Roadmap to Advance Web-based E-Learning in South Eastern Europe
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Roadmap
to Advance Web-based E-Learning in South Eastern Europe

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1. Introduction

1.1. Purpose of the roadmap

The road mapping work was conducted to provide decision makers with an overview of current and future developments in e-learning and to derive an action plan for South Eastern European (SEE) countries.

The purpose of the roadmap is advancement of web-based education in SEE countries as a key for wider social, networking, and community purposes. For these purposes, ICT shall be accessible to a wide basis of citizens of the Western Balkan, regardless of their age, gender, prior ICT knowledge, literacy level, nationality, or social status.

Such intentions are perfectly covered by general EU strategies and action plans, some of which are already proven and tested [eSEE-guidelines, eTeach, ICT Indicator] while some of which are under construction [ICTstrategy-SR, GOV-ActionPlan]. These strategies and plans make the European way clear: relate development of technology as intimately and instantaneously as possible with socio-economic development and keep humanity in the centre of politics.

The relation of technology-driven developments to humanity is particularly required when considering plans for e-learning: e-learning presently depends on access to a computer (connected to the Internet) – but what is the percentage of citizens owning a computer in the SEE countries within the next 5 years? However, the percentage of owning mobile telephones strives towards 100 % very quickly – while the Internet, mobile telecommunications, and TV are presently converging towards all-IP networks offering integrated services [eSEE-guidelines].

The integration of communication services goes alongside with the availability of global position systems (GPS) which will extend the scope of museums and other institutions administering cultural heritage to monuments (a mobile knows the position, and the museum knows the historic details) all over the countries – which opens a completely new range of possibilities for (e-)learning.

1.2. Scope of the roadmap

The fundamental considerations for e-learning require, as mentioned above, a broad view with respect to:

- technology: traditional computer networks, cable and mobile telecommunication, as well as television, because these technologies are converging to universal services.
level of education: this is seen from a wide viewpoint, because kick-off from
e-learning to wider social effects requires connecting various access-points,
universities with their international connections and resources for tool and content
development, schools with their coverage of population, life-long learning with their
coverage of different ages.

service users (students, pupils, vocational trainees, parents) and service providers
(content and tool developers, i.e., universities, museums etc.), because punching
applications most likely come from creative connection of both views.

time frame is set to 5 years (i.e., narrow) for the action plan within this roadmap,
because the time lines for the implementation of ICT cannot seriously be
estimated beyond that.

geography: the resources in the project ASO 3-01-2007 allowed to research the
current situation in the countries the participants of the project are working in
(Bosnia and Herzegovina, Serbia, and Slovenia), so the scope of the action plan is
within these countries. However, it can be expected the scope smoothly being
extended to other countries in SEE.

The contributors to the roadmap within the project ASO 3-01-2007 are:

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1.3. Methodology of the mapping work

The wide scope chosen (Section 1.2.) for the roadmap needs to be related to rather specific goals (Section 1.1.).

The basis for the mapping work is a research on the status of using ICT for education in Bosnia and Herzegovina, Serbia, and Slovenia. In Slovenia, the status has already been well researched [eMapps]; the findings from that research are extensively cited in this font and are used to give the structure to Section 2. in this report in order to ease comparisons. Into this structure, the findings from Bosnia and Herzegovina, as well as Serbia are inserted; the findings are obtained from direct contacts of the participants in the project with officers in the respective governmental institutions.

The planning started with a review of the general EU strategies and action plans, some of which are already proven and tested [..FP7..DH..] while some of which are under construction [ICTstrategy-SR, GOV-ActionPlan, ..DH..]. The review identified the relevant details which are cited in this font. Some goals needed to be specified in more detail according to the specific intentions of the roadmap, and some goals are added due to actualities within the chosen time frame of 5 years and due to local specialities.

The areas of action again (Section 3.) are given a wide scope. This scope ensures reliable survey for decision makers, as well as sufficient freedom for the administration realising the follow-ups of the roadmap. The wide scope may also provide for better transfer to countries beyond those considered in detail within this roadmap.

However, the action plan (Section 4.) concentrates on a selection of most promising actions within the given time frame. The selection also reflects specific expertise within the contributors for this roadmap.
2. The local status of using ICT for education

In order to provide a sound basis for planning a roadmap, a survey of national policies in ICT at universities, schools and specific cultural institutions (libraries and museums, as far as related to education) has been conducted.

2.1. Institutional roles and responsibilities

The administrative integration of academic institutions and schools (i.e., primary and secondary education) is varying from country to country.

The survey of institutional roles and responsibilities below gives an overview of major actors for ICT in schools and academic institutions in the NMS and illustrates how responsibilities are shared at various levels (national, regional, local, or school levels). In general, responsibilities are decentralised and shared at three to four levels: national, regional, local and school levels in most of the countries. Schools are to a large extent autonomous in [...] Slovenia concerning the actual integration of ICT. This autonomy is the result of a decentralisation process at various stages [eMapps, p. 37].

In Serbia, the Ministry of Education (MP – Ministarstvo prosvete) (http://www.mps.sr.gov.yu) has the leading role in coordinating education in Serbia at all three levels, in primary, secondary and university education. However, since universities are regarded to be autonomous institutions, many activities on the improvement of higher education are led by the universities themselves, mainly through their projects (e.g., TEMPUS). As for the primary and secondary education, most activities on the enhancement of education process are led by the separate branch of the MP – The Institute for Improvement of Education (ZUOV - Zavod za unapređivanje obrazovanja i vaspitanja) (http://www.zuov.sr.gov.yu). The primary role of ZUOV is general improvement of quality of education in secondary schools, and to some extent in primary schools. As an important part of their activities, ZUOV works on improving Information and Communication Technologies (ICT) in schools.

Ministry of Science and Technology (MNTR – Ministarstvo nauke i tehnologije) (http://www.mntr.sr.gov.yu) is partially involved in university education process. Ministry of Telecommunications and Informational Society (MTKID – Ministarstvo za telekomunikacije i informatičko društvo) (http://www.mtid.sr.gov.yu) is responsible for developing the ICT infrastructure in the entire country and offers vital support for the educational institutions.

In the past, this ministry was the Ministry of Education and Sports. The institutional responsibilities for telecommunications are also interesting with respect to the integration of communication technologies (see Sections 4.1. and 4.4.).
Overview of institutional roles and responsibilities by country:

<table>
<thead>
<tr>
<th>Country</th>
<th>Institution</th>
<th>Responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosnia and Herzegovina</td>
<td>Federal Ministry of Education and Science</td>
<td>Financing, organising, public tenders</td>
</tr>
<tr>
<td></td>
<td>Ministry of Education and Culture of the Republic of Serbia</td>
<td>Financing, organising, public tenders</td>
</tr>
<tr>
<td></td>
<td>Cantonal Ministry of education and science</td>
<td>Financing, organising, public tenders</td>
</tr>
<tr>
<td></td>
<td>Schools</td>
<td>Financially dependents of Cantonal Ministry of education and science</td>
</tr>
<tr>
<td></td>
<td>University of Tuzla</td>
<td>Provide technological, organisational and didactical support to development of</td>
</tr>
<tr>
<td></td>
<td>UCDED – University Centre for Distance Education Development</td>
<td>distance education at the university.</td>
</tr>
<tr>
<td>Country</td>
<td>Institution</td>
<td>Responsibilities</td>
</tr>
<tr>
<td>---------</td>
<td>-------------</td>
<td>------------------</td>
</tr>
<tr>
<td><strong>Serbia</strong></td>
<td>Ministry of Education (MP - Ministarstvo prosvete) <a href="http://www.mps.sr.gov.yu">http://www.mps.sr.gov.yu</a></td>
<td>coordinates education at all three levels, primary, secondary and university levels</td>
</tr>
<tr>
<td><strong>Slovenia</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Ministry of Education and Sports</td>
<td>Financing, organising, public tenders</td>
</tr>
<tr>
<td></td>
<td>National Institute of Education</td>
<td>Professional supervision over curricula, didactics, standards, content</td>
</tr>
<tr>
<td></td>
<td>Schools</td>
<td>- Co-financing, - Independent in ICT introduction.</td>
</tr>
<tr>
<td></td>
<td>University of Ljubljana LTFE.org Faculty of Electrical Engineering</td>
<td>E-learning systems development and support; Multimedia based content development; R &amp; D projects, consultancy in national strategy; national e-learning action plan;</td>
</tr>
<tr>
<td></td>
<td>University of Maribor <a href="http://moodle.uni-mb.si/file.php/1/Predst_Centra.htm">http://moodle.uni-mb.si/file.php/1/Predst_Centra.htm</a></td>
<td>University Centre for e-Learning and Lifelong Education</td>
</tr>
</tbody>
</table>

<sup>1</sup>Text in <em>this font</em> cited from [eMapps] pp. 68–69.
2.2. Available ICT technologies and contents

The ICT technologies accessible and affordable for universities, schools, museums etc. vary from country to country.

In Bosnia and Herzegovina, BIHARNET formally exists, but does not function in practice. Bosnia and Herzegovina is a rarity – it is the only country in Europe where academic research and education network do not function.

At the moment, there are some actions concerning revitalisation of two BiHARNET connections toward GEANT network (DF node in Doboj (AMRES) and 100 Mbps node in Mostar (CARNET)).

Similarly, other educational institutions have inadequately or not at all dealt with the issue of connection (University centres in Sarajevo, Tuzla, Mostar, Banja Luka, and Bihać are trying to offer some sort of support while large number of faculties and other institutions are connected to commercial providers). These are partial and very different arrangements, but this is certainly not the education or research network.

It is quite clear that the key problem is that there are no or only negligible funds in the state, entity or cantonal budgets for the support to scientific and research work, and even less for connecting research and educational institutions [IS Strategy-BiH].

In Serbia, there are still schools, mainly in rural and undeveloped parts of the country which do not have computer equipment at all or have insufficient equipment. The statistics from the year 2005 show that there is one computer on approximately 25 pupils.

In cooperation with the Internet Service Providers in Serbia, the MP offers free internet access to primary and secondary schools which have appropriate computer equipment. Most schools in Belgrade and other larger towns use this commodity, while the situation in smaller towns and villages is much worse. Most schools that have Internet connections use ADSL.

