

SelMa – New Perspectives for Self-guided Learning in Teaching Mathematics at Senior High School Level

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Keywords: classroom teaching, curriculum change, learner-centred learning, open flexible learning, secondary education

Abstract: How can new media make the teaching and learning of mathematics more exciting? How can school prepare for lifelong, self-guided learning? It is questions like these that the project ‘SelMa – Selbstlernen in der gymnasialen Oberstufe – Mathematik’, which is supported by the Federal Republic of Germany and the state of North Rhine-Westphalia, addresses. The aim of the project is to show ideas and possibilities for the ways in which mathematics can be taught if student activity and self-guided learning are supported, and how the idea of self-guided learning in general can be integrated into daily school routine. SelMa is run in close co-operation with schools.

1. GENERAL INFORMATION

The pilot project ‘Selbstlernen in der gymnasialen Oberstufe – Mathematik’ (SelMa) is one of 25 pilot projects taking place in Germany within the framework of ‘Systematic Incorporation of Media, Information and Communications Technologies in Teaching and Learning Processes’ (SEMIK). The aim of the SEMIK programme is to support the permanent integration of new media in all types of schools and at all levels. SEMIK includes various projects that make use of new information and communications technology. New media are to be integrated in teaching and learning processes and to help to put into practice innovative concepts of

teaching. The main focus is upon problem-orientated, self-guided and co-operative learning.

The four-year SelMa project, which is funded by the federal government and by the state of North-Rhine-Westphalia, started on February 1, 1999.

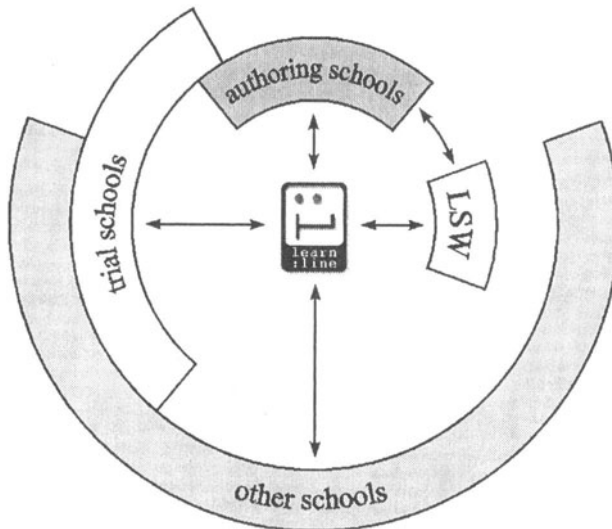


Figure 1. The SelMa structure

SelMa is monitored by the LSW (State Institute for School and Further Education). The aim of the pilot project is to show what teaching mathematics at senior high school level can look like if self-guided learning and activities are supported by the use of new media. Special importance is placed on integrating aspects of self-guided learning in everyday teaching.

Learning, mathematics and the use of new media – these are the pillars on which SelMa stands. Special emphasis is placed on the delivery of the new curriculum for mathematics, which focuses upon aspects of self-guided learning and must be integrated in everyday school life. The purpose of SelMa is to give teachers orientation and impulses for their own teaching.

Scenarios and materials for self-guided learning phases in teaching mathematics at senior high school level are being developed in five 'authoring schools'. These learning arrangements are accessible for teachers for trial purposes on the North-Rhine-Westphalian web-site 'learn:line'. learn:line provides an information, communication and co-operation environment for this purpose. Pupils can contact a 'teacher on demand'. learn:line also encourages the exchange of information and experiences between teachers, and initiates discussions with experts.

The development of materials by the authoring schools is to take place in an ‘open workshop’, so that other schools can also try out them at an early stage and regularly report on their own experiences. A special role is played by ten ‘trial schools’ which systematically try out and evaluate the materials which have been developed to see whether they work in everyday usage. Their feedback will be incorporated in the on-going development of materials.

Furthermore, authoring and trial schools are to disseminate their practice so that networks of schools can be created in the different regions and the materials on learn:line can be further developed. In this way the scenarios will be used in an increasing number of schools. Publishers are to be included at an early stage. This is expected to lead to high-quality (offline and online) media which will support phases of self-guided learning in teaching mathematics.

2. IMPORTANT ISSUES

Based on the focus upon learning, mathematics and use of media, the pilot project addresses various issues. The work of the authoring schools is monitored by academics and experts. Some of the aspects of methodology that are pertinent to learning/self-guided learning are:

- Which topics are suitable for phases of self-guided learning?
- How must the topics be presented?
- What different kinds of support do teachers need?
- What different kinds of support do pupils need?
- How can progress in learning be monitored?
- How do pupils acquire and use their knowledge?
- How can knowledge be consolidated by means of intelligent practice?
- How are media used by pupils?
- How does the use of media improve the quality of learning?
- What off-line and on-line materials must be provided?
- How can communication between the pupils be encouraged?
- What kinds of support are requested?
- What role does a ‘teacher on demand’ play?
- What opportunities for co-operation exist?

