# The Application of EM for Knowledge Flow Analysis and the Development of an Educational IT Ecosystem

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**Abstract.** Knowledge flow is invisible but plays an important role in educational processes. A wide range of accessible information technology (IT) for educational purposes as well as the potential for new technologies allow people to learn throughout their lives. Accelerated IT development and short amount of time for learning activities emphasize the requirement for continuing education and the synergy between accessible technologies. Analysis of knowledge flow becomes important during the learning process within an educational information technology (IT) ecosystem. Learning objects within IT are the major medium that enables knowledge to pass between teacher and learner. The developer of an educational system can identify factors that may impact on the learning process more successfully by using enterprise modeling The objective of this article is to apply the enterprise modeling approach to the analysis of knowledge flow in continuing education. The proposed approach can be applied not only to educational institutions but also in business organizations. The digital ecosystem approach is implemented in the model to support the knowledge flow analysis within educational and business processes.

**Keywords:** Enterprise Modeling Method, Information Technology, Continuing Education, Knowledge Flow Analysis.

## 1 Introduction

Analysis of knowledge flow within the educational system has become more important during the development of information technologies (IT). The main characteristic of an educational system is its organization which is controlled by knowledge flow within learning processes. Other qualities are that they are selective and are continued within and are certain limits self-regulating [Skyttner, 2005]. The lack of a comprehensive approach to using technology for educational purposes means that there is a limited approach for linking technologies used for teaching purposes, to the learning content and the learner's portfolio. Consequently there is a need to apply the principles of ecosystems in the development of teaching systems. User portfolio and technology communication are an important obstacle to be taken into account in the analysis, design and evaluation of teaching systems. Knowledge flow is invisible but plays an important role in educational processes and can enhance creativity and competitiveness of knowledge-intensive business processes.

The focus of this paper is on educational IT ecosystems in continuing education. A wide range of accessible information technology (IT), as well as the potential of new technologies allow people to learn throughout their lives. The necessity for life-long learning defines turbulent change and the rapidly-changing demand for new knowledge and skills. Current IT development and the short amount of time for learning activities emphasize the requirement for continuing education. The objective of this article is to present practical experience of enterprise modeling applied to the analysis of knowledge flow as well as the requirements for the development of software prototype. The ecosystem approach matches more precisely the needs of the learner to become and remain competitive in the ever-changing world. The aim of the applied approach is to support knowledge flow analysis in an educational IT ecosystem according to the learning situation, learner needs and the available technology in a specific time, place and learning situation.

The following sentences briefly outline the main points of the paper. The concept of knowledge flow analysis is analyzed in Section 2. Section 3 describes related work. Section 4 reflects enterprise modeling for knowledge flow analysis while section 5 provides the conclusions.

## 2 Concept of the Knowledge Flow Analysis

The aim of this section is to discuss the main concepts of particular research. The main concepts analyzed in this section are: knowledge flow, an educational IT ecosystem, continuing education service providers and consumers, the learner's portfolio and learning processes.

*Knowledge flow* in the context of knowledge-intensive teamwork is the passing of knowledge within a team [Zhuge H., et al., 2006]. Knowledge flow begins and ends at a knowledge node [Zhuge H., et al., 2006]. A knowledge node is either a team member or a role that can generate, process, or deliver knowledge [Zhuge H., et al., 2006]. From the organizational perspective, knowledge flow is defined as a method that supports knowledge accumulation and sharing [Uden L., Damiani E., 2007]. In the context of an educational IT ecosystem, knowledge flow is the passing of knowledge between knowledge nodes which are between the continuing education content provider and the consumer of education. The provider of the continuing education content is teacher in the education institution or another professional in this field. The consumer of the content is student.

*Continuing education* is a broad concept which includes all of the learning opportunities which any person wants or need outside basic and primary education. It extends beyond the completion of formal studies and into the less formal area of adult education [Stale G., Cakula S., Kapenieks A., 2011]. In the context of this paper, continuing education is defined as the active and informal learning process of adults, using different learning options, content accessibility, applied methods and IT solutions according to learning needs, learning solution, style and accessible technologies.