The universities mainly have computer-equipped laboratories and Internet access. The departments of the University of Belgrade are connected by optical fibre.

The Academic Net of Serbia (AMRES – Akademka mreža Srbije) is the network that connects research and higher education institutions, and provides them with the connectivity to the Internet and other research institutions in Europe and around the world. It also provides a number of advanced IT services mainly to researchers and
scientific community.

The AMRES connects 126 various institutions: universities (Belgrade, Novi Sad, Niš, Kragujevac), several high schools, scientific institutions (e.g., SANU – Serbian Academy of Sciences and Arts), Students’ Cultural Centre, Clinical Centre of Serbia, several museums, libraries, botanical gardens, etc. It includes institutions from Belgrade, Novi Sad, Niš, Subotica, Kragujevac, Sombor, Leskovac, and Bor.

The Computing Centre of the University of Belgrade (RCUB – Računski Centar Univerziteta u Beogradu) is in charge of providing and maintaining the Internet connections for the University of Belgrade.

In Slovenia, there is [...] a well-developed infrastructure and the broadband infrastructure is expanding. The Ministry of Education and Sports (MES) has financed the introduction of broadband connectivity to schools since 2003. Whilst the MES finances the infrastructure, the schools are responsible for financing the costs of bandwidth. Schools will also be linked to the ARNES (Academic and Research network of Slovenia) via optical fibres. [eMapps, p. 40]

Overview of broadband access and networks by country (the rightmost column only accounts for schools, not for universities which are all connected with broadband already):

<table>
<thead>
<tr>
<th>Country</th>
<th>Technologies used for broadband access</th>
<th>Broadband networks</th>
<th>Number of schools connected to broadband</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosnia and Herzegovina</td>
<td>Schools mostly use:</td>
<td>BIHARNET (Bosnia and Herzegovina Academic and Research Network)</td>
<td>43 % (P), 70 % (S) year 2002</td>
</tr>
<tr>
<td></td>
<td>- Dial-up connection (56 Kbps)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ISDN connection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>- ADSL connection</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Universities mainly use:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Leased line 1–2 Mbps</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UMTS by the end of 2008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Country</td>
<td>Technologies used for broadband access</td>
<td>Broadband networks</td>
<td>Number of schools connected to broadband</td>
</tr>
<tr>
<td>---------------</td>
<td>----------------------------------------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>---------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Serbia</td>
<td>Primary and secondary schools have free Internet access, mainly from private providers</td>
<td>ADSL</td>
<td>in some undeveloped parts of the country, there is still no computer equipment connects 126 institutions: universities, some high schools, Clinical Centre of Serbia, several museums, etc.</td>
</tr>
<tr>
<td></td>
<td>UMTS</td>
<td>Academic Net of Serbia (AMRES)</td>
<td></td>
</tr>
<tr>
<td>Slovenia²</td>
<td>Schools use:</td>
<td>ARNES (Academic and Research Network)</td>
<td>428 (O), 297 (P), 170 (S) year 2005³</td>
</tr>
<tr>
<td></td>
<td>• optical fibre(100 Mb)</td>
<td><a href="http://www.arnes.si">www.arnes.si</a></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• ADSL (2Mb, 4 Mb, 8 Mb)</td>
<td></td>
<td>//////</td>
</tr>
<tr>
<td></td>
<td>• cable TV operators (between 2 Mb–5 Mb).</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UMTS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Overview of learning resources and repositories for primary and secondary education by country⁴.

<table>
<thead>
<tr>
<th>Country</th>
<th>Online learning resources and tools</th>
<th>Online learning repositories</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosnia and Herzegovina</td>
<td>No data⁵</td>
<td>No data</td>
</tr>
</tbody>
</table>

²Text in this font cited from [eMapps], pp. 75–76.
³P = primary, S = secondary, O = overall.
⁴Learning resource repositories have in general the following features: resources are indexed, searchable and database-driven, and contain metadata.
⁵On the date of writing this report, there were 12 (twelve) ministries concerned with education in BIH.
Country | Online learning resources and tools | Online learning repositories
---|---|---
Serbia | Several specialised primary and secondary schools that offer much better ICT. | Mathematical High School (Matematička gimnazija) ([http://www.mg.edu.yu](http://www.mg.edu.yu))
Computer High School (Računarska gimnazija) ([http://www.rr.edu.yu](http://www.rr.edu.yu))
Slovenia⁶ | E-CHO is LMS (Learning Management System) and LCMS (Learning Content Management System) software, completely developed at the Faculty of Electrical Engineering, University of Ljubljana ([http://dl.ltfe.org/](http://dl.ltfe.org/), [http://sola.ltfe.org/](http://sola.ltfe.org/)). | SIO: Slovenian School Net – Slovensko izobraževalno omrežje. SIO was developed in the 1996 and was designed as the national learning repository. It provides information and materials for parents, teachers, and students. It also offers various communication methods, such as forums, newsletters, etc. ([http://sio.edus.si](http://sio.edus.si))
E-CHO e-learning system ([http://sola.ltfe.org](http://sola.ltfe.org))
E-CHO e-learning system has seven bi-semester interactive courses on Mathematics, Natural Sciences, English and Slovenian Language for primary school education.
Web Based Educational Television ([http://www.SiTV.tv](http://www.SiTV.tv))
SiTV is a project which brings together school video production groups and other creators of video educational contents.
Kvarkadabra ([http://www.kvarkadabra.net/](http://www.kvarkadabra.net/))
Kvarkadabra is a “newspaper for explanation of science”. It is a comprehensive web portal with articles on a variety of subjects, e.g. astronomy, physics, biology, mathematics, history, philosophy, and other.
[http://www.e-um.si/](http://www.e-um.si/) is the most complete site for school mathematics (grades 1–13) which also contains some lectures on topics from natural science and should be further extended to complete the school curricula.

2.3. E-learning, content, and tool development at universities

In Bosnia and Herzegovina, eLearning applications are partially developed by individual institutions. There is almost no cooperation in this regard and it is often the case that applications are developed in parallel to meet the same needs. That results in many partial attempts with solutions of lower significance [IS Strategy-BiH].

Most of Universities for LMS/LCMS use Open Source tools like Moodle or

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⁶ Text in this font cited from [eMapps], pp. 75–76.
commercial tools like LearningCubes [eLTFR].

For development of eContent, most universities use some of the following authoring tools: Course Genie, Accordent PresenterOne, Helix Producer, Microsoft Producer, CourseBuilder for Dreamweaver MX, Camtasia Studio.

In Bosnia and Herzegovina, 12 eLearning centres exist, but only two of them are at the university level (in Tuzla and Zenica), while the other ten provide their services at the faculty level [eLTFR].

At the universities in BiH, there are five eLearning experts and six eContent developers. The table shown below indicates the number of eLearning experts and eContent developers per university [eLTFR]:

<table>
<thead>
<tr>
<th>University</th>
<th>eLearning experts</th>
<th>eContent developers</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Zenica</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>University &quot;Džemal Bijedić&quot; Mostar</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>University East Sarajevo</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>University of Tuzla</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>University of Mostar</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>University of Banja Luka</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>University of Sarajevo</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>University of Bihać</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

The next table shows the capacities of rooms available for eLearning:

<table>
<thead>
<tr>
<th>University</th>
<th>No. of rooms and space available</th>
<th>Number of seats</th>
<th>Number of multimedia rooms</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Zenica</td>
<td>20x12m²</td>
<td>20x12</td>
<td>2</td>
</tr>
</tbody>
</table>
Several electronic educational courses have been developed at the universities in Bosnia and Herzegovina. The table shown below indicates the number of courses per university:

<table>
<thead>
<tr>
<th>University / Faculty / Centre</th>
<th>Courses Developed</th>
</tr>
</thead>
<tbody>
<tr>
<td>University of Banja Luka</td>
<td>4</td>
</tr>
<tr>
<td>Faculty of Economic, Sarajevo</td>
<td>18</td>
</tr>
<tr>
<td>University of Zenica</td>
<td>14</td>
</tr>
<tr>
<td>University of East Sarajevo</td>
<td>0</td>
</tr>
<tr>
<td>University of Mostar</td>
<td>13</td>
</tr>
<tr>
<td>University “Džemal Bijedić” Mostar</td>
<td>6</td>
</tr>
<tr>
<td>University of Tuzla</td>
<td>11</td>
</tr>
<tr>
<td>University of Bihać</td>
<td>0</td>
</tr>
<tr>
<td>Exit Centre Banja Luka</td>
<td>3</td>
</tr>
</tbody>
</table>

The following table gives a comparative survey of academic institutions involved in development of content and tools for e-learning; contents and tools are listed explicitly only if they concern mathematics and technology teaching.
<table>
<thead>
<tr>
<th>Country</th>
<th>Institution</th>
<th>Developed tool or content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bosnia and Herzegovina</td>
<td>University of Tuzla: &lt;br&gt;Faculty of Electrical Engineering &lt;br&gt;Faculty of Mechanical Engineering &lt;br&gt;Faculty of Mining, Geology and Construction Engineering &lt;br&gt;University Džemal Bijedić Mostar, Faculty of Information Technologies &lt;br&gt;University of Banja Luka &lt;br&gt;University of Mostar &lt;br&gt;University of Sarajevo Faculty of Electrical Engineering &lt;br&gt;Faculty of Economics &lt;br&gt;University of East Sarajevo</td>
<td><a href="http://www.ucded.untz.ba/lc">www.ucded.untz.ba/lc</a> &lt;br&gt;<a href="http://www.fit.ba/ba/">http://www.fit.ba/ba/</a> &lt;br&gt;<a href="http://el.etfbl.net/login/index.php">http://el.etfbl.net/login/index.php</a> &lt;br&gt;<a href="http://www.fsr.ba/index.php">http://www.fsr.ba/index.php</a> &lt;br&gt;<a href="http://courses.etf.unsa.ba/">http://courses.etf.unsa.ba/</a> &lt;br&gt;<a href="http://dl.efsa.unsa.ba/">http://dl.efsa.unsa.ba/</a> &lt;br&gt;<a href="http://el.eff.unssa.rs.ba/">http://el.eff.unssa.rs.ba/</a></td>
</tr>
<tr>
<td>Slovenia</td>
<td>University of Maribor &lt;br&gt;University of Ljubljana and University of Primorska &lt;br&gt;10,000 students at 3 Slovenian universities use open source based eLearning rooms (Moodle)</td>
<td><a href="http://moodle.unimbble.si/index.php?lang=en_utf8">http://moodle.unimbble.si/index.php?lang=en_utf8</a> &lt;br&gt;<a href="http://www.moodle.si/moodle/mod/data/view.php?id=1">http://www.moodle.si/moodle/mod/data/view.php?id=1</a> &lt;br&gt;Some teachers also use some other software, for instance WIMS: <a href="http://wims.auto-">http://wims.auto-</a> upsud.fr/wims/wims.cgi?session=VP87A597A1.2+%lang=si+%module=adm%2Fclasses%2Fclasses.si+%type=participant</td>
</tr>
</tbody>
</table>
2.4. Primary and secondary education

2.4.1. Curricular strategies

Besides the access to the computer and Internet, the use of ICT in schools is in general determined by the curriculum development and collateral teacher training.

