THE USE OF ICT IN MATHEMATICS STUDIES - BALTIC STATES' EXPERIENCE

ANNA VINTERE[1], EVE AREVEE[2], DAIVA RIMKUVIENE[3]

[1]*Latvia University of Agriculture, Latvia*
Anna.Vintere@llu.lv
[2]*Estonian University of Life Science, Estonia*
eve@emu.ee
[3]*Aleksandras Stulginskis University, Lithuania*
Daiva.Rimkuviene@lzuu.lt

Abstract: *In this article are collected experience and knowledge about ICT usage in mathematics studies and applied software in three Baltics States Agricultural Universities: Latvia University of Agriculture, Estonian University of Life Science and Aleksandras Stulginskis University (Lithuania). The problem has been approached by analysing and evaluating the scientific literature for the development of the methodological basis of research, which includes three directions: the evaluation of ICT use in the mathematics study process organization (syllabus organization, used e-environment, study materials availability and accessibility to students, ICT use in assessment, ICT for teaching methods and communication); used courseware (mandatory, by teachers initiative) and support for teachers (opportunities to develop professional ICT capabilities, technical support, an access to digital resource materials, exchange of ideas).*

Keywords: information communication technologies, mathematics, Mathcad, Moodle.

Introduction

The new and rapidly growth of ICT has changed the face of the world. ICT has become the main influential determinant in economic, social and human development (Dertouzos, 1997). ICT is being considered as the umbrella for the communication and networking devices and software with applications (Jain, 2006). Rapid technological development is changing society and its attitudes towards education. This process is caused urgent needs to change the education environment. The Mathematics is very much touched by this process. It is necessary to prepare specialists with ability to use ICT, and transfer knowledge and technology into the economy. Mathematics is a discipline which is required as a background for specialists who work in environmental protection, engineering, construction, business, telecommunication, textile, new energy sources, etc. EU directives distinguish 8 key competencies that should be developed for lifelong learning. One of them is for mathematical literacy and competences in science and technology. Mathematics knowledge and competences becomes essential in lifelong learning process. Thus raises the questions: what technological and educational innovative conditions would be necessary in the process of change? What educational environments it is necessary to create in order to motivate the students successfully and effectively act in the professional sphere?

ICT definitely play a crucial role in developing the teaching/learning processes at all stages and no new teaching/learning environments can be created without ICT. The use of new media in higher mathematics education has to help, support and fulfil its most important objectives. One of important areas of their use is in lectures to make them more illustrative and better understandable. The teacher should keep in mind, that technical means are not only to make them the lecturing easier, but that they are for making easier following and understanding the content of the presented material. Applying ICT in the teaching/learning process does not object to the basic didactical principles such as visualization, systemization, links between theory and practice, knowledge consolidation, encouragement of student participation in different activities, individualization and differentiation of teaching etc. There are two connected but distinct issues related to this expansion in the availability of computing power which are of considerable importance in relation to the higher mathematics curriculum. The first is that new approaches to teaching and learning are made possible. The second is that enormously sophisticated mathematical software is now commonly available which routinely allows analysis of problems of such size and complexity that only a few years ago they would have been regarded as research activities (SEFI, 2002).

Given that all students spend only a year to acquire the basic course in mathematics the questions stands as follows: how to organize the mathematical education in the first or second studies' year and to design learning environments that enable students to develop broad spectrum of knowledge and capabilities? The questions had been already answered by the Bologna documents. The aim of the Bologna Process is the improvement of the mobility of students and teaching staff as well as the strengthening of the competition of the European universities in a global education market. As the consequence of the Bologna declaration is the promotion of European co-operation in higher education, particularly with regards to curricular development, inter-institutional co-operation, mobility schemes and integrated programs of study, training and research as well as exchange of experience between institutions and countries. The reform affects not only the structure of university studies, but furthermore leads to European-wide reflection on the suitability of the syllabuses in mathematics subjects and, of greater importance, on the manner in which mathematics is taught. Therefore in this article are collected experience and knowledge about ICT usage in mathematics studies and applied software in three Baltics States National Agricultural Universities: Latvia University of Agriculture (LUA), Estonian University of Life Science (EMU) and Aleksandras Stulginskis University (ASU).