These questions show the broad range of issues the SelMa pilot project addresses. The measures taken to qualify teachers so that they can profitably incorporate both the individual learning process and the use of new media in their teaching should not be forgotten, either.

3. WEB-SITE

The current state of affairs can be viewed on-line on the NRW educational web-site learn:line (<http://www.learn-line.nrw.de/angebote/selma/index.htm>). The web-site offers a wide range of opportunities for information, communication and co-operation in the fields of self-guided learning, mathematics and use of media.

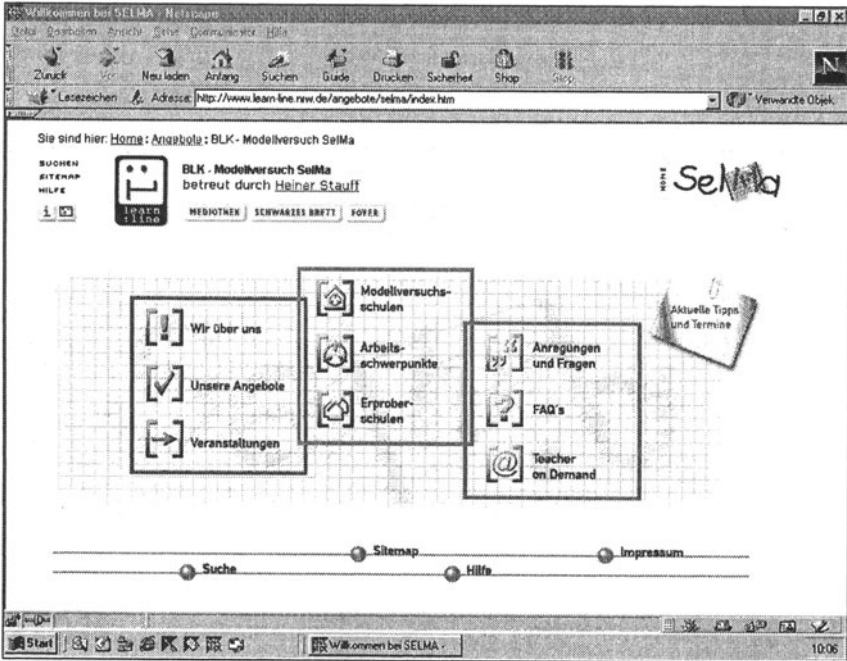


Figure 2. Home page of the SelMa web-site

The contents of the SelMa web-site are arranged in three blocks which are marked in different colours.

The left-hand 'red block' contains information which the SelMa-LSW team has compiled. This is where general information can be found on the pilot project as well as material on the topics of self-guided learning, mathematics, use of media. In addition to transcripts of talks, this section also offers references to literature, software and internet addresses.

The right-hand 'green block' offers a wide range of opportunities for communication which are supported by the 'teacher on demand'. For questions and suggestions relating to mathematics and self-guided learning

users can have a look at the FAQ section. Of course, users can also leave their own messages on a message board.

The 'blue block' in the centre is linked to information about and from SelMa schools. This is where the pilot schools present information on themselves and their projects. Up to now five authoring schools have developed projects for Year 11, and additional projects will be following soon.

4. PROJECTS

The self-guided learning scenarios and materials which are being developed by the authoring schools are at the core of the SelMa. Various models of self-guided learning have been used as a basis. Materials for use in self-guided learning centres, collections of exercises for use in everyday teaching, and suggestions and materials for learning at stations using different approaches are included. Each project is accompanied by a project description.

4.1 Materials for the independent learning centre

The work of a SelMa authoring team is closely related to further developments in their school. In an independent learning centre, pupils work on their own, on mathematical topics specified in the curriculum for Years 11 and 12. The material which is prepared for the independent learning centre consists of courses on the one hand and of collections of problems on the other. Graded aids for learning relating to the pupils' existing knowledge provide both food for thought and initial approaches towards solving the problems. Suggested solutions to the problems allow the learners to check the progress they are making. The computer provides opportunities for simulation and visualisation of mathematics.

Pupils normally meet in groups of two or three in the independent learning centre and discuss individual problems. The aim is for the individual pupil to establish as precisely as possible those areas where practice is most necessary. Under no circumstances must the pupil's personal speed of learning suffer from group pressure.

