

DAAD-Sonderprogramm "Akademischer Neuaufbau Südosteuropa" im Rahmen des Stabilitätspakts Südosteuropa

Application for the Project: „Multimedia Technology for Mathematics and Computer Science Education “

1. Overview

We apply for financial support for a University cooperation of our faculty groups at the mathematics institutes of Freie Universität Berlin / Zuse Institut Berlin and Technische Universität Berlin with faculty groups at the faculty of mathematics at the University of Belgrade, the Mathematics institute of SANU (Serbian Academy of Sciences), the faculties of Sciences and Mathematics, Mechanical Engineering and Occupational Safety at the University of Niš, the department of Mathematics at the University of Sofia and the department of geometry at the University of Technology and Economics in Budapest.

Key aspects of the cooperation are

- Knowledge transfer in the field of multimedia technology in education and research in the fields of Mathematics and Computer Science
- Establishing of local competence centers in multimedia technology and their cross linking in a network
- Development and use of new multimedia content and software for Mathematics and Computer Science education

For example, the cooperation includes the use of 3D visualization tools in Mathematics and Computer Science education, the development of interactive course material and electronic books, as well as the continued upgrading of the local infrastructure to host scientific web services and publications at the participating institutions.

Based on the success of the previous project, where we established a local competence center at the University of Belgrade and Mathematical Institute of SANU, we are confident that the structures being developed in this project will have a long-term impact on the improvement of the education and research at the participating Universities and through multiplier effects at other institution in south east Europe (SEE).

2. Previous Activities

The project extends an existing cooperation „Development of Electronic Information Infrastructure and Multimedia Courseware“ initiated by K. Polthier and B. Wegner between TU-Berlin and the University of Belgrade / SANU, which was funded by DAAD in the framework of the Stability Pact South East Europe during the period 2002-2003.

A report about the previous project is attached to this application.

Within the previous project the Berlin group helped to setup a local competence center in Belgrade for multimedia technology, supported the creation of a local infrastructure (hard- and software) and gave courses on the use and development of multimedia courseware. Also, the group at the University of Belgrade and the Mathematical Institute of the Serbian Academy of the Sciences and Arts (MI-SANU) has been further developed as the main competence center in the region for mathematical information infrastructure. Nowadays it hosts mirrors of the European Mathematical Information Service (EMIS) as well as the bibliographical mathematics database ZMATH. Furthermore, local editorial offices actively provide input for both EMIS and ZMATH.

The success of the previous project with Belgrade is mainly due to the fact that a large number of students and assistants were motivated to learn new technologies and take an active part in the development of new material. For example, within the previous cooperation between Berlin and Belgrade we obtained the following results:

- Development and completion of a fully electronic textbook in analytic geometry
- Internationalization of JavaView software to Serbo-Croatian language
- Integration of multimedia software tools in Berlin and Belgrade
- Development of mathematical information infrastructure in Belgrade to host mirrors of major information services.

3. Aims of the Project

The major aim of the project is setting up competence centers in multimedia technology in Mathematics and Computer Science at the participating Universities in south east Europe. Especially through the motivation and active participation of assistants and students, additional to the participating professors, we plan to setup a broadly supported and long-term focussed competence in electronic multimedia technology. Professors of the project will incorporate the developed courseware directly in the curriculum at the participating Universities.

The cross-linking of the competence centers in Belgrade and Niš with groups in Hungary (Budapest) and Bulgaria (Sofia) will strengthen the cooperation of the participating Universities in south east Europe and complement the current bilateral cooperation with Berlin. Additional to the international cross-links we will present the developed infrastructure to other groups in Yugoslavia during a final project workshop. Special focus also lies on the involvement of different groups at each University.

The project will not start from scratch but incorporate and integrate existing software projects already developed at the participating Universities. A strong role will be the use of the awarded multimedia software JavaView developed in Berlin. This software allows online visualization and numerical computations and has proven its usefulness in many electronic publications, like mathematical web-services, the online magazine PLUS or the multimedia book on Analytic Geometry developed in Belgrade in the previous project. Beside the integration and localization of software packages we will create re-usable modular software applets to multimedia courseware in the mentioned scientific topics.