Matherials and methods

The problem has been approached by analysing and evaluating the scientific literature for the development of the methodological basis of research. The article includes theoretical analysis of topical issues like the factors determining good ICT use, technological aids of the learning cycle and potentialities of ICT use in the mathematics education. The literature review unequivocally found that it is not possible to provide clear indicators to describe or measure the use of ICT. However, in several educational researches identifies four main dimensions of ICT assessment (Pelgrum, Law, 2003; Law et al., 2008; Newhouse, 2002): School environment; Teachers ICT capabilities; School ICT capacity and Students. Australian researcher Paul Newhouse gives the outcomes for those dimensions and an explanation of components (Newhouse, 2002).

Table 1.

Factors determining good ICT use

	Outcomes	Components	Description
SCHOOL ENVIRONMENT	That school environment is supportive of teachers and students use of ICT that prepares students to learn, work and live successfully in a knowledge-based, global society.	Leadership & Planning	The school provides leadership and planning structures based on clear goals that encourage and support teachers and students in their use of ICT.
		Curriculum Organisation	The intended curriculum is organised in a manner that is conducive to the use of ICT to support learning and teaching processes.
		Curriculum Support	Teachers are provided with adequate support to select appropriate applications of ICT to address the requirements of the intended curriculum.
		Community Connections	The school recognises local and global communities as critical partners and stakeholders in the learning and teaching process.
		Accountability	The school has adequate systems to ensure accountability in the use of ICT.
TEACHERS ICT CAPABILITIES	The teacher exploits the characteristics of ICT to support the learning of students and contribute to relevant learning communities.	Vision & Contribution	The extent to which actions in the use of ICT are based on understandings of the purposes and roles of ICT to support all learners with a focus on the two-way relationship between learning and ICT use. The extent to which involvement in learning communities, professional learning and school planning in the use of ICT occurs.
		Integration & Use	The extent to which ICT use is integrated within learning environments to support learning communities. The extent to which the use of ICT is a critical factor in achieving teaching-learning objectives more effectively.
		Capabilities & Feelings	The extent to which a teacher feels capable in supporting the use of ICT and inclined to do so in a manner that considers the roles of the teacher and students.
ICT INFRASTRCTURE	The school provides ICT capacity to ensure that all teachers and students have immediate access to all software that is required to support the curriculum and adequate support to implement its use.	Software	A wide range of applications is available to students and teachers where the applications are designed to match user characteristics and the requirements of curriculum tasks.
		Hardware	Students and teachers have access to computer processing adequate to use required software applications and digital resource materials. Students and teachers have access to peripheral devices suited to user characteristics and the requirements of curriculum tasks.
		Connectivity	Students and teachers have access to networking, including to the internet that provides high quality access to online services.
		Technical Support	Technical support and maintenance is available to teachers and students when and where required.
		Digital Resource	Teachers and students readily select and access digital resource materials appropriate to their needs.
S T	Students develop an appropriate level of	ICT capability	ICT skills and understandings

	capability, become more engaged with their own learning, and achieve learning outcomes across the curriculum at a higher level.	Engagement	Independence and resilience
		Achievement of learning outcomes	Personal responsibility etc.

In international comparative studies conducted by the Evaluation of Educational Achievement (IEA) were found curriculum and assessment factors: curriculum goals, content, methods, assessment goals and methods (Pelgrum, Law, 2003). Content goals and contents include information, communication, and social skills, as well as meta-cognitive skills, but students' performance should be assessed with great diversity of methods (open test methods, portfolio, diagnostic and summative tests).

Lithuanian researchers Lipeikiene J. and Lipeika A. describe the use of technological tolls in the learning cycle of teaching mathematics which includes conceptualization, construction and dialogue phases (Lipeikiene, Lipeika, 2009). The primary courseware intended for the conceptualization phase include visualization tools as well as on-line resources. For the construction phase they recommend the secondary courseware which consists of lower level procedures among then visualization tools, mathematical games and on-line resources and dialogue phase - tertiary courseware – virtual learning environment and teacher's blogs (Lipeikiene, Lipeika, 2009).