In practice it has been found that pupils can contribute a lot of help and suggestions when it comes to designing the materials. In further projects, pupils who are already experienced in using the materials should be involved even more closely as co-designers.

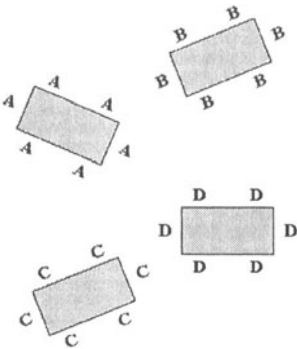
4.2 Group jigsaw puzzle

At one of the other authoring schools, a teaching unit on optimisation has been developed and tested. It focuses on mathematical modelling and working on problems involving extreme values. The teaching unit is divided into the following phases:

- Instructory phase
- First independent learning phase: partner work
- Second independent learning phase: learning by teaching (group jigsaw puzzle)
- Presentation and reflection phase.

What is particularly interesting is the approach of using group jigsaw puzzles for independent learning. The first phase involves individual familiarity with the mathematical problems, as far as possible. In subsequent phases, it is up to each individual pupil to pass on their knowledge and, on the other hand, the group aim is to ensure that at the end of the process all pupils involved have acquired the relevant knowledge.

Phase 2: experts



Phase 3: teachers

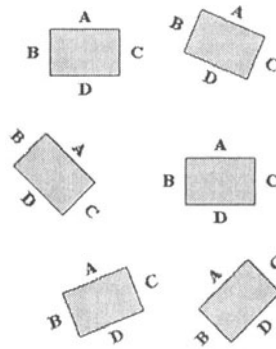


Figure 3. Phases 2 and 3 of the group jigsaw puzzle

In an initial phase, pupils work on the topic on an individual basis. In the second phase, a group of experts is set up. Any matters which are unclear are discussed and clarified. This is how the transfer of the knowledge is prepared. In the third phase, new groups are formed. Each pupil now teaches the topic which he or she has prepared. A computer algebra system allows pupils to work on new fields of teaching mathematics, whether in groups or with a partner. The work rate varies from one group of partners to another. The lessons plan has been designed for Year 11.

It has been shown that the teacher's main function is to initiate the individual learning process, to explain what needs to be done, to organise the formation of groups and to ensure that the time schedule is kept to. The degree of teacher control is reduced increasingly, and the pupils take on responsibility for their own learning process.

4.3 The collection of exercises

Another authoring team has developed a 'linear optimisation' learning plan for co-ordinate geometry. Through the learning plan pupils study a mathematical optimisation procedure and at the same time revise the concept of linear functions they were taught at lower secondary level. The learning plan links new material with what the pupils already know in order to guide them step by step towards assuming responsibility for their own learning. It is important that the problems dealt with are relevant to real life situations in order to emphasise the relevance of mathematics in general to real life situation.

In this project, the interests, speed of work and the different learning paths of the pupils are accommodated. Pupils are not told to work through the materials in a given way. They practise the meaningful use of graph plotters and computer algebra systems, which visualise mathematical concepts. It has become clear that the use of computer algebra systems does not always have the desired effect, especially in the case of the weaker pupils, i.e. supporting their confidence in their own solutions and calculations through graphic representation and through easy ways of checking their own work. It has been found, in particular, that many pupils have very little experience with more open and complex problems when they first enter the senior high school level. They seem to have rarely been working on mathematics problems in groups. Obviously, in the past, they have hardly given any thought at all to their own learning strategies, to how they take in knowledge and solve problems.

4.4 Learning at stations

The project 'Learning stations: higher order quadratic functions' focuses on the revision and development of aspects of co-ordinate geometry, and pupils also study new subject matter individually. Here, too, the importance of problems relevant to real life situation is stressed. In this project, individual learning is particularly supported by having pupils study materials at different learning stations. The complete learning circle consists of 21 stations, which are assigned to four thematic areas. The stations are set up in such a way that different background levels of learning, different speeds of

learning and working, and different needs in terms of working individually, in pairs or in groups, are accommodated.

There are compulsory and optional stations. To help pupils find their way, they are given a 'docket' which lists all the stations (number; title; topic; compulsory or additional station; individual, pair or group work). Different media are used at different stations, e.g. the Derive computer algebra system, or the TI-89 calculator (which can show graphs), but also worksheets or index cards. The tasks are usually activity-orientated, such as a jigsaw puzzle or a physics experiment. Teaching covers 6 to 8 hours, which take place at the stations using different media. The main function of the teacher here is that of an advisor and co-ordinator. The authoring team has found that the opportunity for and necessity of pupils checking their own work and taking their own decisions as to which station to use has increased the responsibility they take for their own learning and their awareness of their own strengths and weaknesses. The difficulties which have been found to occur, when this type of teaching was used more frequently, lie in the extremely time-consuming setting up of the individual stations and the organisational problem of setting up a suitable room in the school for a longer period of time. However, putting up the problems in HTML form may have solved the first problem to a great extent.