*An Educational IT ecosystem* is a term developed from digital ecosystems. A digital ecosystem is a self-organizing and adaptive digital infrastructure that supports an organization or communities working together to create and share of knowledge [Uden L., Damiani E., 2007]. An IT ecosystem for educational purposes is an adaptive digital infrastructure that supports the learning process in an organization [Stale G., Madsen P., 2009]. The digital infrastructure consists of digital components which comprise software components, applications, services, knowledge, business processes and models as well as training modules. An educational IT ecosystem in the context of this paper is defined as a digital environment which supports the continuing education process according to the learner's needs and competences. Competence includes knowledge, skills, attitudes, values and experience to solve particular problems, obstacles or barriers [Karampiperis P., 2006].

*A learner's portfolio* contains the results written and record of previous education and competences in a particular field [Yang T.C., et al., 2012]. The portfolio reflects the level of competence within a subject or area of knowledge.

Figure 1 represents the concept of knowledge flow. According to Figure 1, knowledge content is provided by the knowledge provider – a teacher or other professional. The knowledge content is the learning object which is delivered through the internet in the knowledge space. The knowledge repository collects knowledge metadata for the educational IT ecosystem to provide a knowledge flow analysis.

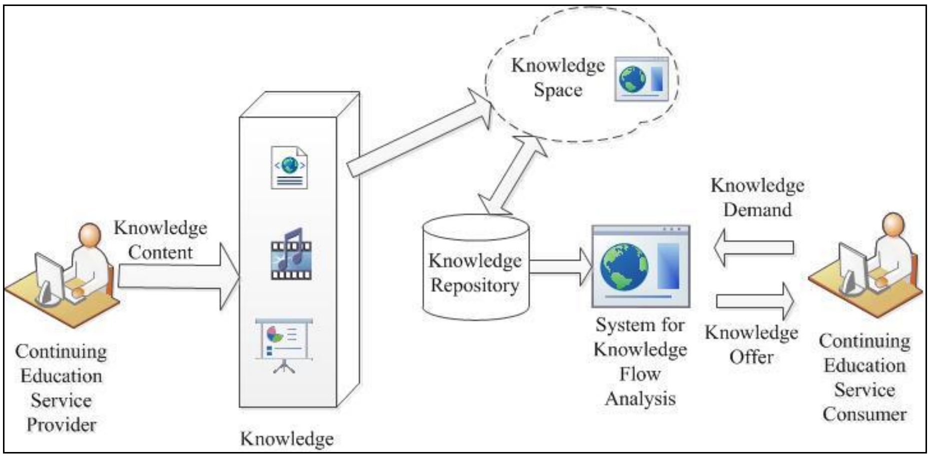


Figure 1. The concept of knowledge flow

The main concepts have been discussed in this section. The next section describes related work in this field.

## 3 Related Work

There are three main categories of work related to the IT ecosystem approach. The first category concerns is supporting a more effective learning process – the application of a learning ecosystem approach. The second concerns the analysis and modeling of knowledge flow. Third is the technological support of the educational process.

First area includes Educational Modelling Language (EML), a learning design specification [Whitman L., Huff B., 2001] and an education-oriented development framework [Jing, M., Li, X., Bin, Q., 2008], digital ecosystem paradigm for IT course development [Chin L. K, Chang E., Atkinson D., 2008] and an e-Learning ecosystem [Uden L., Damiani E., 2007] where the research describes the behavior of a learning ecosystem.

Koper and Tattersall described the necessary preconditions for the learner to become active in the learning process [Koper R., Tattersall C., 2005]. They are:

- the development and delivery of educational courses which include role-plays and game-playing, where multiple users perform a variety of interdependent tasks;
- the provision of problem-based learning courses where teams of learners collaborate in problem-solving and teachers have assessment, coaching or monitoring roles;

• the application of learning community approaches based on social-constructivist principles, where the design of the learning environment stimulates collaboration and the sharing of knowledge and resources;

• the application of performance-supported approaches, where learning tasks are assigned depending on the knowledge gaps assessed;

• the development of courses which can be adapted according to pedagogical models, learning processes and learning needs, preferences and the learning style of consumer

• the application of peer coaching and assessment approaches, where learners support each other.