ICT support inquiry projects by providing visualizations of scientific processes that are difficult to see and consequently, are quite challenging to understand. Visualizations include interactive models, graphs and simulations. New technologies also support inquiry with analytic tools (e.g. drawing, graphing, data tabling and concept mapping), guidance, support for student collaboration, online interactions with experts and access to information through databases or websites (AAAS, 1993; Linn et al., 2004). Researches prove that approximately 40-50% of traditional classroom material could be eliminated for targeted students; this implies that we should employ a new approach for improving the educational system. In order to duly co-ordinate the study program and teaching with the student's abilities, interests, and learning styles, a variety of instructional strategies and challenging content are used, performing differentiation, which can occur in (Yamin, 2007): content (e.g., teachers must pre-test students, determine which students need direct instruction, plan application of concept through problem solving, and allow students to work ahead independently), process (e.g., vary the learning activities or strategies, use graphic organizers, maps, diagrams or charts to display comprehension, and vary the level of graphic organizer), product (varying the complexity of the product that students create to demonstrate the mastery of concepts) and environment (accommodating the students' individual learning styles).

Different strategies for teaching students can be employed to develop alternative activities that go beyond the regular curriculum, to work with students to design an independent project that they would be interested in completing for credit, to involve students in academic competitions in several areas, to create tiered assignments, which have different expectations for different levels of learners, to make efficient use of technology. Virtual Learning Environments can be an essential tool in providing special provisions that meet gifted students' special needs.

ICT could be seen as a facilitator tool for the intensification of study process in the studies of mathematics development. According to Pale in order to intensify the study process we have to get rid of the so called "non-educational" performances such as (Pale, 2005): administration, support, organization etc. by minimizing or automatizing the previously mentioned performances. The support functions are those that are needed in the study process but on their own do not add up to the knowledge or skills of the students. For these processes the students and lecturers use a remarkable amount of time. An essential question is to free the student from a physical presence. Of course it is possible if students have access to all the necessary resources, as well as training and the support for the knowledgeable usage and the professionals who could assist if the student feels doubt or is in need of consultations. These aims could be reached if all the present teaching/learning materials are digitalized and at the same time new e-materials are developed. The materials should be available on-line. A digital library is also a must. It has to be mentioned that the student's marks in previous exams as well as the questions and answers are of great importance for the study processes. Communication with e-mails among students, virtual work-groups, distant synchronized (performed in real time with the lecturer who is connected to the system, a direct communication with the lecturer and with each other) and non-synchronized (communication is possible via e-mails, discussion groups etc.) learning, summaries of lectures, tasks and other processes make the study process more qualitative and easy.

A very important aspect in the development of the future ICT competence is in e-studies. E-studies are the process where the person learns on his own by using technologies. If the classical teaching (face to face) to be aided with teaching using elements of e-learning it is defined as a blended learning. The term itself is quite difficult to define since it is used in diverse ways by different people. On the one hand, there is the traditional face-to-face learning environment that has been around for centuries. On the other hand, there are distributed learning environments that have begun to grow and expand in exponential ways as new technologies have expanded the possibilities for distributed communication and interaction. The biggest and most common factor behind successful applications to support both learning and knowledge development is the presence of creative people who can drive initiatives forward. This requires a constituency or community who want fast access to ideas and knowledge and have a well-formed model of whatever they want to contribute, preferably do-able within existing technology (Nyhan et al., 2003).

On the findings from different theoretical approaches as well as many years of personal experience in mathematics teaching, is built the methodology for the collection data about ICT usage in mathematics studies at Baltic States national agricultural universities which includes three directions: the evaluation of ICT use in the mathematics study process organization (syllabus organization, used e-environment, study materials availability and accessibility to students, ICT use in assessment, ICT for teaching methods and communication); used courseware (mandatory, by teachers initiative) and support for teachers (opportunities to develop professional ICT capabilities, technical support, an access to digital resource materials, exchange of ideas).