In Bosnia and Herzegovina, there is no specific ICT in education-related initiative with long term goals and objectives, and the development of ICT in education has been carried out through several programmes including various actors.

In Serbia, most formal documents and laws that regulate the development of ICT were passed between 2003 and 2005. These documents include the Fundamental Law of Education System, Reform of Secondary Education, Strategy for Development of Informational Society in Serbia, and Law on University Education. These documents recommend the use of ICT through the use of computing technology, e-learning and Internet in regular curriculum, as much as possible. Furthermore, they recommend the reform of current subjects and their syllabi, and the modification of their content so that they can take better advantage of modern ICT.

In Slovenia, there is a National Curriculum Council7 which prepares and adopts education programmes for all levels of education. The curriculum is goal-oriented and decentralised, leaving it to the teachers to choose the best methods to reach the goals. The national curriculum, which has been amended several times, sets out more precisely that the training of teachers in ICT is an ongoing process with the combination of didactical, organisational, and technical knowledge (and not only an one hour or week course as before) [eMapps, p. 44].

However, there is no specific ICT in education-related initiative with long term goals and objectives, and the development of ICT in education has been carried out through several programmes including various actors. The Ministry of Education and Sports finances the introduction of ICT in primary and secondary schools through public tenders [eMapps, p. 37].

The introduction of ICT into primary and secondary education can follow two different strategies: (1) establish a separate (new) subject, and/or (2) integrate ICT in as many existing subjects as possible.

Bosnia and Herzegovina

ICT is introduced in primary and secondary schools through compulsory or elective

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7http://www.mss.gov.si
subjects.

On the other hand, secondary schools include ICT as compulsory curriculum [ICT Indicator]. Students learn how to use computers and network services, including the use of all components of the computer, basic word processing, presentation tools, basic database structures, table calculators, and Internet [IS Strategy-BiH].

Education system in Bosnia and Herzegovina does not provide elementary digital literacy for its citizens. Primary and secondary school curricula are not appropriate for that use (or do not include education for the use of ICT in some grades of primary and secondary education or the curricula are appropriate or the textbooks or instruction are entirely inappropriate) [IS Strategy-BiH].

**Serbia**

In primary schools, the basics of ICT are taught in two optional subjects. In the lower grades (1st through 4th), the subject is called *From toys to computers*, and in higher grades (5th through 8th), it is called *Informatics*. The practice from the previous several years shows that the children and their parents are very interested in these optional subjects, but the problem is insufficient computing equipment in schools. It is often the case that pupils have computers at home, but not at their schools. Moreover, in rural parts of the country there is lack of skilled professionals who can teach these subjects to small children.

In secondary schools, the subject *Informatics* was introduced in 1994 as an obligatory subject. It is taught during the whole four years, with two hours per week. As a part of this subject, pupils are taught the basics of computer literacy, the use of Microsoft Windows and Microsoft Office tools, the history of computers and computing, and the basics of programming.

Apart from these specific subjects, ICT is very seldomly used in regular curriculum.

There are several specialised primary and secondary schools in Serbia that offer much better ICT education that ordinary schools. Some of such schools are the Mathematical High School (Matematička gimnazija) (http://www.mg.edu.yu) – a public secondary school funded by the MP, and the Computer High School (Računarska gimnazija) (http://www.rg.edu.yu) – a private school funded by the pupils' parents.

Information and e-learning technologies are much more widely used within the university education. Some of the faculties that partially use distance learning in their regular curriculum are the Medical Faculty in Belgrade (http://www.med.bg.ac.yu), Electro-technical Faculty in Belgrade (http://www.etf.bg.ac.yu), Faculty of Science and Mathematics in Novi Sad (http://www.pmf.ns.ac.yu), Electro-technical High
School in Belgrade (http://www.vets.edu.yu), Electronic Faculty in Niš, and Faculty of Economy in Belgrade (http://www.ekof.bg.ac.yu).

In Slovenian primary schools, ICT is not integrated in the compulsory curriculum. ICT-related subjects (‘Information Literacy’ and ‘Computer Science, Multimedia’) can be chosen from an optional subject list. However, these subjects are performed at the end of primary school at the age of 12, 13, 14, which equates to lower secondary level in other countries. Within the Information Literacy, students learn how to access, select, analyse, evaluate, use, and present information. Computer science teaches about the computers and computer networks [eMapps, p. 45].

In Slovenia, ICT is more widely used in subject lessons than during the separate ICT lessons, and in 25 % of school lessons the computer, the Internet or a projector is used. 1.4 % of teaching takes place in computer rooms. ICT is mainly used in technical education, social subjects, and mathematics. The use of ICT in science subjects is declining. A study shows that the use is strongly correlated to the existing local software in a given subject [eMapps, p. 54].

ICT innovative projects in Serbia were mainly sponsored by the European Agency for Reconstruction (http://www.eu.ear.int) through its cooperation with MP.

One of such projects is the Vocational Education and Training Reform Programme (http://www.vetserbia.edu.yu). The intention of this project is to provide help with the new approaches to learning and teaching in vocational education and training, and the assistance in identifying and responding to individual, community and enterprise needs for skills and competences. As a part of this, the project of Moodle Internet Classroom (http://www.vetserbia.edu.yu/moodle) was organised. It includes several secondary schools from the entire Republic of Serbia (Belgrade, Niš, Leskovac, Subotica, Zrenjanin, Kula, Kragujevac, Novi Sad, Užice, and Žaječar) and several university departments (Faculty of Philosophy, Belgrade, Faculty of Medicine, Belgrade, and University of Banja Luka).

MP has funded the project of innovation and introducing e-learning methods in electro-technical schools in Serbia. The internet portal (http://www.skolaelektrotehnike.co.yu) offers pieces of information to teachers and pupils in these schools. Its goal is to advance the education process in these schools. It contains syllabuses of subjects, tests of knowledge, virtual laboratories, news from the field of education in electronics, materials for teachers, etc. Furthermore, the project includes the development of the first multimedia textbook for the subject Introduction to Electronics, developed by the group of authors led by Gordana Mijatovic. Today, 25 secondary schools are involved in the project. One group of pupils from each school is chosen and trained in this subject using e-learning methods, exclusively. The first results show that the pupils are very keen on
this kind of work and show good progress.

ZUOV organises an annual competition called *Creative School*. It gathers electronic materials sent by the teachers focusing on interdisciplinary approach to education and joining several different subjects. The best works are awarded and published as a part of the knowledge base that is publicly available for use in education.

*The Centre for Development and Applications of Science, Technology and Informatics* ([http://www.cnti.info](http://www.cnti.info)) is operating in Novi Sad and aims at the education of teachers, professors, and high school principals. It is one of the initiators of the project of formulating the Strategy of advances of informatics in education, and the project of networking in primary and secondary schools in Novi Sad and Vojvodina. It also organises competitions for pupils in informatics and stimulates them to learn and work in this field.

### 2.4.2. Support strategies

European countries have established various activities which accompany the advancement of using ICT and of e-learning.

**Bosnia and Herzegovina**

Education system in Bosnia and Herzegovina is based on the concept of oriented secondary education, knowledge transfer based on the use of chalk and blackboard in classes, even at universities, and it significantly differs from modern European education processes adopted and applied in Europe (computer and web-based learning, distance learning, knowledge-oriented learning).

The fact is that ICT technologies are underrepresented in the education process, the entire hierarchy of it, either as a field of study or as a tool for the acquisition of new knowledge. In comparison with the total number of teaching staff, the percentage of teachers that use ICT in classes is very small. Around 45% of employees in education know how to use a computer, while only 5% of professional IT staff is employed in the field of informatics or equivalent services. There is no mandatory training of teachers in the use of ICT in education, nor are there specially designed courses for their training and preparation for the use of ICT in education.

Almost no education institutions have a developed mechanism of investment in enhancing computer capacities and education of staff in ICT [IS Strategy-BiH].

**Serbia**

The development of ICT in public schools in Serbia is funded almost exclusively by the government. Most funds are coordinated by the MP. Some funds are also
reserved from the National Investment Plan (http://www.nip.sr.gov.yu) – the project of the Government of Serbia aimed at developing the overall country infrastructure that is the basic element for socio-economic development of Serbia.

Teachers in schools that teach ICT subjects are usually full-time employees, sometimes also teaching some other subjects (e.g., mathematics, technical education). Schools in Serbia usually do not employ IT professionals responsible for maintaining the ICT infrastructure, but these teachers try to maintain the equipment as much as possible. MP usually covers the expenses of maintaining hardware equipment.

In order to improve ICT in Serbia, MTKID (Ministry of Telecommunications and Informational Society) offers scholarships to PhD students focusing on the development of ICT and also applying ICT in education.

Technical and pedagogical support is provided in Slovenia to various degrees and with a focus on technical on-site support. Formally, every school in Slovenia has an employee (full-time or part-time teacher) called the Organiser of Information Activities, with the following tasks:

- maintaining ICT infrastructure in schools and introducing new infrastructure,
- teaching ICT-related subjects.

