarized and scientifically justified the outcomes of the research on the impact of technologies on competence developemnt in continuing education IT ecosystem;
- developed and obtained evaluation of the IT ecosystem model for support of continuing education from the perspective of the student;
- developed and obtained evaluation of an algorithm for forecasting of knowledge flows and selecting the shortest learning path in the continuing education IT ecosystem;
- defined software requirements for the support of the continuing education IT ecosystem from the perspective of the student.

Implementing the set objectives the following **practical outcomes** have been achieved:

- developed and evaluated a software prototype for knowledge flow analysis in the continuing education IT ecosystem which will be applicable for further research in the sphere of continuing education.

While implementing the set tasks for the doctoral thesis and evaluating the achieved outcomes, the author has come to the following **conclusions:**

- research spectrum of other researchers is wide, and each of the examined models, technologies or methodologies characterises a specific situation in education and application of a particular technology; however, none of them can offer scientifically and methodologically grounded answers to what technology package should be used for development of concrete competences of the given person;
- after studying respective literature the author has come to the conclusion that the use of technologies in continuing education models is limited to introduction of the experience in traditional continuing education into information technologies without presenting a model that would offer evaluation of adequacy of the particular technology for the given situation in the continuing education, or it would give a possibility to set requirements for the development of a new technology or improvement of the existing technology;
- authors have researched and reflected certain types of technologies and their application in various situations in continuing education; however, there are no models that would sufficiently include synergy and comprehensive technology application;
- the authors who have studied application of some specific types of technologies in various situations in continuing education, emphasize the importance of a comprehensive IT ecosystem model in continuing education;
- other researchers have done research to solve questions of an IT ecosystem development in general, including different contexts of education; however, there is no research in the sphere of continuing education which would characterize components of the system, their correlation and knowledge flows, although, when interviewing people who are practically involved in the solution of problems in continuing education in Latvia, they all admit the necessity for such research;
- various technologies have been analyzed and research done in the sphere of application of these technologies, yet, there are no continuing education models in IT ecosystem;

- knowledge flows in IT ecosystem depend on synergy of several factors which include the individual's meta-competences, competences, technologies for relevant application for promotion of knowledge flows and knowledge contents;
- IT ecosystem provided with analysis of knowledge flow provides for ten times less time consuming for learning activities;
- technological support is essential for the promotion of knowledge flows, however, research proved that the higher person's education, the less technological support is necessary;
- multimedia play an important role in the use of various technologies in the situation of the continuing education IT ecosystem, and it is proved by the research outcomes which show that the more elements of various multimedia are used for promotion of knowledge flows, the less necessity there is for face-to-face meetings in lecture rooms;
- knowledge flow in the situation of the continuing education IT ecosystem is more intensive in cases when the person's everyday work is related to the field of knowledge flow;
- intensity of knowledge flow depends on the level of meta-competences: the higher the level of all meta-competences, the less technological and methodological support of various types is necessary for the development of the competences;
- the elaborated continuing education IT ecosystem model reflects requirements for the developemnt of a respective software prototype;
- the knowledge flow support prototype of the continuing education IT ecosystem should include competence analysis and offer learning paths for the participants of the process of the continuing education;
- the developed software prototype analyzes the spectrum of students' competences and selects the shortest learning path for each individual;
- the developed prototype makes it possible for each student to find the shortest competence development way faster and more accurately;
- the developed software prototype offers a possibility to evaluate knowledge overlapping and time in the continuing education IT ecosystem;
- the main components of the continuing education IT ecosystem are:

- the student as the main participant of the ecosystem, the data of whom are saved in the system portfolio;
- knowledge contents providing for the learning activity in the continuing education IT ecosystem;
- continuing education service provider who develops and provides for the contents of the continuing education;
- knowledge flow provided through information technologies;
- continuing education service receiver's technologies providing for the students learning activity;
- approach to information technology interaction, adaption and self-organization;
- an essential role in the provision of knowledge flow in the continuing education is played by the offer of technologies, methods and knowledge contents depending on the user's portfolio and technologies for the learning activities;
- the applied technologies are important for the provision of the effectiveness of knowledge flow in the continuing education IT ecosystem;
- observations and research within this paper have proved that the applied technologies are essential for promotion of learning activities, however, from the aspect of knowledge flow the knowledge overlapping and the student's achieved level of meta-competences are equally important;
- the correlation of the main components in the continuing education IT ecosystem is determined by:
- the set learning goals;
- the number of learning objects and their overlapping in the ecosystem;
- meta-competences of the participants of the ecosystem;
- larger knowledge overlapping in the continuing education IT ecosystem provides for a shorter timeframe for the development of competences;
- in order to make knowledge flow effective and the student could acquire the competences in the shortest possible time, it is necessary to provide a 100% knowledge overlapping and carry out an analysis of possible learning paths for the particular situation in the continuing education;
- the developed software prototype gives an opportunity to carry out an analysis of the student's possible learning paths, thus helping to find the

shortest possible learning path according to the competence and meta-competence levels of the particular student;

- the character of learning contents is determined by the level of meta-competences; higher level of meta-competences provide for a shorter competence acquisition in the ecosystem.

Possible **directions of further research:**

- knowledge flow analysis from the perspective of the continuing education contents provider;
- use of social networks possibilities for knowledge flow analysis in the continuing education IT ecosystem;
- automatic retrieval and storage of learning objects' metadata in the common database of the continuing education IT ecosystem;
- research of various continuing education situations in the context of continuing education IT ecosystem knowledge flows;
- integration of the continuing education IT ecosystem into the Personal Knowledge Management.

Novelty of the research for the doctoral thesis:

- defined theoretical framework for the continuing education IT ecosystem (definitions, correlations, interdependence of components);
- developed and evaluated a model for the continuing education IT ecosystem;
- developed software prototype for evaluation of knowledge flows and for forecast in the continuing education IT ecosystem.

The theoretical significance of the research for the doctoral thesis:

- the theoretical aspects of the continuing education IT ecosystem provide for a theoretical basis for further research in this problem sphere;
- the developed model for the continuing education IT ecosystem reflects the necessity for development of new technologies and requirements in promotion of knowledge flows and development of continuing education services;
- the developed software prototype for the support of the continuing education IT ecosystem proves for analysing knowledge overlapping and evaluation of a student's learning path.

The practical significance of the research for the doctoral thesis:

- the model of the continuing education IT ecosystem gives a possibility to analyze and forecast knowledge flow according to the student's meta-competence level which in its turn provides for promotion of activities in the continuing education;
- the developed software prototype for the continuing education IT ecosystem may be used for an individual's personal competence development planning and facilitate finding the shortest learning path in the particular situation;
- the developed software prototype makes it possible to evaluate knowledge overlapping and possible learning paths in the continuing education IT ecosystem;
- the developed model for the support of the continuing education IT ecosystem gives a possibility to plan lifelong learning on a national and university level and facilitates development and implementation of various projects.

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