Results and discussion

For the evaluation of ICT use in the mathematics study process organization are created six indicators' groups – syllabus organization, used e-environment, study materials availability and accessibility to students, ICT use in assessment, ICT for teaching methods and communication. Each group consists of several indicators (Table 2).

Table 2.

Evaluation of ICT use in the maathmatics study process organization

Indicators' group	*Indicator*	*LUA –LATVIA*	*EMU – ESTONIA*	*ASU – LITHUANIA*
Syllabus organization	Mandatory - in the programs is allocated the ECT for ICT	*For engineering*	*For environmental engineering, forestry*	*No*
	Used only by the teachers initiative			*Yes*
Used e-environment	Moodle	Yes	*Yes (for statistics)*	*Yes*
	University information system (IS)		*Yes*	*Yes*
Study materials availability and accessibility to students	Only reading on-line resource	*Yes*	*Partly for economics, forestry*	*Yes*
	An interactive materials in internet	*No*	*No*	*No*
	Tests or tasks for self-control	*Partly (Moodle)*	*Partly*	*Partly (ThatQuiz, Moodle)*
	Solving examples	*Yes*	*No*	*Yes*
ICT use in assessment	Final exam /test in e-study system	*No*	*No*	*No*
	Tests during the semester	*Partly (for theory)*	*No*	*Partly*
	Electronic assessment records during semester, available for students	*Partly*	*No*	*Partly*
	Course final mark	*Moodle and in university IS*	*In university IS*	*In university IS*
ICT for teaching methods	An e-lecture	*No*	*No*	*No*
	Independent work tutoring by teacher	*No*	*No*	*No*
	Independent work	*Yes*	*Yes*	*Yes*
	Project work	*No*	*Yes (for statistics)*	*Yes (for statistics)*
	Group work	*No*	*Yes (for statistics)*	*Yes (for statistics)*
	Collaborative learning	*No*	*No*	*No*
Commu-nication	Using Moodle tools	*Yes (20%)*	*Yes (for statistics)*	*Yes (20%)*
	By e-mail	*Yes (35%)*	*Yes (mostly)*	Yes (20%)

Despite the fact that the size of Mathematics studies by the means of contents has not been changed for several years, it tends to decrease by the means of time. The question arises - how to intensify the contents of the lectures? One of the possibilities is to use the slide shows during the lectures. In this way the teachers do not have to spend time on writing the material on the blackboard. The slide shows are used in all three universities. However 60-80% teacher prefer to use classical teaching methods.

Nowadays the Course Management System (CMS) Moodle has become one of the most popular e-learning environments in the world. In mathematics studies at LUA are introduced Moodle, at ASU are introduced Moodle and is used the university information system, but in EMU for teaching and learning mathematics widely are used the university information systems. In LUA Moodle is used primarily for reading on-line materials, assessment records, communication and a little - for uploading students' homework.

Between the three universities only EMU has a good experience in using of Moodle in statistics studies. The Estonian author of this article has made four e-courses: *Theory of probability*, *Mathematical statistics for engineers*, *Programming*, and *Logic*. The oldest course is the statistics one and have be used it for three years, already. First, it was created it in the Blackboard environment, but last year, it was transferred it to Moodle. What are the benefits? The teacher does not have to give lectures anymore. The students read all the material on the Internet and after reading it, they take the test, which will reflect how familiar with theoretical material they are. In this course feedback, the students have said that they like answering the tests the most. The course environment allows students to upload their homework, and teacher can write all their grades there as well. The students can even do teamwork in Wiki by writing the analysis for the given task together. Now the students work more than before and teacher can better monitor their work. The same system is introduced in LUA – the teacher can choose to give lectures face-to-face or use e-learning environment, but it is not used by teachers of mathematics yet.