The latest survey shows that 48.6 % of schools in Slovenia have full-time employees, 42.7 % of schools have half-time employees and the rest are outsourcing services and activities related to ICT. Only 4 % of schools have no support of this kind. The majority of such schools are small rural branches of bigger primary schools.

Pedagogical support is provided by the consultants of the National Education Institute and Faculties of Education at the University of Ljubljana and the University of Maribor. This support is not provided systematically and is dependent on teachers taking it up [eMapps, pp. 57–58].

A Slovenian survey looked at teacher’s opinion on the contribution which ICT can make on improving the learning outcomes
de8. 73 % of teachers from all schools in Slovenia answered that computers have a positive impact on learning outcomes. Increased motivation of students was mentioned as a major positive impact of ICT use in the classroom [eMapps, p. 61].

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8 http://www.pfmb.uni-mb.si/raziskave/os2003/oracost.htm
2.5. Links education – community

The aim to use e-learning as a kick-off for wider social effects requires to consider the links between schools and the world outside. [eMapps, pp. 42–43] mentions two kinds of links: school – home links (e.g., the e-diary project in Estonia providing parents the information about their children's work at school) and school – community links (e.g., telehouses in Hungary).

In Bosnia and Herzegovina, Internet is rarely used as a medium for the delivery of electronic learning content. Very few education institutions have developed web portals to support the teaching process, and even a fewer number dispose of web-based platforms offering the possibility to develop electronic learning content, learning content management system, learning management system, and electronic communication of participants in e-Learning. It is evident that Bosnia and Herzegovina has a long and demanding way to go in the field of applying ICT in education and one of the first steps is to enhance computer capacities in education institutions.

Serbia

The Academic Net of Serbia, AMRES, connects 126 different institutions: not only universities, but also several museums, libraries, botanical gardens, etc. It includes institutions from Belgrade, Novi Sad, Niš, Subotica, Kragujevac, Sombor, Leskovac, and Bor.

In Slovenia, ICT has been introduced in museums and libraries which are now called e-libraries, with which cooperation happens mainly at the local level. A recent, PHARE-funded life-long learning project aims to encourage the links between the formal and informal education, and connections between schools and external educational organisations, such as libraries or museums. In several projects, e-content was exchanged between external organisations and schools, and vice versa. Teachers as users gained most benefit from the project. [eMapps, p. 43]

It is worth mentioning that 30 schools in Slovenia are ‘e-schools’ which have multimedia-equipped classrooms that can be used by the external public, as well, in order to optimise their use. [eMapps, p. 42]
3. Goals envisaged by the roadmap

Since decades of experience show that e-learning, i.e., using computers for learning, does not necessarily improve learning, neither at universities nor at schools. Neither can it be expected that computer-supported communication will make our living together more fruitful or more pleasant if just following the drive of development in ICT. Such experience confirms the “European way” to relate development of technology as intimately and instantaneously as possible with sustainable socio-economic development and keep humanity at the centre of politics. And this roadmap is at the centre of plans for decision makers.

European strategy papers state that the information society represents a challenge and chance […], instead of natural resources or industrial capacities, knowledge is the vital resource in the information society and generation of new knowledge represents the basis for the wealth in this post-industrial society. Hence, the term knowledge-based economy is coined. The generation of new knowledge undoubtedly depends on human capacities, i.e., on their ability for innovative thinking and skills to effectively use modern information technologies, which represent technological underpinning of the information society […]. Education together with the scientific research & development (R&D) play the major role in turning this chance into a reality [ICTstrategy-SR, p. 85].

3.1. Making citizens computer literate and equal members of information society

The goal aims at educating the wider population about the ICT, i.e. ensuring that the citizens have the basic but critical ICT skills. As wide use of ICT and emerging public electronic services change many areas of our lives, such skills will become necessary for performing the everyday activities. Only computer literate citizens will become equal members of information society. The fulfilment of this goal is important for the prevention of digital division in society[ICTstrategy-SR, p. 85].

Modern communication technologies can contribute essentially to the specific local issues of connecting distant and displaced communities: transmission of voice, pictures, movies, as well as communication structured by web2.0 technologies.

3.2. Improve scientific networking within SEE and Europe

This goal most directly coincides with the primary intention behind the call for this mapping project, the goal to promote international scientific cooperation, and networking between Europe and SEE countries.

There should be a set of mechanisms and instruments provided by the government in order to foster innovative R&D. Appropriate funds supporting scientific and technological innovations must be established. The existing programmes fostering innovations and collaboration
between R&D institutions and industry should be extended. Instruments such as technology transfer centres, scientific parks, incubators, innovative centres, etc., should be supported.

Cooperation with academic and research institutions from abroad and participation in international research projects is very significant for strengthening the national research capacities, improvement of quality of research, enhancement of knowledge and skills of researchers, and prevention of “brain drain”. The participation in EU funded research projects is particularly important, because it enables national research institution to become part of the unique European research space. [ICTstrategy-SR, p. 89]

Local strengths should be identified such that at the universities in SEE countries, they will contribute significantly to specific areas and demonstrate that they need not be in a beneficiary role within the Europe.

3.3. Adapting educational practice to the needs of information society

With a need for more independence and creativity, engagement in teamwork etc., the need to support development of the role of the individual in society is often asserted. The role of the individual in society is becoming more and more important. It is argued that school curricula should be reformed in order to support development of these attributes in children. Linked to this is the idea that the ICT should not be taught and learned solely as a closed or self-contained subject independently from other subjects, but should be treated interdisciplinary, integrative, and cross-curricular and taught in a way which supports learning by applying technology in forms that are meaningful for students [eMapps, p. 6].

The skills and knowledge required in society and at workplaces has changed. Rather than the students requiring specific bodies of declarative knowledge they require very flexible and more general sets of procedural knowledge. These tend to involve conceptual understanding, problem-solving, personal interaction, and resource usage. Much of the procedural knowledge required is supported by the use of ICT.

In the future, it seems likely that more learning will occur outside school buildings. Some schools are pursuing the creation of such a ‘virtual school’ that is: an online community of students, staff and parents with Internet access at home or workplace, where online communications are enabled and students can work on projects from school or home [eMapps, p. 7].

3.4. Providing access to information about the cultural and historical heritage

Preservation and dissemination of cultural and historic heritage is important for any society in order to provide better understanding and tolerance among different nations. In economical terms, cultural and historic heritage helps establishing national trademarks and
promote advantages of national goods and services offered to the global market [ICTstrategy-SR, p. 86].

All primary and secondary schools, universities, research institutions, museums, libraries, and student halls should have broadband connection to the Internet [ICTstrategy-SR, p. 88] – and the cultivation of historic heritage is an appropriate cause for schools to open the classroom, for universities to contribute with their expertise, for museums to adopt new positioning technology for mobiles and to extend the scope to monuments outside in the country (a mobile knows the position, and the museum knows the historic details).

This seems a good opportunity to include mobile telephones into considerations of new kinds of learning, which are then available for other activities in e-learning.
4. Areas of action to advance e-learning in SEE

The areas of action identified below are drawn from a synopsis of several strategy papers and action plans. These areas are presented in a general view which includes the various interconnections between various planned actions, and which allows pursuing long-term goals. However, in Section 5., the roadmap will concentrate on the most promising actions within the next years.

4.1. Access to telecommunication with respect to universal services

Strategy papers on ICT (e.g., [ICTstrategy-SR, p. 63]) expose the following trends which will have inevitable impact on the use of computers, and e-learning depending on them:

- Integration of mobile telephone networks with computer networks to 'universal services'.

- Integration of terminal satellite systems (mobile satellite communications and satellite TV) with terrestrial networks.

- Dynamic growth of broadband Internet as a predominant way for the transmission of information and as a common communication network in our society.

Establishing 'universal services' is not primarily a technical problem, but an organisational challenge for the cooperation between commercial providers and governmental authorities.

Finally, computers will underly an “always connected” concept, where the student has access to all kinds of digital information everywhere, not only in the computer lab. This is important, since computer labs tend to undermine “ICT as a tool” and innovations in pedagogy (See Section 4.3.1.).

With respect to universal services, for governmental ICT administration, “a specific institutional commitment is given by

- subsidising telecom services for economically weaker social groups,

- the possibility of connecting schools, libraries, health centres, and hospitals to the Internet at special prices”. [ICTstrategy-SR, p. 72]

The dedication of EU to this commitment is clearly pronounced: “The ministers participating in the conference adopted a declaration stressing the need to further develop the exchange of good practices and to ensure inclusion and security in online public service delivery.” [eEurope, p. 11].
The commitment mentioned above deserves even more consideration, since a full and complete dominance of digital technologies is coming up (even in museums; See Section 4.4.).

The development of universal telecommunication services goes alongside the development of devices connecting to these services. [eTeach, p. 85] gives the following account:

- **Notebook** computers [...] do not contain any drive for removable discs (floppy, CD or DVD), but have USB ports to which you can plug in a flash card or external drive. Notebooks can communicate with all peripheral devices via RF and IR channels, and with the outside world via radio-channels, as well.

- To make it even smaller and cheaper, there are also **sub-notebooks** that have a less convenient keyboard, smaller and weaker display, and less functionality, in particular, usually having a less powerful OS than desktop and notebook computers; See, for instance, the project “one laptop per child” ⁹.

- For greater savings, you can get **smart keyboards** with a very simple (for example, 8 lines of text) display, with the major function to store text input. The price can be 3- to 4-times smaller than the price of a regular computer, and so it is a popular option for schools.

- **Palm computers** or palms (or PDAs, personal digital assistants) have the functionality of sub-notebooks, but are even smaller with just a screen of palm size. The screen is also used as an input device for handwriting, pointing and moving objects. Palms are really good for taking notes on the move and for collecting data from various sources (like measurements from sensors).

- **Wearable computers**, finally, lead to “the disappearing computer” – and this, too, is relevant for learning: there are already educational tools (e.g. ¹⁰) which send measurements from sensors on moving objects such that they can be explored with respect to laws of physics.