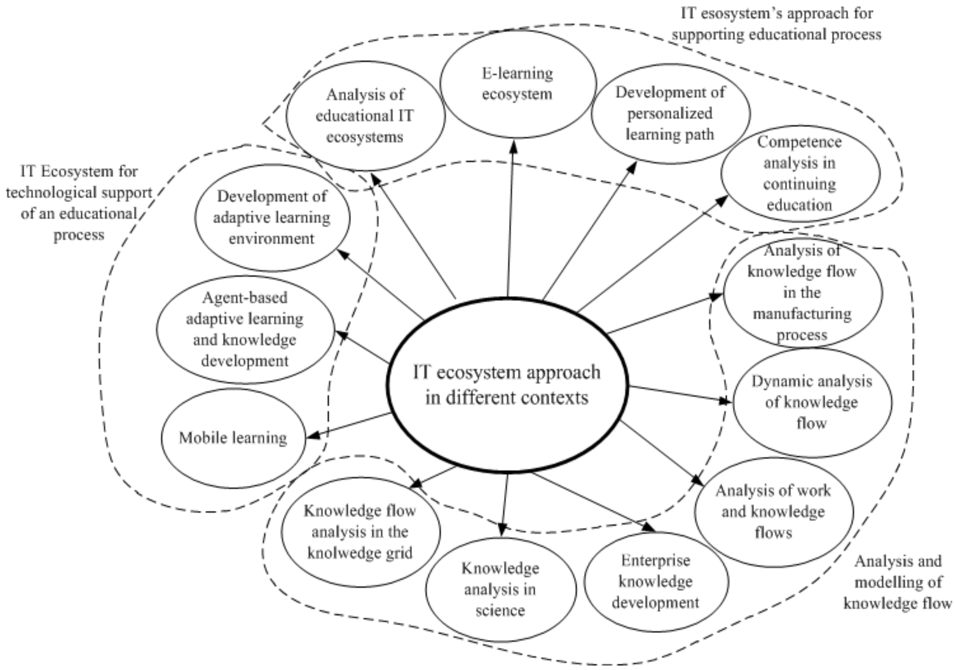


Figure 2. Fields of related work

From the learning ecosystem viewpoint there are models developed [Chang V., Guelt Ch., 2007], [Quinones, M., et al., 2008], [Guetl, C., et.al., 2005] where the main conceptual parts of learning ecosystem have been described. Chang described a learning ecosystem consisting of biotic abiotic units. Biotic units are learning communities, stakeholders, teachers, tutors, content providers, instructional designers and pedagogical experts. Abiotic units are the learning utilities, the learning environment which includes the learning media and technology [Chang V., Guelt Ch., 2007]. The significant part of a learning ecosystem is the learning ecosystem conditions which are determined by external influences such as the evaluation of knowledge, educational goals, learning tasks, cultural and social aspects, as well as the expectations of society, private industry and business organizations, the government, public service and not-for-profit organizations. The significant areas of interest in the learning domain are relationships and interactions related to the information flow as well as knowledge transfer and transformation [Guetl, C., et.al., 2005].

The second part of related work includes analysis and the modeling of knowledge flow in different contexts [Fan I., Lee R., 2009], [Huggins R., Johnston A., 2010], [Leistner

F., 2010], [Park H.W., et al., 2011], [Zhuge H., 2006]. The results describe knowledge flow principles and application domains. The aim of this particular piece of research work was to develop an enterprise model for knowledge flow analysis in an educational IT ecosystem. This model could meet the challenge of supporting learning organizations with appropriate technological and content solutions to support knowledge sharing and management, and the life-long learning process in learning communities.

The third related field is the technological support of the educational process [Jing M., et al., 2008], [Peter-Quinones M.A., et al., 2008]. The main problem defined in the related work was that, in many cases, the software applications on all the user's devices were designed to be functional copies of each other, often with an emphasis on keeping their form and function consistent with the same application on other device platforms. In one part of the related work [Jing, M., Li, X., Bin, Q., 2008], the idea of a personal information ecosystem was presented, as an analogy to a biological ecosystem which allows us to discuss the interrelationships between users' devices. A complementary approach defined the IT ecosystem as an interconnected system within which computing services were requested and delivered [Driscoll M.P., 2005]. The components of the ecosystem included any and all items that were required to conduct these service-based transactions, including, but not limited to, handheld - mobile phones, PDAs, laptops, etc., desktop computers, in-home networked appliances, networked printers, servers and storage devices, networking equipment and data centers. Defining an IT Ecosystem in this way highlights the interconnections and interdependence of the components within the system.

## 4 An EM for Knowledge Flow Analysis

Enterprise modeling enables a common understanding of all the pertinent aspects, the clear description of problems in an educational IT ecosystem and the requirements for knowledge flow analysis. It also enables the definition of various design alternatives and a mechanism to analyze these options for design implementation at strategic, tactical, operational and technological levels [Whitman L., Huff B., 2001].