Different courseware is used in LUA and EMU by the teacher initiative. But in the programs of both universities are allocated the ECT for *Mathcad* use. The mathematics syllabus organization at LUA includes the laboratory works - using software *Mathcad* in mathematics study process. In the engineering programs (1^{st} – 3^{rd} semester) is allocated the 0.5 ECT. Currently *Mathcad* is implemented in environment engineering and forestry study programs. For students it allows to get know one of the Math software. They have to solve the homework on the paper, showing the process of solving step by step, but during laboratory works – to solve it using *Mathcad*. For teachers it decreases the time for checking the home works. In LUA master's level mathematics studies are used software *Matlab*.

There are no separation of contact hours for laboratory works in EMU but *Mathcad* is integrated in the practical lessons (3^{rd} and 4^{th} semester). It occupies up to 50-70% of practical works and for *Mathcad* use allocated the 1.0 ECT. *Mathcad* is used to solve complicated tasks with much technical work, to design work, to make graphs as well as to solve very simple, but important calculations. It helps to understand various functions and operations through visualization. The comparison of *Mathcad* use in LUA and EMU are given in the Table 3. The strengths of laboratory works in LUA - computer classrooms have only 15 and 20 work places. There are more than 20 computers in EMU and ASU classes.

Table 3.

Mathcad use in LUA and EMU mathematics studies

Themes (topics)	What is done with Mathcad?	EMU		LUA
		For visualization	Practical works	Laboratory works
Linear algebra	Operations with matrices, solving determints and systems of linear equations: with *Cramer's formulas, Inverse matrix* A^{-1}, with *functions rref(augment( ));* *geninv( ); lsolve( ); Given ...Find( )*		*yes*	*yes*
Vector geometry	Calculation the vector coordinates, Knowing origin and destination. Vector reference, if known the coordinates. Operations with vectors.			*yes*
Analytic geometry of plane and space	Create a drawing and drafting of the equations. Check homework, creating drawings.	*yes*	*yes*	*yes*
Limit and continuity	One–side limits, functions limits calculation. Discontinuous function graphs.		*yes*	*yes*
Derivative of a function of one variable	Finding the derivative by the function definitions and by the use of *Calculus*. Investigations of one variable fuctions.	*yes*	*yes*	*yes*
Indefinite integral	Calculation of the indefinite integral using the toolbar *Calculus*, Integral expressions symbolic transformation. Drawing the integral lines.		*yes*	*yes*
Definite integral	Calculation by the Newton-Leibniz formula.	*yes*	*yes*	*yes*

and its applications	Creation the drawings (included functions in parametric and polar forms). Targeting the parameters.			
Differential calculation of functions in several variables	Draw a two-variable function. Finding the partial derivatives and differentials of higher order. Calculation the function extremes.	*yes*	*yes*	*yes*
Multiple and curvilinear integrals	Determine the areas of integration, a mark, The equation system boundary calculations		*yes*	
Differential equations	Finding integral; Calculations the uncertainty coefficients.	*yes*	*yes*	*yes*
Numerical and functional series	Expansion of functions by series and its applications in integration and for differential equations.	*yes*	*yes*	*yes*

It could be mentioned that the *Mathcad* use needs to acquire a license. Therefore in mathematics studies at ASU is used *Maple* for teaching of students of Faculty of Forestry and Ecology (Magister Level). But concern financial and organizational problems it is not possible to use this program for teaching students of others faculties. It could be mentioned that the *Mathcad* and *Maple* use needs to acquire a license. Therefore in mathematics studies at ASU are widely used *Excel* and open source as *Sage*.

The availability of the ICT infrastructure or software is a condition but it does not automatically result in advanced use of ICT by the teachers in the learning activities. The successful implementation of ICT in learning process depends on the teachers' personal uses of ICT: access to resources, continuing professional development and communities of practice. Using ICT to transform teaching and learning involves understanding teachers' motivation, perceptions and beliefs concerning learning and technology.

Nowadays the pedagogical culture is greatly defined by the teacher's awareness of the basis of the alterations starting from the idea and finishing with real-life implementation in everyday work as well as from the teaching staff's ability of the acquisition of the suitable teaching tools and change his professional activities. The offer of innovations is rather big but the teaching staffs needs time to accept it in accordance with their professional experience and later structure it in their present experience or drastically change it.