The prices of all these devices heavily depend on mass-production and the investment in production is demand-driven. Thus, within the next years, it is not possible to give recommendations on hardware which are valid for more than one or two years – serious advice cannot avoid this regrettable fact.

Finally, a comment on the layout of computer labs: The furniture in most of these labs has been configured by the “traditional view of pedagogy” where the relation

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between the individual student and the source of information is prevailing; thus, each student has their computer in front of themselves, the computers in lines. This configuration does not only take the teacher out of sight, but it inhibits collaborative work in reality (collaboration in virtual realities can only be the next step).

Thus, UNESCO suggests [eTeach, p. 172] movable desks “to be reconfigured for different functions in the room. For example, individual triangular desks can be reorganised into hexagonal tables for group work.” A comparable flexible configuration already realised in some few labs is: desks with computers on the walls (i.e., students are oriented towards the walls) and some other desks in the middle of the room so that students can collaborate there.

Thus, the recommendations for communication networks and hardware are:

1. For teaching basic ICT skills and extended ICT knowledge, establish computer labs with the best Internet connection available. Provide furniture enabling collaboration (Section 4.3.1.).

2. For using “ICT as a tool”, be prepared to decide for novel devices coming up in the range between workstations and mobile telephones.

3. Make the purchase of novel devices a concern of 'bottom-up processes', initiated by teachers, schools, etc.

4. Governmental regulatory authorities must ensure 'E-Inclusion', i.e., affordable connection to communication networks for economically weaker social groups including schools, museums, etc.

5. Observe the development of 'unified services' (integrating Internet and mobile telephone networks) for opportunities to establish a restricted region as a testbed for such services.

4.2. Tool development, content development, and e-learning at the universities

Strategic papers, e.g. [ICTstrategy-SR], stress the importance of e-learning in a very general way: „ICT in education and R&D is needed because:
• ICT can be used to support efficient education and R&D,
• ICT in education can be used to introduce the concepts of e-Learning methods and open distance learning,
• ICT in R&D.

Social aspects of e-Education should not be neglected:

• Digital divide should be prevented,
• Rural areas, income, education, age and gender gaps must be overcome,
• Special learning needs of particular social groups should be adequately addressed." [ICTstrategy-SR, p. 86]

4.2.1. Strategic planning for e-learning

Most tools and content used in the present e-learning originally stem from academic R&D: authoring tools, simulation systems, algebra systems, etc., and content from the astronomy, medicine, cultural studies (e.g. [SLOVO]), etc. Up until now, the interdependency between the development of tools and digitised knowledge and usage in e-learning was no concern of planning. This is changing now, since e-learning is becoming a widely-established practice and is raising requirements by itself.

Usually pragmatic reasons promote e-learning at the universities:

• courses which require distant learning, for instance in-service training, post-education and life-long learning concepts,
• lectures on specific subject matter which are important, which require computers anyway, where assessment of students or other evaluation is crucial,
• administrative requirements raised by unforeseen high number of students for particular lectures or courses, by testing requirements, etc.,
• new kinds of universites, usually called 'open universities', are based on distance learning, exclusively; the growing success of these universities is caused by the opportunities of e-learning,
• etc.

The motivation to be „up-to-date“ is not a good reason for e-learning: lecturers can hardly be convinced to do the enormous additional work required for the preparation of e-learning, and administration can hardly be convinced to provide the enormous
amount of money required for professional development of e-learning content (estimated between € 25,000 and 75,000 for 1 weekly hour of lecture for a year [eCosts]). Thus, the administration in science and education is challenged by identifying 'good' reasons from the list above (which intentionally contains an „etc.“) in time.

4.2.2. Support actions for e-learning

Once established, e-learning externalises inherent interdependencies of academic education and intensifies the respective issues.

![Diagram of interdependencies of e-learning](image)

The areas of action interlinked by e-learning in Figure 1 are the following.

(A) **Academic R&D** is a source of tools and content, both developed without concern for e-learning in general.

(B) **Practice of lecturing and studying** may lead to the desire for e-learning, or there may be some compulsion imposed from outside to do so.

(C) **Training and support** for lecturers and for students comprises administration, use and maintenance of accounts, software, content management systems, assessment tools, specific rooms, equipment, etc.

The European Pedagogical ICT License, EPICT, already seems to be stable enough to be recommended. It is a course concept that offers educators basic ICT skills on a personal and professional levels through focusing on the pedagogical integration of
ICT in the teaching practice.\textsuperscript{11}

\textbf{(D) Integrated media development} already takes into account that there are links between the four areas of action (A)\textemdash(D).

The links between the areas of action in Figure 1 are the following:

\textbf{Link [1]} is the 'bottom-up' source of innovation, often facilitated by actors from (A) and (B) cooperating at one institute, or even being one and the same person: a researcher (A) looks for application of his or her new tool or content, or a lecturer (B) requests e-learning tools or content from R&D capacities available nearby.

The detection of such 'bottom-up' innovations is a challenge for strategic planning, and the provision of contact points, awards, etc., is an important issue.

Usually ad-hoc implementations of e-learning create demands very soon: demands for administrative support (C) (See links [2], [5]) and for instance, sharing with colleagues or distribution creates demands for media-development (D) (See links [4], [6]).

\textbf{Link [2]} plays a vital role for e-learning to thrive and prosper; although facility management systems take over some tasks, additional personnel must be provided in order to immediately solve problems analogous to 'the beamer doesn't work'. The growing complexity of services at university centres for e-learning indicates the high relevance of this link.

There are several new administrative issues, for instance: how to reimburse mail conversations between lecturer and students (an additional task for the lecturer) or lectures without assessment (accomplished by some software relieving the lecturer).

\textbf{Link [3]} concerns two services, which (if supported already) are considered tightly related such that these services are allocated within one institution at many universities. One example is given in more detail.

\textbf{Link [4]} is predestinated for planning: e-learning tools and content created R&D can lead to commercial spin-offs, or at least should lead to interchange between universities on a regional, national and international level. Several legal issues like copyright (who owns content, the lecturer or the department or the university or who?) are indicated by this link.

\textbf{Link [5] and link [6]} play different roles, depending on the way of how the interdependencies in e-learning are institutionalized.

\textsuperscript{11}http://www.epict.org
A centre for e-learning usually combines the areas of action (C) and (D) in Figure 1 and it may have the following mission\textsuperscript{12}:

"The main orientation and the target [...] is the implementation of eLearning and life-long learning [...], according to the guidelines of the Lisbon strategy, Bologna process, and strategic development orientation of Republic Slovenia, through the educational, research and development activities, as well as by offering various services and consultations in the area of:

\begin{itemize}
  \item guidelines for a good quality offer of life-long learning, e-Learning materials, and courses;
  \item organisation of meetings and workshops on e-Learning and life-long learning;
  \item education in the field of e-Learning and ICT, presentation of their possible applications;
  \item participation in the development activities at various faculties of our university, related to e-Learning and life-long learning processes;
  \item following the development of modern learning methods in the area of e-Learning and their implementation in the learning process at the university level."
\end{itemize}

\textsuperscript{12} Cited from \url{http://moodle.uni-mb.si/file.php/1/Predst_Centra.htm}, University of Maribor, Centre for E-Learning (unauthorized translation from Slovenian).
Thus, for e-learning at universities, it is recommended to:

1. collect competence, equipment, and staff for e-learning and distance education in a centre at each university;

2. integrate the centre tightly with the universities, institutes, lecturers, and researchers, and with the students’ representations; provide ‘bottom-up’ contact points;

3. interlink the centres at a national and international level, and with respect to the administration and R&D; promote the development of various focuses for various centres; reward the exchange of content;

4. implement awards in order to detect ‘bottom-up’ innovations;

5. provide strategic planning to identify the needs for new studies and courses based on distance education.

4.3. Curriculum, teacher training, and e-learning at schools

A major theme in this roadmap follows the directives of UNESCO, it “concerns how ICT can create new, open learning environments and their instrumental role in shifting the emphasis from a teacher-centred to a learner-centred environment, where teachers move from being the key source of information and transmitter of knowledge to becoming a collaborator and co-learner; and where the role of students changes from one of passively receiving information to being actively involved in their own learning. ” [eTeach, p. 3]

E-Learning is in a constant state of flux; this can be observed in recent developments all over EU. In this context, it is not disadvantageous that the approaches to e-learning in SEE are fairly different, as described in Sections 2.4.1. and 2.4.2.

The constant state of flux is a necessary consequence of the rapid development in ICT, and the flux is connected with the hope to employ ICT as a lever for adapting educational practice to the needs of information society and for innovative open learning environments (Section 3.3.).

This state of flux has consequences, in particular on curricular strategies and on the education and training of teachers. The flux is considered important, such that a
separate section, Section 4.3.3., will address the challenge of how to 'institutionalise innovation' (a contradiction per se, in general) in the field.

4.3.1. Promote curricular strategies

The impact of ICT on innovation in pedagogy is beyond doubt. It “can be summarised as leading to approaches that:

- are more learner-centred,
- are more cooperative and collaborative,
- involve more active learning,
- are based on greater access to information and sources of information.” [eMapps, p. 29].

As mentioned in Section 2.4.1., the introduction of ICT into primary and secondary education can follow two different strategies: (1) establish a separate subject (usually named 'Informatics'), (2) integrate ICT in as many existing subjects as possible. The SEE countries investigated in Section 2.4.1. implement more or less both strategies in parallel.