The following methodologies were chosen as benchmarks [sown in Table 1]:

- the Yu methodology – strategic relationship development [Horkoff J., Yu E., 2009];
- the EKD (Enterprise Knowledge Development) – an enterprise modeling method [Bubenko J.A., Kirikova M., 1999], [Persson A., 2001];
- the Keith A.Butler method – for business process modeling and software requirements definition [Buthler K.A., 2000];
- the BPR (Business Process Redesign) – a method aimed at business process redesign and optimization [Gao Sh., Krogstie J., 2009];
- the Business Process Management Systems – a method for business process analysis from organizational, functional and behavioral viewpoints [Carvalo J.P., French X., 2009];
- the DRM (Decision Relationship Model) – reflecting actors, processes, input flows und decisions [Shahzad K., Zdravkovic J., 2009];
- the Service-Driven Information Systems Evaluation – this provides an analysis of business processes and abilities to use resources accessible to enterprises [Arni-Bloch N., Ralyte J., Leonard M., 2009];
- the Zachman Enterprise Architecture; this is a two dimensional classification scheme for describing different characteristics of an enterprise which consists of different characteristics of the final product [Zachman, 2006].

Table1.Benchmarking of the Methods used for the Analysis of Knowledge Flow and Development of an Educational IT Ecosystem

| **Methodology Criteria** | **Business Process Management Systems** | **DRM (Decision Relationship Model)** | **Service-Driven Information Systems Evaluation** | **Zachman Enterprise Architecture** |
|---|---|---|---|---|
| Defining goals | - | + | - | + |
| Defining processes for comparing with goals and recourses | -/+ | + | + | +/- excluding relationship between models |
| Possibility to define knowledge gaps | - | -/+ | - | - |
| Definition of hierarchical structure | - | + | - | + |
| Define requirements for a CE system | - | + | +/- | - |
| Defining goals | - | + | - | + |
| Defining processes in comparing with goals and recourses | +/- | + | + | + |
| Possibility to define (reflect) knowledge gaps | + | +/- | - | + |
| Definition of hierarchical structure | + | - | - | + |
| Define requirements for CE system | + | + | +/- | + |

The Enterprise Knowledge Development (EKD) method has been chosen as the Enterprise modeling method. The use of enterprise modeling methods and an “ecosystem” approach to knowledge flow analysis within the educational IT ecosystem provided a wide range of options to implement a more dynamic analysis of educational processes and supports definition of requirements for the development of a prototype to support these processes. Figure 3 shows a developed model for knowledge flow analysis within an educational IT ecosystem.

The EKD methodology is one of the enterprise modeling methods that was developed some years ago and is increasingly used by business consultants. This method has been the subject of research in a number of multinational European projects, including the 7th framework programme. It has proved its effectiveness both in the business and public sector by providing a framework for stating, modeling, and reasoning regarding pertinent knowledge in difficult problem situations which typically occurring in organizations and society.