There are difficulties in the teacher's academical and professional education. In the process of becoming an innovative person the teacher might encounter with difficulties in letting go from the previously acquired conclusions and even harder is to change the attitude and his individual didactical model which has already been tested and is rather stable (Žogla, 2001). People must be stimulated to acquire new technologies. A very essential is the education process.

What is the situation in these three universities? All three universities have implemented Moodle, as well as organized training for teachers to use Moodle as open source system for integrating new, interactive courses in the study process. Pooling of expertise it is concluded that these courses are about general principles of building e-course, without giving any information about customized virtual environment tools for mathematics teaching in Moodle. Nowhere are offered the courses about tools used directly in mathematical e-learning course design.

A second factor, which characterizes the teachers' dimension, is technical support. In LUA and ASU the technical support for teachers and maintenance is provided by skilled experts: e-studies methodologists. That's why teachers are not stopped from using a Moodle due to technical failure.

In Estonia the situation is more centralized. The Estonian Information Technology Foundation oversees all the e-courses and the problems arising from their creation and use. All Estonian universities and vocational schools are connected to the consortium. There are two projects: one for universities, called "Best", and other for vocational schools, called "Vanker". These projects are mostly financed by the European Union. After the teacher creates an e-learning course or a learning object, she/he could ask for funding from the Foundation.

The third factor is an access to digital resource materials appropriate to teachers' needs. Currently LUA started to create a storage of mathematics methodological e-materials which consists of materials created by department's teaching staff, materials available in on-line, three levels of homework tasks, their solution samples, laboratory work samples, as well as of theoretical tests questions bank. These activities are financing by European Union funds. Thus is formed a team of teachers that share ideas and strategies about incorporating ICT into teaching and learning. It follows that the fourth teachers dimension is to facilitate individuals and groups, enabling the active exchange of ideas between those people.

Conclusion

To create the e-materials for mathematics studies unfortunately is a time-consuming process. To do the material of the course in Moodle is very hard and uncomfortable for teachers. The input of mathematical text is almost impossible. Although Moodle has a mathematical text redactor, it is very bad, as teacher cannot enter every equation what is needed. This is the main reason why the creation of the mathematics e- courses still in the progress in all three universities. However, the students face difficulties when inputting mathematics text as well. There have to be tools which will help collecting equations from screen very easily with the mouse. In tests or forums could be asked only those questions where the answer is in text format, but for mathematics, it is impossible. At the moment, we can be used only very small part of all the e-learning possibilities. It is able to give the materials on Moodle but could not use any active learning methods.

Thus it could be concluded that ICT are able to use mainly for “non-educational” performances: administration, support and organization functions - course plan, teacher consultations, the summaries of the lectures, self-education materials, examples of task solutions, self-assessment tests, training tasks, the descriptions of practical works, laboratory works examples, methodological pointers, the links to such materials on the internet, communication among students and teacher, to record the marks and the results of tests on the internet as well as to see the changes in the schedule etc.

The other conclusion arises by evaluating the virtual environment tools for mathematics teaching on Moodle. There is necessary for the exchange of ideas between teachers to promote using Moodle for active learning purposes as well as collaboration among the lecturers for the balanced usage of e-studies methods mathematics. Three Baltic States Agricultural Universities should have one place where could be shared teachers experiences. The collaboration and teamwork unites the teacher’s improvement and the study program’s development which is based on the exchange of information among people.

Evaluating the courseware used in the mathematics studies, several conclusions could be outlined. At first, commercially available software packages have become more user-friendly and *Mathcad* is recommended software for mathematics studies. One alternative would be the open source software *Wolfram Alpha*. It is relatively easy to use, gives a solution "step-by-step", provides an opportunity to look for alternative ways of tackling, but, unlike *Mathcad*, it does not allow presentation of results and is not compatible with Microsoft Word.