There are good reasons for implementing both strategies in parallel as there is no definite advantage (+) or disadvantage (-) of one strategy over the other:

<table>
<thead>
<tr>
<th>Aspect of comparison between (1) and (2)</th>
<th>Strategy (1): Separate subject 'Informatics'</th>
<th>Strategy (2): Integration into other subject (OS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>expertise of teachers</td>
<td>+ coverage of the subject matter of 'Informatics' can be envisaged</td>
<td>-- lack of basic knowledge in 'Informatics' may cause inappropriate use of ICT</td>
</tr>
<tr>
<td></td>
<td>-- approach to use ICT 'as a tool' is limited</td>
<td>+ knowledge in the OS guaranteed motivating applications of ICT</td>
</tr>
<tr>
<td>Aspect of comparison between (1) and (2)</td>
<td>Strategy (1): Separate subject 'Informatics'</td>
<td>Strategy (2): Integration into other subject (OS)</td>
</tr>
<tr>
<td>----------------------------------------</td>
<td>---------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>time used for ICT in education</td>
<td>+ the minimum is fixed in the schedule</td>
<td>-- use of ICT may vanish in certain classes (due to personal inclinations of the respective teachers)</td>
</tr>
<tr>
<td></td>
<td>-- extra time, in particular for meaningful application may be less</td>
<td>+ extra time, in particular for meaningful application may be more</td>
</tr>
<tr>
<td>coverage of (basic) ICT knowledge</td>
<td>+ can be envisaged (but what is 'basic ICT knowledge'?)</td>
<td>-- cannot be expected; the acquisition of knowledge is determined by OS-specific applications</td>
</tr>
<tr>
<td></td>
<td>-- the concepts and tools of ICT are separated from their application</td>
<td>+ the application of specific ICT concepts and tools can be motivated</td>
</tr>
<tr>
<td>use of ICT 'as a tool'</td>
<td>+ specific ICT concepts and tools exhibit their specific strengths</td>
<td>-- ICT concepts and tools may be used inadequately</td>
</tr>
<tr>
<td></td>
<td>-- the use of ICT 'as a tool' tends to be demonstrated by 'toy examples'</td>
<td>+ transfer and application of ICT is guaranteed</td>
</tr>
<tr>
<td>impact on innovative pedagogy</td>
<td>+ guarantees technical prerequisites</td>
<td>-- no negative impact is known!</td>
</tr>
<tr>
<td></td>
<td>-- the classical furniture of computer labs hinders collaboration</td>
<td>+ the novelty of ICT can be used as a lever for introducing innovative pedagogy</td>
</tr>
</tbody>
</table>

The table above shows that almost each advantage (+) of the one strategy faces disadvantages (−−), as well, and often the respective (−−) and (+) are quite the opposite for the other strategy.

It seems clear that the strategy (1) must establish an academic education for
teaching the subject 'Informatics' (See Section 4.3.2.). Strategy (2) particularly creates opportunities to make “profound changes in the whole existing system of education” as proposed by UNESCO [eTeach] – a thorough study of this handbook going beyond the cited outline in Section 4.3.4. is highly recommended.

Deterministic allocation of content matter to (1) and (2) seems clear:

- strategy (1) allocates general ICT knowledge to the subject 'Informatics'
  - basic ICT knowledge is presently considered word processing, presentation and basic ICT knowledge, as well as the use of mail and web, probably some knowledge about the social impacts;
  - specific and extended ICT knowledge may be computer networks, databases, web design, etc.

- strategy (2) provides for the adoption of ICT as a tool, applying the basic knowledge to various questions in various subjects, and for employing specific concepts and tools in specific applications.

Projects as specific parts in education belong to the most appropriate ways to address the innovations in pedagogy listed at the beginning of this section.

Thus, for the curriculum and support at schools, it is recommended:

1. to interlink curriculum development with developing support actions for innovative open learning environments (See Section 4.3.4.);

2. to fix a mixture of the two strategies, (1) separate 'Informatics' and (2) integration of ICT, with a minimum of details on the scheduled time;

3. for 'Informatics', there is a compulsory subject with a minimum of time scheduled (not more than 1 hour in a certain year) necessary for ensuring inclusion of unprivileged and handicapped students. Suggesting a 'minimum' takes into account that the 'basic knowledge' as defined above will be acquired before and outside the school by many students in the near future (See Section 4.1.).

4. for extended ICT knowledge as defined above provide selective subjects; leave a maximum of choice to different regions, individual schools, individual teachers, and individual students;
5. for supporting ICT as a tool provide pools of e-learning content and tools, and support teacher training (See below).

At the beginning of this section, there is a list of desirable innovations in pedagogy; in order to bring that to bearing, the last point in the recommendations is most important.

4.3.2. Strategies for teacher training and education

With respect to the goals stated in Section 3.3., “the impact on teachers of introducing ICT […] may be identified as:

- the balance of roles they play with a perceived risk of reduced influence,
- providing greater access to information, leading to increased interest in teaching and experimentation,
- requiring more collaboration and more communication with other teachers, administrators, and parents,
- requiring more planning and energy,
- requiring the development of skills and knowledge of ICT, leading to greater productivity.” [eMapps, p. 30]

“The request to use modern technology as versatile tools for productivity, communications, research, problem solving, and decision making (See the ISTE Educational Technology Standards at www.iste.org) generates challenges for mathematics educators, as well. In order to improve teachers’ interest to do so, the attitude towards technology may be improved by means of (student) teacher experience with that technology, which should be institutionally arranged in a way that respects this experience gained/required by teachers” [Kadijevich 2008].

These issues have to be tackled by the in-service training, and in the future an academic professional education has to cope with these.

In-service training will provide models of learning as envisaged for students (See Section 4.3.1.). These models implement different kinds of knowledge acquisition:

- presence in a classroom versus distance learning,
- learning by listening to a teacher or reading from certain media versus actively
collecting, structuring, and presenting knowledge,

- working alone versus collaborative learning,
- teaching alone versus team teaching.

The various method mixes lead to various namings like course, workshop, study or working group, etc. A most essential part in teachers' learning is joint reflection of the method mixes, together with colleagues and instructors, if any.

For the administration, there are two ways of organising courses:

- Centrally ('top down') organised courses on the national and regional level. These cover:
  - 'basic ICT knowledge': handling standard software and the like; administrators should be aware that these courses will become obsolete soon, i.e., when teachers have learned the basics (in their education);
  - selected topics of 'extended ICT knowledge'.

- 'Bottom-up' organised courses, workshops, study or working groups. These are initiated by teachers, groups of teachers, or other interest groups and cover:
  - ICT as a tool in various subjects;
  - didactics and teaching strategies;
  - etc.

Section 4.3.3. collects some ideas on how to organise the dynamic field of learning and teaching with computers such that innovation remains vivid.

**Professional education of teachers for informatics** at universities can be expected in many European countries within the next decade.

One example of a 'Teacher Training Programme in Computer Science & Computer Management' [InfoTeach] specifies the requirements in didactics, computer science, and educational science; the requirements for performing the subject matter are detailed as:

- knowledge in informatics, with respect to theory and practice, in particular the knowledge provided by the curricula at high schools,
• basic knowledge in the most important applications of informatics,

• competence to take over the integrative tasks raised by the application of informatics in other subjects,

• examination of socially relevant consequences from applications of informatics,

• knowledge in psychology (in particular developmental psychology) and educational sciences in order to understand the situation of adolescents,

• knowledge in didactics, in general and with respect to informatics, in order to be able to independently perform classes,

• competence to communicate with students, colleagues, parents, and school administration,

• knowledge in the provisions of law on schools and on data protection,

• competence to organise in-service training of colleagues,

• competence to take over the role as an expert in informatics with respect to administration and consultancy (acquirement of hardware and software, maintenance of equipment, installation of software, and maintenance of the computer network).

This kind of academic education will relieve teacher training from some of the assigned tasks.

For some ideas on how to organise the development of teaching skills, see below.

4.3.3. Institutionalise ongoing innovation

Educational systems in EU are more or less oppressed by two disadvantages for innovation:

1. curricula are over-determined and over-loaded (at least as they are implemented in practice).

2. teachers divorce from academia as soon as their studies are finished.

E-Learning is an efficient lever to overcome both disadvantages,

1. because curricula are not yet settled with respect to e-learning, and because using ICT as tools has an impact on the learning environments, as well as
2. because (almost) no academically educated teachers of informatics and thus more academic instructors directly meet teachers in in-service trainings.

In order to demonstrate the potential of e-learning as a lever for innovation, let us recall the interdependencies from Figure 1, assume the following scenarios, and discuss best practices.

(A) Academic R&D may have developed a novel tool or content provisionally appropriate for e-learning.

(B) The practice of learning and teaching may take maximum profit from the novel tool or content, incorporated into ready-to-use e-learning sequences and additional materials for exploration, exercises, teamwork, and assessment.

(C) Teacher training (let us omit academic studies in ‘teaching informatics’) may not only concern technicalities and handling, but also academic background knowledge and design variations for learning scenarios.

(D) Integrated media-development may be responsible for adapting the tool or the presentation of the content to the needs of the users (students and teachers), as well as for providing easy access.

With respect to the facts that learning by doing is also efficient for teacher training, and that in complex matters personal contacts are more educational than electronic information, let us design some interaction patterns between the partners (A)...(D).

Figure 2: Innovative interlinking in teacher training
Interactions [1][2][5] between (A)(B)(C) may be team teaching and expert intervention: An academic expert coming from R&D of the tool or the content might have the background knowledge appropriate for introducing the tool or the content. However, the expert may well be lost in a class of twenty students of age fifteen; the class must be prepared by the teacher in service, and the sustained yield of an expert's intervention needs to be optimised by the follow-up actions by the teacher, as well. Thus, it is straightforward that the teacher and the expert teach as a team.

Even more sustainability can be expected if the expert's intervention has been planned in a teacher training; or if an e-learning sequence would have been worked out embedding the intervention; and then, it might be an advantage if that expert is directly engaged also in the training, not only in the lesson.

Teacher training would also benefit from the personal presence of the teachers in some lessons observing parts of the e-learning sequence of some colleagues. Moreover, the teachers might then be accompanied by experts in didactics, who give supervision and monitor the discussion of the observations afterwards.

Interactions [3][4][5] between (A)(C)(D) may concern development of teachers media competency: If the observations of lessons using the new tool are discussed in a subsequent teacher training, the input of both might be valuable, input from the R&D expert, as well as from the didactics expert.

The role of the media-developers might be to organise the process so that there is an efficient feedback between observations of the tool usage and the respective adaption of the tool to the needs of the users, the students and the teachers. However, generally it is not a teacher’s task to provide feedback for experimental tools or content; the teacher’s task of teaching is difficult enough so that she or he deserves any support available and not additional burdens.

Giving feedback on experimental tools or content, however, is an opportunity for specifically interested teachers to gain expertise in both, usability of design, as well as in media didactics. And both kinds of expertise are valuable not only for further teacher training, but also for the feedback to academic R&D of the tool or content.