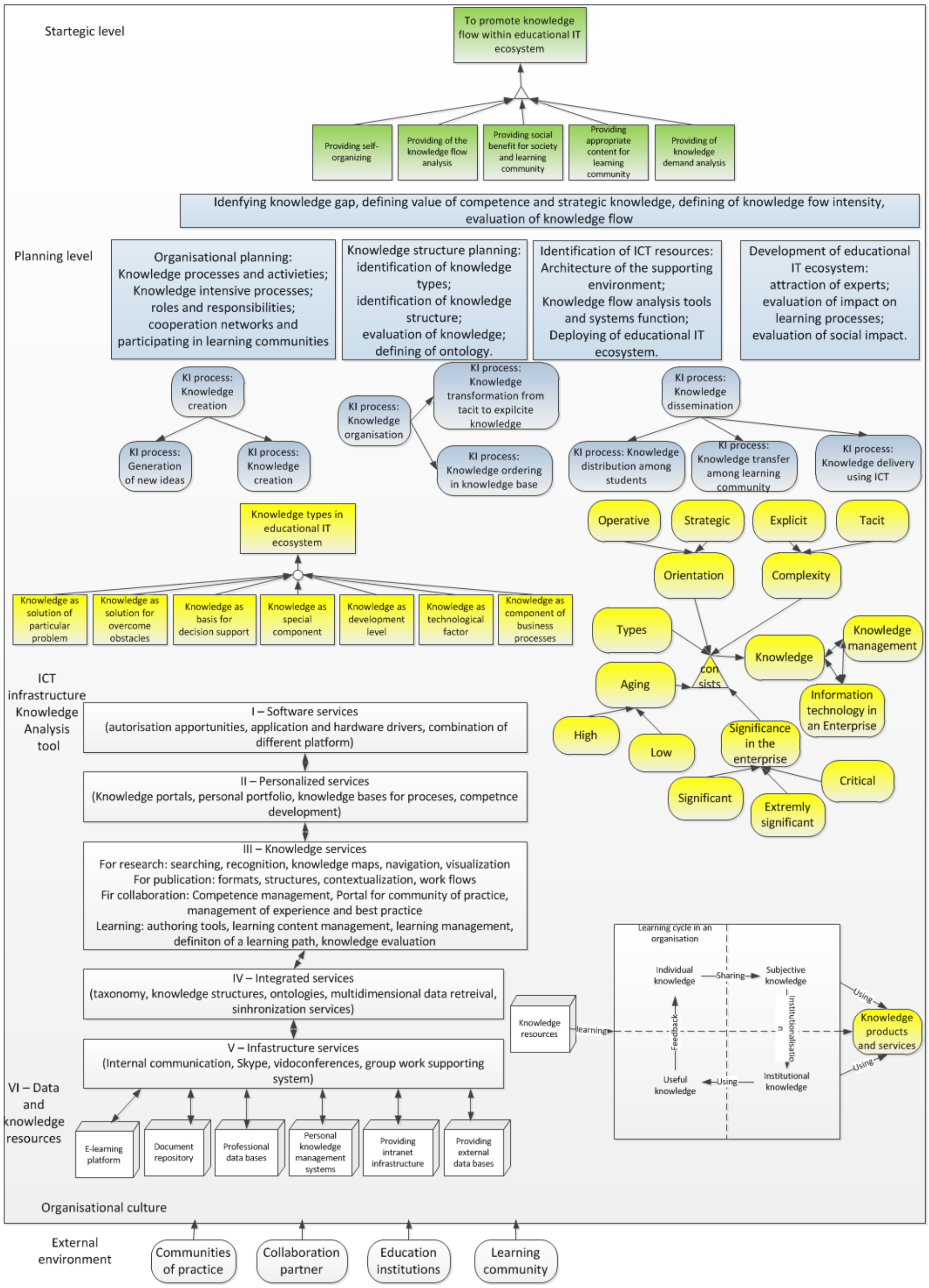


Figure 3. A Model of a Knowledge Flow Analysis within an Educational IT ecosystem

The EKD aims at setting an organization's vision, mission and goals, providing guidance in restructuring in changing different processes. EKD methodology has been expanded in this article by providing different levels of the model.

The Figure 3 shows a strategic level where goals are reflected and planning level where processes and concepts are shown. The next level shows the requirements for information and communication technologies and the knowledge analysis tool. The final level shows data and knowledge resources. Figure 4 reflects a conceptual model for the a prototype of an educational IT ecosystem to support the knowledge flow in the learning process. Knowledge flow analysis is implemented in the knowledge support system by analyzing the competence level of the student and matching to an appropriate learning path. A learning path is constructed depending on the learning objects.