4. Scientific Aspects

The scientific activities of the project are related to the three areas of 1. Visualization applied to research activities such as differential geometry, non-linear dynamics, special functions, and computer science, 2. Multimedia courseware for Mathematics and Computer Science and 3. Electronic publications and databases for communicating Mathematics.

Visualization in Research Activities

All participating groups are experts in differential geometry and many of them are developing and using interactive software. Therefore Geometry is a good starting field to bring new technology into the classrooms of south east Europe. Each participating group in SEE has proposed a set of topic to be investigated and visualized for University courses. Additionally each group will apply the developed multimedia tools to their own field of expertise.

- Visualization in differential geometry (Berlin, Belgrade, Budapest, Niš, Sofia)
- Algorithm visualization in computer graphics (Niš, Berlin)
- Discrete geometry of polyhedral surfaces (Belgrade, Berlin)
- Classic and basic q-hypergeometric functions (Niš)
- Modelling chaotic dynamics using neural networks (Niš)
- Geometry of skew-symmetric curvature operators (Sofia)
- Crystallographic groups in Euclidean and non-Euclidean spaces (Budapest)
- Geometric problems in mechanical engineering (Budapest)

Multimedia courseware for Mathematics and Computer Science

Multimedia courseware is the heart of modern teaching material and distant learning projects. Early visualization tools required specialized hardware while modern web-based tools will be usable by all students from any place of the world including from home. In this project we will base the development on established software components and adjust the modules to the specific needs of the scientific topics.

- Extension and English translation of the electronic book “Analytic Geometry” developed within the previous project (Belgrade, Berlin)
- Development of electronic course material for teaching special functions (Niš)
- Writing an e-book on modelling of chaotic dynamics using neural networks (Niš)
- Interactive programs for visualization of geometric transformations and projections for teaching CAD and descriptive geometry (Budapest)
- Crystallographic groups in 2D and 3D, visualization of their orbifolds and fundamental domains (Budapest)
- Courseware in elementary and differential geometry (Sofia)

The developed courseware will simultaneously be used within regular University courses.

Electronic publications and databases for communicating Mathematics

The developed courseware and electronic modules such as Java applets must be viewed within the scope of mathematical publishing. Here our activities will ensure that the developed material is consistent with long-term archiving and searching database. In cooperation with Zentralblatt für Mathematik we will develop meta-tags for mathematical applets in the same way as it was done for electronic geometry models.

- Development of meta tags for mathematical applets (Berlin, with Zentralblatt)
- Archiving and searching applets in electronic databases (Belgrade, Berlin)

5. Planned Activities

The activities of the projects planned for the year 2004 consist of the following components:

- Introductory Seminars on “Multimedia Technology for Mathematics”
- Development of Multimedia Courseware
- Mathematics Knowledge Management Infrastructure
- Integration of multimedia content in existing mathematical databases
- Guest Visits and Project Meetings

Introductory Seminars on “Multimedia Technology for Mathematics”

The transfer of multimedia competence and the involvement of the local staff is an eminent prerequisite for the success of the project. Based on the experience of the previous project we will immediately give seminars at all participating institutions in SEE.

Three week-long seminars on „Multimedia Courseware for Mathematics and Visualization“ will be given by a colleague from Berlin at each of the participating universities. The seminars will introduce the students, assistants, staff and professors to newest multimedia technologies and provide hands-on experience. A special focus lies on the task to enable students and assistants to develop multimedia content on their own.

The seminars are a key component of the project to transfer know-how and initiate local developments. It is intended that at a later stage of the project the local staff will itself offer such seminars to the next but one generation of students.

Within the seminars we will also strengthen the electronic infrastructure and setup mathematical web services based on webMathematica and JavaView on the web servers of the institute. These services will

not only be useful for the scientific education and research of the institutes but also provide a sample implementation and can later be extended by local activities.

Development of Multimedia Courseware

The project requires modern software tools for the use and creation of multimedia courseware. This includes interactive visualization tools capable of integration with web browsers, database software as server based backend system, and tools for setting up mathematical web services.

The JavaView software developed in Berlin has turned out as a flexible software component which smoothly integrates with standard Mathematics software like the computer algebra packages Mathematica, Maple and MuPAD as well as the original software WinGCLG written at the University of Belgrade. The open software API of JavaView also enables the easy creation of new mathematical online applications.