Thus, for the teacher training, it is recommended:

1. for the instruction on ICT knowledge, basic and extended, employ the best experts. Organise this instruction centrally, ‘top-down’;

2. support major parts of teacher training on demand from 'bottom-up' for both, extended ICT knowledge and soft-skills in teaching;
3. implement a variety of training formats: courses, workshops, study or working
groups, present or distant, team teaching, expert intervention, etc.;

4. remember: also teachers most efficiently take profit from 'learning by doing', in
particular when training complex competencies like teaching skills – team
teaching;

5. the most important teaching-skill is reflection and self-observation – personal
discussion with colleagues and supervision.

4.3.4. Practical suggestions for planning

We conclude this section with a citation from a handbook of UNESCO [eTeach, p.
221], “with a few specific suggestions that can be helpful to all those involved in the
education process in their planning to use ICT in schools.

- Use all ICT and pre-ICT spatial and visual environments to achieve the new
literacy.

- Use technology across the curricula; introduce it with the cooperation of various
teachers.

- Use ICT intensively in teacher preparation and in-service training.

- Buy the newest affordable technology, but do not reject donations of reliable
equipment provided there are enthusiasts to support it technically.

- Do not lock computers in the computer lab and restrict them to the teaching of
computer science and programming to advanced students.

- Create an information environment that incorporates libraries and laboratories,
and extends beyond their walls.

- Do not provide equipment to the poorest schools or to all schools equally, but to
schools that are ready and eager to use them. Use resource centres for other
schools to gain experience in and to prepare themselves for ICT implementation.

- Do not forget administrators – their personal use of technology is usually the key
to understanding teachers’ needs.

- Construct a new education using traditional in combination with modern local and
global sources. Build up an informal community of teachers and connect to the
international community, the national and international intellectual resources of scientists, industrialists, and officials via networks. Make schools centres of the new information culture.” [eTeach, p. 221]

4.4. University – school – community – cultural links

This roadmap regards e-learning at schools as as a kick-off for a wider social, networking, and community purposes. Thus, it discusses concrete means to achieve more general goals: The envisaged digital network shall be accessible to a wide basis of citizens of the Western Balkan regardless of their age, gender, prior ICT knowledge level, nationality, or social status.

Such a network will be actually used, if it serves the needs of the individuals with respect to business demands, as well as social and cultural concerns. Commercial demands will be imposed by the global economy (saving money by digitised banking, digitised train schedules, e-commerce, etc). The latter are public concerns, where governmental authorities shall involve themselves by E-Government and specific support in cultural affairs.

“Preservation and dissemination of cultural and historic heritage is important for any society in order to provide better understanding and tolerance among different nations. In economical terms, cultural and historic heritage helps to establish national trademarks and promote advantages of national goods and services offered to the global market” [ICTstrategy-SR, p. 86].

Since this roadmap is concerned with e-learning, it shall deal with community – cultural – school – university links. Such links may serve the actual needs of citizens in the following ways:

- **Schools** may inform parents about their children’s success on a regular basis, may use the Internet for distributing material and for collecting homework, may make the school library accessible to the public, may use the net to prepare events together with the parents, or perform projects with various partners.

- The Internet may “encourage links between formal and informal education, and connections between **schools** and external **education organisations**, such as libraries or museums. [...] Teachers as users gaine[d] most benefit from the project.” [eMapps, p. 43]

- **Museums** are particularly interesting, since old texts can now be digitised at reasonable prices. The ASO-funded project [SLOVO] is a good example. It promotes the integration of Slavic cultural objects into EU by means of information technologies and makes the objects accessible for everyone from everywhere.

- **Universities** are pools of experts not only in history; such experts very often
contribute to events organised by schools or other educational institutions. Their contribution can become more sustainable if the material is provided for the preparation to the event and for follow-up investigations (See Section 4.3.3.).

- **Townships and communes** might use the Internet for e-government, as well as for attracting visitors by presenting their cultural activities. Local associations and clubs concerning cultural heritage like music, traditional costumes, local dances, etc., may use the net for organisational tasks, presentations to the public, to announce events, etc.

Interlinking of such activities takes advantage from digitised data being accessible for everybody from everywhere, and takes advantage from electronic communication – as soon as it is accepted; and as soon electronic communication is accepted, it unfolds its advantages – thus bootstrapping a socially-oriented computer network is a complex task, which can best be accomplished by observing local opportunities.

---

**Thus we recommend for education – cultural links to:**

1. carefully provide basic services top-down (e.g., via e-government – but never risk objections!) and observe bottom-up requests concerning cultural and social needs;

2. use the digitisation of historic objects in museums ('virtual museum') for interlinking with the townships and communes related to these objects. Thus make the communities conscious about their cultural and historic heritage, and provide them with means to present it to visitors, as well;

3. promote the access to virtual museums by students, and do not miss the chances for innovative pedagogy (Section 4.3.3.): let students touch the objects, visit the localities in reality motivating thorough investigation;

4. universities are pools of experts not only in history, but in many other fields important for life-long learning. Make appearances of experts more sustainable by promoting respective digital information in advance and for follow-up activities;

5. use the parents’ interest in their children to promote the usage of ICT: show locally relevant digitised information at school events, consider affordable devices (in between computers and mobile telephones) for connecting parents and students to schools.
5. Action plan selecting actually promising initiatives

This action plan selects some items from the areas of action identified above. The criteria for selection were (1) specific actuality within a time frame of 5 years and (2) specific strengths of the contributors to this roadmap.

5.1. Main obstacles

As the above overview of the current situation in some of the South Eastern European countries shows (See Section 2.), the main obstacles of a wider application of ICT in education are insufficient technological infrastructure, low level of computer literacy in different social and demographical categories (e.g., especially older and population without academic degrees), as well as unawareness of the huge possibilities offered by ICT in education. On the other hand, the younger generations or social categories with academic background are very well aware of such a great potential. Moreover, these social categories exhibit externally high levels of motivation in using, applying, or even developing solutions for education by means of ICT.

5.2. Possible approach: accessing as many potential users as possible

The younger and youngest generation in South Eastern European countries contains a huge potential for accepting and further distributing immense possibilities of ICT in education. The demographic structure of the South Eastern European countries shows that the majority of the population belongs to the young generations; that is that these countries are rather “young” countries in comparison with the modern Western countries. Obviously, accessing, in the first step, this specific part of population has numerous advantages. Firstly, the younger generation possesses higher levels of computer literacy. Secondly, younger people are in general more open to new and novel ideas, not only in education in particular, but in how they use ICT in general. Thirdly, there is an immense wish and need of the younger generation in SEE to be a part of the modern Western world, and the knowledge and know-how of technological innovations coming from the West are generally seen as a first step towards becoming more “modern” and more “European”. Last but not least, the goal has to be not only to remedy the current rather unsatisfying situation with ICT in education, but also to invest in the future and to develop long-term and sustainable plans. The best approach is, of course, to transfer the knowledge and the know-how to generations that will, in the future, be able to further distribute the acquired knowledge to their fellow citizens. After thorough analysis of the current situation in SEE countries, an optimal approach would be to access pupils in high and elementary schools. By doing so, as many as currently possible of the potential users will be accessed. The users themselves belong exactly to the category as discussed above – the younger generation with a huge motivation to learn and adapt
modern technologies and approaches in education – a generation which, once when the required knowledge is obtained, will be able to pass and transfer that knowledge to the wider social basis.

5.3. Short Term Actions

During the project meetings, a number of possible short term actions that can bootstrap the process have been discussed. The conclusion was the following. The universities in South Eastern European countries have typically two types of lecturers and researchers. The older generation of lecturers is typically very skeptical about using ICT in education. A similar phenomenon has been observed in the Western universities. Essentially, the older lecturers have their long-time lecturing and teaching procedures, and do not want to change them. The younger lecturer generation in SEE countries has lecturers that have been, mainly because of the recent Balkan Wars, studying, researching, and lecturing abroad. Thus, this generation has already the knowledge on the novel teaching procedures that include ICT in education. Moreover, the motivation of such lecturers to modernize the educational processes in their countries is enormous. Speaking informally, they have been and have lived in modern Western countries, and they want to improve the teaching practices in their countries by following their experiences from the West. Moreover, since the educational practices, their definition, and their standardisation in SEE countries is an ongoing process, such a situation leaves a lot of areas where experimentation, innovation, and introduction of completely new and promising approaches is possible.

Thus, taking into the account the above-mentioned context and the current situation, the following short-term actions have been considered:

In order to access as many promising users as possible, ICT should be introduced in elementary and high schools (Section 2.4.2.);

University lecturers belonging to motivated younger lecturer generation will provide a link between the universities and their know-how and the schools (that is they will go to lecture to schools and try to identify younger and motivated teachers that will adapt the new approached and be able to develop their own ICT approaches in the schools); See Section 4.3.

Faculties of education need to be involved in the process to educate new generation of teachers that will, in the future, be able to develop and pass the knowledge to the wide basis of pupils in the schools (Section 4.3.).

The universities in SEE countries are mainly technology-centered and, therefore, for the first phase of the process, a technical educational field can be put into the centre. Obviously, mathematics is a common denominator for all of the technical
fields. Thus, mathematics lecturers, math teacher students, and math classes in the schools are, for sure, a perfect area for bootstrapping the process (Section 4.2.).

The current content, already available in the digital form, should be prepared in such a form that it is easily ported to the infrastructure available in schools and universities.
6. Key references


[eEurope] eEurope: An Information Society for All. Brussels: Commission of the European Communities, 2002


[eMapps] eMapps – Motivating Active Participation of Primary Schoolchildren in Digital Online Technologies for Creative Opportunities Through Multimedia (project no.28051). European Schoolnet

[eTeach] Information and Communication Technologies in Schools: A Handbook for Teachers or How ICT Can Create New, Open Learning Environments, UNESCO 2005


[ICT Indicator] Indicators of ICT Application in Secondary Education of South–East European Countries, Statistical survey, 2005


[SLOVO] SLOVO, Towards a Digital Library of South Slavic Manuscripts,
http://slovo-aso.cl.bas.bg
7. Annex
7.1. Case study on tool development and e-learning in mathematics

Case study on tool development and e-learning in mathematics

This appendix collects work done during the project “Technical and Social Challenges Related to Collaborative E-Learning in Central and South Eastern European Countries” preparing for follow-up projects.