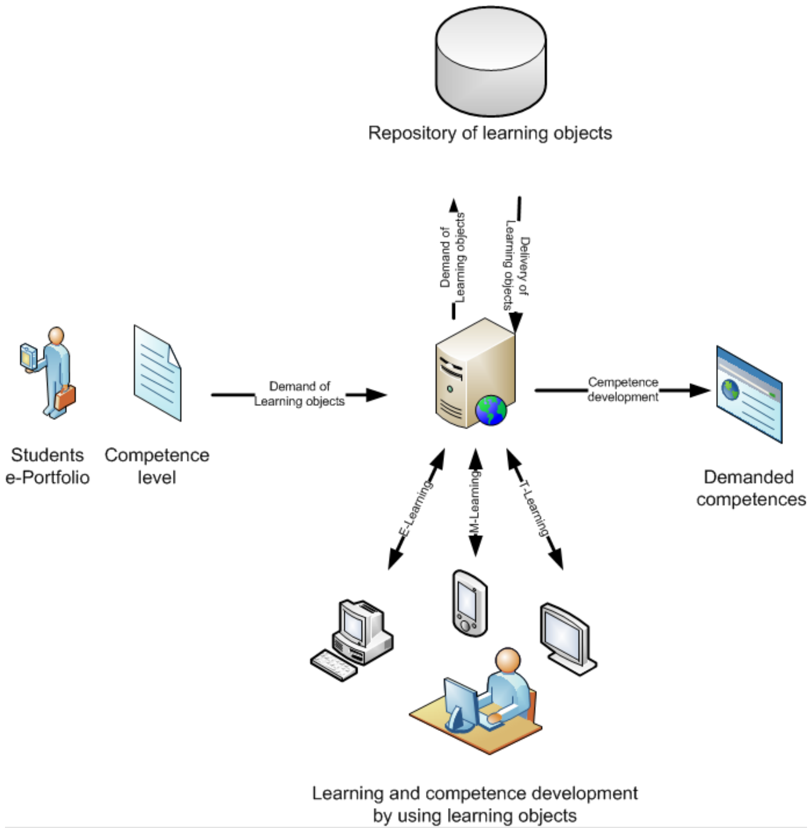


Figure 4. Conceptual Model for the Prototype of an Educational IT Ecosystem

Figure 5 and Figure 6 show a prototype of the software for a knowledge flow analysis in an educational IT ecosystem. Figure 5 shows the main screenshot form of the prototype. It demonstrates a competence field where the users can demonstrate their competences within particular subject. A meta-competence field is also shown. Meta-competences are defined by the study of the research done within 6$^{th}$ Framework Project [Berlanga A. J., et al., 2008]. Figure 6 shows the screenshot from the module for a knowledge flow analysis within business processes. An appropriate learning path is shown to the user after the definition of the student's competences, business processes and knowledge flow. The learning path is analyzed according to the user's initial competences, business processes and knowledge flow.