The software WinGCGL developed in Belgrade enables the easy creation of static and animated 2D graphics, and their inclusion in TeX documents. The 2D integration of WinGCLC with JavaView will be extended to allow full 3D integration. Both packages will be connected with software from Budapest and Niš within this project. A special module for descriptive geometry will be added to WinGCLC.

The electronic textbook on Analytic Geometry developed in the previous project will be improved and extended. For example, additional applets for descriptive geometry will be added. The book will also be translated to English.

Database software is required to store and access larger documents, such as electronic mathematical textbooks, dynamically from through a web interface. The local database developments in Belgrade are the server-side backend of the electronic geometry book and will be further developed for the needs of the present activities. For example, the search functionality of the database will be extended to make applet descriptions searchable.

In the previous project the groups from Belgrade and Berlin have demonstrated how to link these different multimedia software tools to build an interactive textbook on analytic geometry. In the new project we will make the software components more general to allow the easy inclusion of new content for the purpose of individual courses in university education as well as for the creation of self-contained multimedia books. For example, the project partners in Niš and Budapest will develop interactive courseware in differential geometry using the developed modules.

The group in Niš will study the modeling of chaotic dynamics using neural networks. The goal of this research is a development of a software toolbox for nonlinear dynamic system modeling given a time series of observations which will be accompanied by the electronic book with the same title. It will support reconstruction and prediction of chaotic dynamics applying well known classical tools and algorithms and adaptive systems, especially artificial neural networks.

A multimedia textbook with graphical representations of special functions will be developed in Niš. Special functions are interesting objects for visualization because of their complexity and unforeseen behaviour. Our particular attention will be devoted to the study of classic and basic q -hypergeometric functions, the visualization of their zero sets in the complex plane and their parameter dependence. For this purpose, we will use JavaView and Mathematica package. The results will be prepared in the form of online presentations.

Mathematics Knowledge Management Infrastructure

In the previous project, the Belgrade group at the University of Belgrade and the Mathematical Institute of the Serbian Academy of the Sciences and Arts (MI-SANU) has been further developed as the main competence center in the region for mathematical information infrastructure. It hosts mirrors of the European Mathematical Information Service (EMIS) as well as the bibliographical mathematics database ZMATH. Furthermore, local editorial offices actively provide input for both EMIS and ZMATH.

Within the current project, the focus will be on helping to share this competence with the other regional partners in Niš, Sofia and Budapest and thus to encourage networking in the vital areas of mathematical knowledge management. This will entail both knowledge transfer and the preparation of larger initiatives and projects for the future.

Integration of multimedia content in existing mathematical databases

The online geometry textbook developed at the University Belgrade in the previous project contains, in particular, more than 150 interactive applets written in JavaView. As a matter of fact, these applets are independent entities which are potentially reusable in other contexts and learning environments.

The present project will focus on embedding the existing materials into electronic repositories with the goals of accessibility and interoperability with other existing learning technology. For this purpose, the present material will be further developed by providing metadata sets for the textbook elements, which can be used for embedding them into data repositories conforming to international standards such as the IMS Digital Repositories Specification (cf. <http://www.imsproject.org/digitalrepositories/>) with the help of available toolkits for this purpose (cf. <http://www.imsproject.org/tools/>). For example, the meta-tags developed for Java applets will make applets searchable in databases of electronic textbooks.

Guest Visits and Project Meetings

The visits of participating professors and especially assistants will support the knowledge transfer of electronic technologies and the realization of individual scientific projects. In the first year 2004 we are applying for bilateral visits from and to Berlin from the participating groups in south east Europe (SEE).

We also plan a **coordination meeting** of project leaders which will take place in autumn 2004 in Belgrade. The coordination meeting is necessary to synchronize the joint activities and establish the network of competence centers at an early stage of the project.