5. LEARNING DIARIES

In the pilot project pupils gain experience with keeping diaries. One authoring school has already gained experiences with regard to the use of personal learning diaries as a supplementary method in teaching mathematics at senior high school level. Compared with team-related learning diary, this type has demonstrated two strengths. On the one hand, pupils continuously reflect on their progress in terms of the subject matter, and on the other hand, this method allows very personal diary entries about the pupil's progress in learning – provided the learning diary is read only by the teacher.

In an introductory session, during which the pupils were also given a corresponding leaflet, it was explained to them that the learning diary should contain all the important aspects of the lessons in condensed form and, in each case, the pupil's reflections on his or her own learning process. After each three-months period, the learning diary was assessed by the teacher and formed part of the general assessment of the pupil's performance in class. During the first semester of the school year the keeping of the diary was compulsory, in the second semester it was voluntary. Almost half of the class made use of this method in order to monitor their own progress. The

web-site within learn:line presents and documents 25 exemplars from diaries in the six fields of reflections on lessons, aha-effects, individual explanations, self-assessment, analyses of mistakes, and further issues.

So far experiences have shown that the keeping of a learning diary has a permanent and positive effect on the learning process in mathematics at senior high school level if pupils accept this method. We therefore recommend leaving the decision to the pupils. The pupils clearly pay more attention to the learning process, try to answer questions immediately (rather than waiting until the last possible minute before the test), and are far more aware of their own strengths and weaknesses when studying mathematics.

The personal learning diary encourages pupils to reflect more on their own learning strategies. Without exception, pupils who had been using this method for some time gradually displayed more stable and better performance in mathematics compared to that at the beginning of the school year. The learning diary supports comprehending and solving mathematical problems. It increases medium and long-term retention and can relatively easily be incorporated in normal everyday teaching.

6. SYSTEMATIC TRIAL AND EVALUATION

Experiences from SelMa so far have been based primarily on the work done by the authoring schools. Teachers who have developed the methods and materials have tried them out in their own lessons, as well as other teachers in the same schools have been used them in other courses.

One aspect of particular interest to the pilot project is how the knowledge and experiences from the authoring schools can be disseminated to other schools. The results have therefore been documented and made available to all schools via the SelMa web-site within learn:line. In this way, schools that are interested can profit immediately from the work that has been done. Furthermore, it is one objective of the pilot project to identify the pre-conditions for effective dissemination.

Therefore trial schools have been included in the pilot project. It is their task to try out and evaluate systematically the methods and materials that have been developed. The knowledge and experiences gained from these trials will be incorporated in subsequent developments. The trial schools exchange information with the authoring schools.

In-service teacher training has already been recognised as one major factor. On the one hand, teacher training takes place ‘face to face’ in meetings, and on the other hand, issues of whether or how in-service training can be supported by ICT, in particular by the NRW web-site learn:line, are also addressed within the pilot project.

7. FUTURE PROSPECTS

Initial projects for Year 11 have now been developed. All the schools involved are highly interested in further exemplars and materials – in particular with regard to topics which have been newly included in the senior high school curriculum. It is here, in particular, that they see a good opportunity to include new methods and materials. The pilot project must address the issue of how other schools can be integrated. The experiences made with the trial schools are pertinent to this in particular. One has to think about how the present groups of schools can be developed into larger networks of schools and how such networks can be supported both effectively and efficiently. Another issue that needs to be addressed is how the prototypes of off-line media and on-line materials developed within the pilot project can be made available to schools outside the project. The aim is to co-operate closely with producers and publishers of media. It is hoped that thus the prototypes can be developed and distributed further in a more efficient and effective way.

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BIOGRAPHIES

Since 1990 Wolfgang Weber has been working in the Advisory Centre for New Technologies at the State Institute for Schools and Further Education of North-Rhine-Westfalia, Germany, as a manager of several projects in the field of new media in education, and Head of Centre.

Kristine Fankhänel has been working in the fields CBT, authoring systems, hypermedia and multimedia, and the internet. Since 1999 she has been working at the State Institute for Schools and Further Education of North-Rhine-Westfalia, Germany, and coordinates the project ‘Self-guided Learning in Teaching Mathematics at Senior High School Level’ (SelMa).