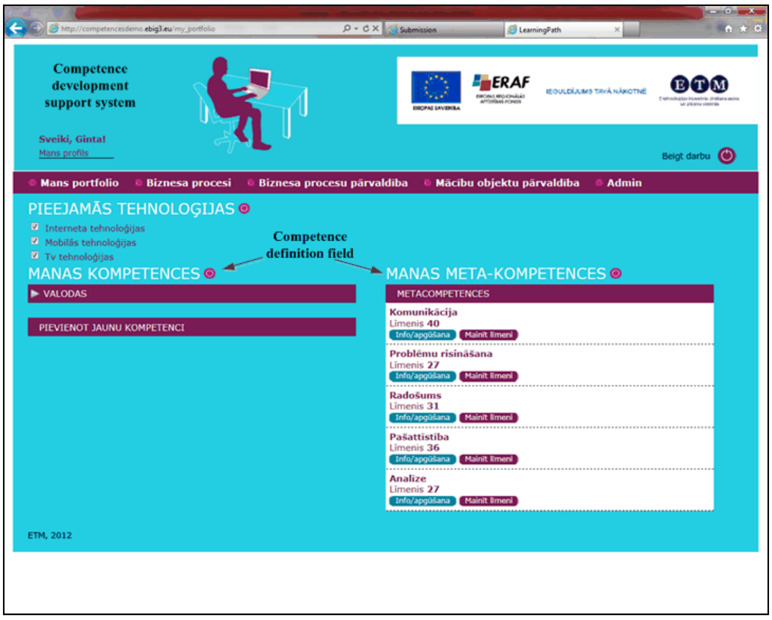


Figure 5. A Prototype of Educational IT Ecosystem - competence definition level

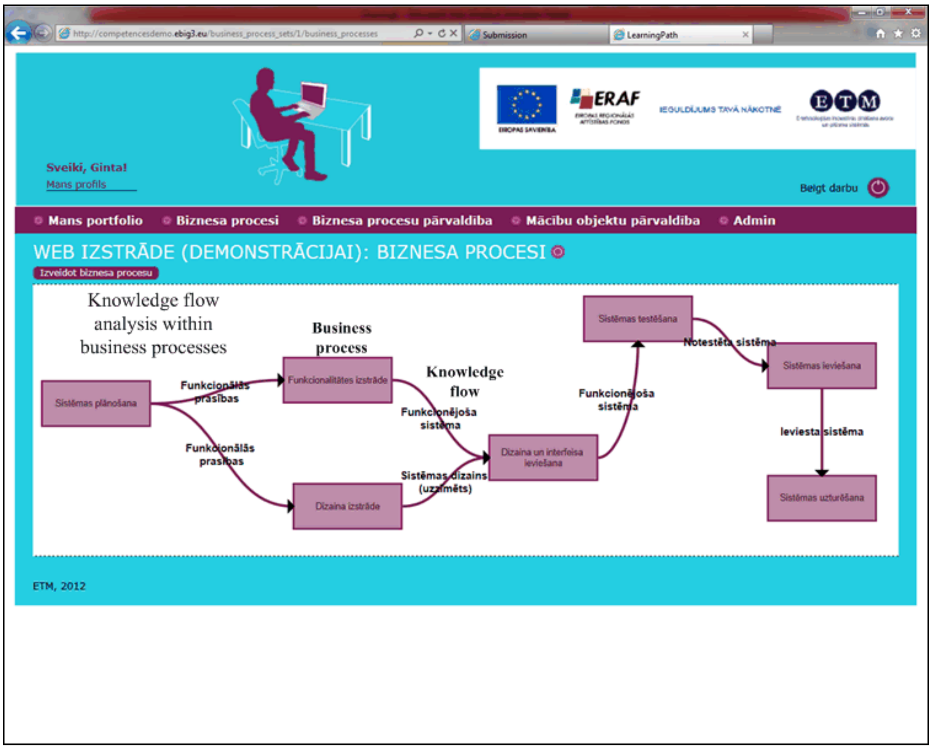


Figure 6. A Prototype of an Educational IT Ecosystem

(level for knowledge flow analysis)

## 5 Conclusions

Theoretical study was carried out during the research process for the knowledge flow analysis and the requirements definition of the educational IT ecosystem. Research on related work has shown that there is wide range of research done in the theoretical aspect of the e-learning ecosystem field and supporting a learning process through the provision of technologies. But, there is luck of knowledge flow analysis in educational processes. Appropriate software could offer a learning path to students for time-consuming learning process with technological solution according to the principles of the educational IT ecosystem.

The use of the Enterprise Modeling Method for the analysis of knowledge flow in continuing education provides a wide range of options to implement a more dynamic learning process in learning communities. EKD methodology also provides core support in the development of an educational IT ecosystem. The definition of different levels also provides a more structured analysis and also supports the detailed development of an educational IT ecosystem.

This paper has described a model for the identification of the knowledge flow and the gap which exists within educational processes and the learning path for competence development to meet an organization's needs and requirements.

Future work will be focused on the more specific and detailed development of the software prototype for knowledge flow analysis within the educational IT ecosystem. This will be done not only from the perspective of service consumers but also from the provider's point of view.

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## References

1. Skyttner L. General Systems Theory. Problems. Perspectives. Practice. WorldScientific Publishing Ltd., Singapore, 2005. pp. 524.
2. Zhuge H., Guo W., Li X., Ding L. Knowledge Energy in Knowledge Flow Networks. Proceedings of the First International Conference on Semantics, Knowledge, and Grid. IEEE, Computer Society, 2006, pp. 1 – 6.
3. Uden L., Damiani E. The future of E-learning: E-learning ecosystem. Proceedings of Inaugural IEEE International Conference on Digital Ecosystems and Technologies. IEEE DEST 2007, pp. 113 – 117.
4. Stale G., Cakula S., Kapenieks A. Application of a Modelling Method for Knowledge Flow Analysis in an Educational IT Ecosystem. Virtual and Augumented Reality in Education (VARE 2011), Valmiera, Latvija, 2011, pp. 92 – 97. ISBN 978-9984-633-18-3
5. 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 Dvelopment". Valmiera, 2009. – Valmiera: Vidzeme University College, 2009.
6. Karampiperis P. Lifelong Competence Development: Towards a Common Metadata Model for Competencies Description - The Case Study of Europass Language Passport.