The project has been funded by ASO, Austrian Science and Research Liaison Office, under ASO 3-01-2007. A central part of this project was a meeting at Belgrade in February 2008 which brought together computer mathematicians (in a Workshop on Formal Theorem Proving\(^{13}\)) and experts in e-learning\(^{14}\).

A1. Problem definition

While eLearning is becoming a mature technology for many curricula in tertiary education at European universities and already undergoes sustainability considerations and standardization efforts, eLearning in technical sciences and in (formula-based) engineering faces certain obstacles.

Technical obstacles become easily evident by the fact that not even the bare representation of formulae has come into effective use on the web. Furthermore, more complex objects like theories, proofs, calculations, geometric constructions, problems, and methods lack standardisation and consequently miss exchangeable formats.

These obstacles are significant, because real-world engineering problems are typically solved in teams. Thus, providing available tools with sufficient interoperability is a necessity. Moreover, the integration of such tools into collaborative environments is still missing.

Another problem concerns the methodical kernel of science, mathematics: due to the

\(^{13}\)http://www.matf.bg.ac.yu/~janicic/ftp-workshop.htm
\(^{14}\)http://coronet.iicm.tugraz.at/aso/wiki/SecondMeeting
inherent nature of mathematics, striving for automation, mathematics tends to make itself superfluous, because solving equations, finding integrals, proving theorems on computers become push-button problems – learning opportunities (and means for control by the responsible engineer) vanish, disadvantages for learning mathematics will grow in parallel with the enlargement of eLearning.

The world of formulae in technical sciences and in engineering is still widely resistant against the acknowledged benefits of collaborative eLearning!

A2. Core questions

The research questions raised by the above problem definition are being tackled by numerous projects identified in Section A3. Here, we are addressing those questions concerning computer mathematics, which have turned out to be most promising for the partners in this project.

A2.1. Core questions on eLearning in technical sciences

*How do stand-alone tools integrate into collaborative environments?*

The two systems, ISAC [2] and GCLC [3,25], employ standard formats as much as available at the present.

How can the present standards be extended in cooperation with respective European networks (for instance, ISAC's knowledge-item 'problem' is not known to OMDOC [4])? Which standards are required for smooth interchange of data between ISAC and GCLC? What about the interoperability between further systems?

What are the possibilities for collaborative construction of step-wise calculations and geometric constructions?

*How can transparent software meet the usability requirements?*

A transparent single stepping system is capable of automatically solve problems and of generating feedback to user-input from this problem-solving capacity, automatically, as well.

How can the highly complex structure of the mathematics knowledge be presented to the user such that the user can understand it best – according to his or her state of knowledge? How can the user overlook the mass of single steps (e.g., in rewriting), automatically generated by such a system? What are further requirements for collaborative learning in mathematics?

A2.2. Core questions in computer mathematics
What are the features of single stepping systems, of geometry construction systems?

The software which reduces mathematical problem solving to 'push-button problems' (as mentioned above) needs to be replaced by the software which supports interactive construction of calculations and interactive generation of geometric constructions – the so-called single stepping systems.

As there are only a few forerunners of such systems, many questions are still open: What are the operations (tactics?) going from one step to the next step? How to identify and represent steps beyond rewriting? Which steps can be done in parallel? What does the workspace for interactive construction look like? How does the (intermediate) state of a calculation or of a geometric construction look like? What about the un-do actions?

What are the aspects of logical frameworks for applied mathematics?

By 'applied mathematics', we mean mathematics as applied by engineers and as taught in secondary and tertiary education: given some items (meeting some 'preconditions'), one has to find some objects (related to the input items by the 'postcondition') – applying some knowledge already available, i.e., we mean a late phase within the 'problem solving cycle' [1].

How can the logical rigor established by computer theorem proving be transferred to applied mathematics (as defined above)? What can be guaranteed by a single stepping system for applied mathematics? What can such a system say about a single step input by the user (correct, incorrect, misleading, etc.)? How can the proof of the postcondition be as close to a particular calculation or a geometric construction? What proof-assistant is most appropriate for which system?

Which concepts and components can be exchanged?

The two preceding questions indicate that the very fundamental research questions arise. Such questions cannot be answered in one year and serious answers can only be given in cooperation with the existing academic networks (See A.3.1. below).

However, two of the project partners have already done the preparations for concrete work and roughly identified concepts and components of two projects: ISAC (a transparent system for applied mathematics [2]) in Graz, GCLC (geometry constructions – LaTeX converter [3,25]).

This roadmap has answered some of these questions: What projects in South-Eastern Europe are similar to these three projects? What concepts and components can be exchanged between the projects for mutual benefit? Can some software tools for interactive calculations, geometric constructions, or dynamic geometry be linked together
A3. State-of-the-art

According to the background of the partners within this roadmap, we divide the discussion of the state-of-the-art into two parts; however, we are aware that the real challenge is the interdisciplinary context between these two parts.

A3.1. State-of-the-art in computer mathematics

Interactive computer theorem proving can be estimated as a well-established academic discipline with widely clarified foundations and well-established technologies (See, for instance, Isabelle [5] and Coq [6]). Considerable portions of mathematics are already mechanised in these systems, e.g. [7]. Even usability of user-interfaces is under consideration [24].

Mathematics applied in engineering and education, however, is not concerned with the proving, but with calculating and graphic data presentation. Such calculations in commercial algebra systems lack a logical framework, guaranteeing the correctness of results. Several projects, e.g., Focal [8] or Axiom [9], are well underway towards the verified math tools, i.e., guaranteeing correct results of calculations.

Furthermore, single stepping systems are under commercial development, e.g., [10], and much ongoing research considers and develops such systems, e.g., [11], [12], [13].

Mathematical knowledge management has become another relevant research area under the umbrella of an academic interest group [14].
Relevant activities of project partners:

The ISAC-project, located at IST TU Graz, developed a prototype of a 'transparent single stepping system for applied mathematics' [2]. This prototype is characterised by three features: it (a) pinpoints open research questions, (b) provides a considerably large portion of mathematics knowledge in a preliminary XML-format, and (c) is ready for field tests with those components, which have been clarified already.

The GCLC project, located at the University of Belgrade, is aimed at integrating a dynamic geometry tool with a geometry theorem prover [3,25]. This gives a system that can be used for mathematical education at various levels and on various layers. Geometric notions and objects are visualised and their properties can be formally verified.

At the University of Belgrade, there is also a 'multimedia technology for mathematics and computer science education' group (MTMCSE), successfully generating online textbooks [15], particularly using JavaView [26] and GCLC.

These three projects/groups have roughly identified common research topics in the field of computer mathematics; and they have identified technologies and components of their respective systems appropriate for collaboration.

All other partner-universities in this roadmap incorporate institutes of mathematics with dedicated interest to cooperate in re-engineering algebra systems to single stepping systems.

A4. Anticipated benefits and relevance of the project

Preparation of cross-border collaboration on eLearning

At least three projects of partners within this proposal, ISAC, MTMCSE, and GCLC, already have identified common technologies and components of their respective systems appropriate for collaborative development. Several more of such collaborations can be expected. We are also looking forward to joint proposals for the European funding agencies, with the joint R&D as a follow-up at the European level.

Networked promotion of knowledge and technologies in computer mathematics

One of the fields in computer science, where Europe is actually leading worldwide, is the field of computer theorem proving. This proposal considers theorem proving technology at the fundament of future eLearning systems in mathematics.
The prover with the largest body of mechanized mathematics, Isabelle ([5], developed in Cambridge and Munich), has been introduced to South Eastern European academia in a 4-day workshop on Isabelle [27]. Isabelle’s worldmap [17] clearly shows the demand for continuing such efforts.

Our project strenghtens the participation in respective European networks like MKM [14], Calculemus [18], and others.

**Preparation of field tests on eLearning in various cultural contexts**

The high standards of education in mathematics in former communist countries from the tertiary level down to the secondary level are well acknowledged; in the respective institutions, there is still another cultural approach to mathematics – quite different from the Western Europe, where research results testify, for instance [19], that the announcements in vocational training restrain the naming of ‘mathematics’, although they actually involve mathematics.

The envisaged tools for eLearning promise to make mathematical rigour a concern of well-founded mechanization (inherent to mathematics), rather than a concern or authority. The partners within this proposal will prepare for field tests in different institutions and in different countries.

In particular, the envisaged tools promise to contribute to novel approaches to life-long learning, and mathematics tools show little concern with cultural issues (which may easier be met). Such tools have the potential to provide a continuum between high-school math, math education at universities, and math research at the international level. Anybody learning elementary math should be able to have a look-ahead to what could come later on.

**A5. Contribution to EU policies and EU integration**

This proposal, beyond the objectives defined by the call for 'Research Cooperation and Networking', particularly contributes to two major research themes addressed by the Seventh Framework Programme: (1) Information and Communication Technologies (ICT), and (2) Socio-Economic Sciences and the Humanities (SSH).

The issues of ICT are addressed by laying foundations (computer theorem proving) for innovative interactive math systems in the context of learning, even life-long learning. The system(s) envisaged in follow-up R&E-projects are 'personalised ICT systems', based on 'digital mathematics content management'.

The issues of SSH are addressed by preparing R&D of tools for 'education and life-long learning', the preparations being aware of various cultural approaches to mathematics education in different countries (Western versus South Eastern Countries, still coined by Lomonossov University), being aware of gender issues,
particularly vivid in computer-based mathematics education.

References and urls:


[4] [http://www.mathweb.org/omdoc](http://www.mathweb.org/omdoc)

[5] [http://isabelle.in.tum.de](http://isabelle.in.tum.de)


[13] [http://www.leactivemath.org](http://www.leactivemath.org)

[14] [http://www.mkm-ig.org](http://www.mkm-ig.org)

[16] www.w3.org/Math


[23] www.mathweb.org/omdoc