Secondly, it is clearly, the computer is here to stay and what is needed is a sensible balance between the use of software and the ‘pen and paper’ manipulation which is so essential to an understanding of fundamental concepts. Euler's method would never be used in practice to numerically solve a differential equation. However, in carrying out a few steps of this method on a simple problem a student will learn much about the nature of numerical solutions. Much of this would probably be overlooked if all the students did was learnt the appropriate syntax to invoke a differential equation solver in a commercial software package (SEFI, 2002).

The authors' observations and the experience outline some conclusions about teachers. Namely, new teachers, presumed to be young and recently graduated from university, have a varying level of experience with ICT but they are also gaining teaching experience and skills to manage the classroom environment. Senior teachers, who may even be approaching retirement age, have more classroom experience but are likely to be less skilled in working with technologies. Therefore in order to facilitate the motivation of the teaching staff in the implementation of new technologies we have to use the privileges of both groups and we have to create collaboration between these two groups.

The research shows that the transition into the new teaching with technologies is a rather difficult and time-consuming process. Even while acknowledging the immense opportunities to enhance the education process at all level many disciplines have been slow in adapting to the new technologies and tradition methods continue to hold sway. Evidently the work of teaching staff, their primary education, continuing education, status and the work environment are the key elements in the development. The role of technologies in learning and teaching depends on the lecturer’s access, how much time is invested in self-education and what things he considers to be suitable.

Acknowledgements

The research done by support of NORDPLUS project No. HE-2011_1a-26784 “Baltic Network in Agrometrics”.

References

American Association for the Advancement of Science (AAAS)., 1993. *Benchmarks for Science Literacy*. New York: Oxford University Press.

Dertouzos, M., 1997. What will be. San Francisco: Harper Collins.

EU, Bolonga Declaration. Available at: http://ec.europa.eu/education/policies/educ/bologna/bologna_en.html.

Jain, P., 2006. Empowering African’s development using ICT in a knowledge management approach. *The Electronic Library*, 24 (1), pp.51-67.

Key competences for lifelong learning. *European Recommendation 2006-2006/962/EC*. Available at: http://www.indire.it/lucabas/lookmyweb_2_file/etwinning/eTwinningpubblicazioni/e_twinning_volume_01ing.pdf

Law, N., Pelgrum, W. J., & Plomp, T. (Eds.)., 2008. *Pedagogy and ICT use in schools around the world: Findings from the SITES 2006 Study*. Hong Kong: CERC, University of Hong Kong and Springer, p.296.

Linn, M. C., Davis, E. A. and Bell, P., Eds., 2004. *Internet Environments for Science Education*. Mahwah, New Jersey, Lawrence Erlbaum Associates.

Lipeikiene, J., Lipeika, A., 2009. Technological aids of the learning cycle in blended teaching of mathematics. *Teaching Mathematics: retrospective and perspectives*, Proceedings of the 10th International conference, Tallinn University, May 14-16, 2009, pp. 245-251

Mathematics for the European Engineer. A Curriculum for the twenty-first century. *A report by the SEFI Mathematics Working Group*, SEFI HQ, Brussels, Belgium, 2002.

Newhouse, P., 2002. Framework to Articulate the Impact of ICT on Learning in Schools. December, 2002. Available at: http://www.det.wa.edu.au/education/cmis/eval/pd/reading/reading1.htm .

Nyhan, B et al., 2003. Facing up to the learning organisation challenge. Vol. I. Thessaloniki, *CEDEFOP*. Available at: www.cedefop.europa.eu/download-manager.aspx?id=17853&id_ct=20

Pale P., 2005. Objectives of ICT in Education. University of Zagreb. Available at: http://maja.zesoi.fer.hr/~ppale/papers/e-learning/IIS2005.pdf.

Pelgrum, W.J., Law, N., 2003. ICT in education around the world: trends, problems and prospects, ENESCO: International Institute for Education Planning, Paris. Available at: www.unesco.org/iiep .

Yamin, T.S., 2007. *Advanced Models in eLearning and school management.* ICL2007. CD.

Žogla, I., 2001. Didaktikas teorētiskie pamati. Rīga: Raka, 2001. (In Latvian)