Sixth International Conference on Advanced Learning Technologies, IEEE, 2006, pp. 677 - 681.
7. Yang T.C., Chiang T.H.C., Yang S.J.H. Creating E-portfolio in U-Learning Environment: A Framework of Cloud-based E-portfolio. Seventh IEEE International Conference on Wireless, Mobile and Ubiquitous Technology in Education. IEEE, pp. 292 - 295.
8. Whitman L., Huff B. On the Use of Enterprise Models. The International Journal of Fleksible Manufacturing Systems, 13, 2001, pp. 195-208.
9. Jing, M., Li, X., Bin, Q., An Education-oriented Development Framework Research for Business Demand Alternation, In: IEEE International Symposium on IT in Medicine and Education, . IEEE Press, 2008, pp. 187—192
10. Chin L. K, Chang E., Atkinson D. A Digital Ecosystem for ICT Educators, ICT Industry and ICT Students. Proceeding of Inaugural IEEE International Conference on Digital Ecosystem and Technologies, IEEE, 2008, pp. 660 - 673.
11. Koper R., Tattersall C. Learning Design. A Handbook on Model-ling and Delivering Networked Education and Training. Springer-Verlag, Berlin Heidelberg, 2005.
12. Quinones, M., Tungare, M., Pyla, P., S., Harrison, S. Personal Information Ecosystem: Design Concerns for Net-Enabled Devices. In: Latin American Web Conference. IEEE Computer Society, 2008, pp. 3--11.
13. Guetl, C., Pivec, M., Trummer, C., Garcia-Barrios, V., M., Modritscher, F., Pripfl J. and Umgeher, M., AdeLE Adaptive e-Learning with Eye-Tracking: Theoretical Background, System Architecture and Application Scenarios. In: European Journal of Open, Distance and E-Learning, 2005.
14. Chang V., Guelt Ch. E-Learning Ecosystem (ELES) – Holistic Approach for the Development of more Effective Learning Environment for Small-and-Medium Sized Enterprises (SMEs Proceedings of Inaugural IEEE International Conference on Digital Ecosystems and Technologies. IEEE DEST 2007, pp. 420 - 425.
15. Fan I., Lee R. A Complexity Framework on the Study of Knowledge Flow, Relational Capital and Innovation Capacity. Proceedings of the International Conference on Intellectual Capital, Knowledge Management & Organizational Learning, 2009, pp.115 - 123.
16. Huggins R., Johnston A. Knowledge Flow and Inter-firm Networks: The Influence of Networks Resources, Spatial Proximity and Firm Size. Entrepreneurship & Regional Development, Vol. 22, No. 5, Reutledge Taylor & Francis Group, 2010, pp. 457 - 484.
17. Leistner F. Mastering Organizational Knowledge Flow. How to Make Knowledge Sharing Work. SAS Institut, 2010, pp. 183.
18. Park H.W., Suh S.H., Lee J.T. Scientific and Technological Knowledge Flow and Technological Innovation: Quantitative Approach Using Patent Citation. Proceedings of Technology Management in the Energy Smart World, 2011. IEEE, 2011, pp. 1-13.
19. Zhuge H. Discovery of Knowledge Flow in Science. Communication if the ACM, Vol. 49, No. 5, 2006, pp. 101 - 107.
20. Jing, M., Li, X., Bin, Q., An Education-oriented Development Framework Research for Business Demand Alternation, In: IEEE International Symposium on IT in Medicine and Education, pp. 187--192. IEEE Press (2008)
21. Peter-Quinones M.A., Tungare M., Pardha S.P., Harrison S. 5. Personal Information Ecosystem: Design Concerns for Net-Enabled Devices. Proceeding of Latin American Web Conference, IEEE Computer Society, 2008, pp. 3-11.
22. Driscoll, M.P.: Psychology of Learning for Instruction. Pearson Education, USA, 2005.
23. Whitman L., Huff B. On the Use of Enterprise Models. The International Journal of Fleksible Manufacturing Systems, 13, 2001, pp. 195-208.
24. Horkoff J., Yu E. Evaluating Goal Achievement in Enterprise Modeling – An Interactive Procedure and Experience. In: The Practice of Enterprise Modeling. Proceedings of Second IFIP 8.1. Working conference, PoEM 2009, Springer, 2009. pp. 145 - 160.
25. Persson A. Enterprice Modelling in Practice: Situational Factors and their Influence on Adopting a Participative Approach. Ph.D. Thesis. Sweden, Department of Computer Science, 2001, pp.334.
26. Keith A.Butler, Ali Bahrami, Chris Esposito, Ron Hebron "Conceptual models for coordinating the design of users work with the design of information sytems", Data & Knowledge engineering, May 2000., Volume 33, Number 2, pp. 191 – 198.