1. K. Polthier and K. Hildebrandt will visit Belgrade/Niš, Budapest and Sofia. The visits are intended to enable discussions on the scientific topics of the cooperation and on various issues related to the development of multimedia tools and mathematical web services. A one-week seminar will be given at each University to provide hands-on experience for students and assistants in multimedia courseware.
2. B. Wegner and A. Perovic visits to Belgrade, Budapest and Sofia are related to the development of knowledge management infrastructure for Mathematics.
3. There will be a visit of two colleagues from each participating university in SEE to Berlin. Each visit will be a week. The colleagues will report about the ongoing developments of the project in their home universities and will discuss new developments. These visits are essential to synchronize the joint activities and to develop new content.
4. There will be two visits from Budapest and Sofia to the coordination meeting in Belgrade (autumn 2004). Polthier and Wegner will synchronize their visits to Belgrade mentioned in 1.) and 2.) to happen during the coordination meeting.

In autumn of the second year 2005 we plan a joint **2-day workshop "Multimedia Technology for Mathematics and Computer Science Education"** in Niš to bring all participating scientists together and to present the archived results. The faculty of Mathematics and Science and of Mechanical Engineering have agreed to host the workshop.

Beside the presentation of archived results the workshop will provide a forum to develop further plans towards a long-time cooperation of the project partners and an extension of the network. For example, we will also invite scientists and a small number of selected assistants / students from other Universities of the former Yugoslavia for participation.

We apply for the following funding related to the 2-day workshop:

5. Support for four visits from Berlin (Polthier, Wegner and two assistants) and each two visits from Budapest and Sofia to the final project workshop in Niš in autumn 2005. The participation of the group from Belgrade will be supported by the University of Belgrade.
6. Support is also applied to enable participation of up to 10 selected assistants / students from other Universities of the former Yugoslavia.
7. Support for the local organization of the workshop.

6. Financial Support

Travel: The main part of the financial support is related to guest visits, the coordination meeting and the final project workshop. Detailed explanations are given in Sections “Guest Visits and Coordination Meeting” and “Project Workshop in 2005”.

Hardware Equipment: We apply for a notebook and beamer including webMathematica software for each of the four participating Universities from SEE. This flexible equipment will enable multimedia based courses in all standard seminar rooms without the need for expensive built-in equipment. We consider the hardware equipment essential for this project.

Student Position: The central visualization component and class library is JavaView. Here we apply for a student position in Berlin to help with the programming efforts related to the necessary adjustments needed in this project. The student will also assist with the translating of the user interface to Hungarian and Bulgarian languages. The translation to Serbo-Croatian language was done within the predecessor project.

Project Workshop: The final workshop of the project in autumn 2005 requires travel support for the groups from Berlin, Budapest and Sofia. The group from Belgrade is supported by the University of Belgrade. The workshop will be organized by the group at the University of Niš. We apply for some financial support to help with the organization and to enable the participation of a selected number of assistants / students from other Universities of the former Yugoslavia.

7. Impact

Relevance

- Knowledge transfer in the field of multimedia courseware for teaching and research
- Development of multimedia supported courses and new learning scenarios
- Interactive and experimental learning

The knowledge transfer in the field of multimedia technology for scientific research and University education enables the participating groups in SEE to establish and use newest technology in their University education and scientific research. During the project runtime staff and students of the department will become competent in the use and the active development of multimedia courseware. Students will be able to use the courseware for interactive and experimental learning. The departments will become able to establish multimedia supported course plans and new learning scenarios.

Longterm Aspects

- Broadly supported multimedia activity in each participating group
- Cross-linking of competence centers within south east Europe

The projects are broadly supported by local members of the participating faculties. For example, the active participation of staff and students in the development of electronic courseware will provide a good chance that the archived multimedia competence will persist beyond the runtime of the projects. As we are currently seeing in Belgrade, the staff members are already giving courses to involve the next generation of students.

The linking of competence centers within Serbia and with other countries in south east Europe will offer the chance to reuse the developed modules and to export multimedia competence.

Academic Quality

- Continued development of University courses, interactive and experimental learning
- Visualization in Mathematics and Computer Science education and research
- Additional qualification of students and praxis relevance
- Access to electronic publications and courseware

The acquirement of multimedia competence offers many opportunities to continue the development of traditional University courses. Students will have the chance to work with interactive and experimental courseware. The practical development of courseware at the participating institutions will also provide an additional qualification. The scientific research will greatly benefit from the archived competence in visualization tools, for example, some of the planned projects already focus on the use of visualization tools.

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