Abstract
In this paper we present an approach of enriching grown structures of teaching in German schools with innovative technology and collaborative software tools. Two applications for collaborative modelling and mind mapping will be introduced. Together with a community of secondary school teachers we have elaborated classroom experiments which give an added value but without redefining well suited pedagogic methods or changing the learning matters. We will present different experiences made by teachers and researchers in the domains of mathematics, biology and German language in secondary schools. We have found out that not only teachers in science are interested in computerised learning scenarios but there are several premises for a successful transfer of technology into schools.

1. Introduction

In the last years, several programmes were conducted in most industrial countries to achieve a complete connection to the Internet for schools. But just providing the technological environment does not mean that this potential is put to a good use and enhances instruction in schools. There is even the danger that the established educational goals of school instruction are obscured behind a veil of technological features, devices, and problems: e.g. a teacher trying to fix networking problems in the computer room of the school instead of conducting the planned Internet recherche with the class. So our perspective for using computers in instruction at schools in the SEED project is to move the computer out of the focus of attention and to enrich instruction with computers where appropriate. We do not want to let the technology redefine pedagogy but want to preserve the style of instruction teachers are used to, with all their individual capabilities and characteristics.

The main questions for that approach are: How can added value be gained by usage of computers and interactive media compared to conventional instruction? How to use the technology in a way as unobtrusive for all participants (pupils, teachers and schools) as possible? The latter question is answered by us by the use of devices that preserve the usual style of instruction without requiring a disruptive change of media when using interactive technology, for example the use of interactive electronic conventional whiteboards which provide all the possibilities conventional chalk boards do, or the use of pen-based tablets instead of the usual exercise-books.

Added value gained by the use of information technology is for example the unrestrained availability of notes taken during class, which can be stored persistently, whereas notes on the chalk board are usually lost after the lesson was finished. A more profound enhancement can be achieved by the use of computer-based simulation and modelling tools, which can be used creatively and interactively as an addition to conventional instruction, where real experiments (e.g. in physics or chemistry) are either too dangerous, expensive, or just not practical. In this paper we will present such tools for the enhancement of instruction, our experiences in practical use and the perspectives we see for the future.

2. Collaborative mind tools and media

Simulation and modelling tools are called collaborative mind tools when used by a group of participants, be it pupils or teachers, together in a co-constructive way with shared goals. These tools bring together two lines of using computers for instruction.

On the one hand "the computer as enabler of group activities", that is computer systems provide technological facilities for spatially and/or temporarily distributed learners, where the focus is more on technical problems of message exchange and not so much on structure and meaning of representations created during collaboration.

On the other hand "mind tools", which are software systems providing interactive learning environments where "computational objects to think with" are created and used to express oneself intellectually and artistically, which complies with Dewey’s notion of expressive media [1]; the student manipulates visual objects whose representations can be computationally processed - a typical example for these "visual languages" [3] are languages for argumentation, where different contributions, such as question, proposal, counterproposal have distinct visual representations and the structure of resulting arguments can be interpreted.

Within collaborative mind tools both of these lines are combined into an environment, where "computational
objects to think with" are created and manipulated in collaborative, distributed settings supported by a technological infrastructure. In the following chapters we show how those tools can be used in school scenarios.

3. Modelling with visual languages in shared workspaces

Cool Modes ("COllaborative Open Learning, MOdelling and DEsigning System") is a platform and tool environment to facilitate co-constructive activities. It offers a shared workspace environment allowing the co-learners to synchronously and jointly elaborate external graph representations based on visual languages [7]. The main difference between Cool Modes and other comparable tools like Sepia [9] or Belvedere [10] is the approach of adding semantic structures to flexibly and externally define co-operative visual languages without assuming a given specific domain semantics for the overall system.

Generalising this aim from the viewpoint of visual languages leads to "partially formal" languages in which some objects have a specified domain-related functionality and semantics, enabling the system to provide e.g. special tools, means of analysis or domain-related support, mixed with other elements that represent generic aspects of the environment (e.g. discussion statements).

The main function of the system component structure is to facilitate the handling of varying visual languages. The environment is able to manage several workspaces represented in different windows. This offers the possibility to have private and shared sessions simultaneously or to clearly separate independent collaborative tasks. Each workspace can contain a number of transparent layers which can have "solid" objects like e.g. handwriting strokes or images. Similar to the workspaces, layers can be private or shared. A typical use case for this is a private handwriting layer used for personal annotations.

Within the European SEED project (IST-2000-25214), new forms of using digital media in classrooms are tested with groups of associated teachers in different countries. This endeavour is based on the premises that we do not want to introduce new computer orientated content but work with the given curriculum. We do want to maintain, maybe enrich, each teacher’s grown teaching style and preferences. Together with each of the teachers, we want to establish richer and more integrated forms of using interactive digital media in the classroom. Now we present some classroom examples conducted with our tools in the course of the SEED project.

4. Modelling with System Dynamics

The system dynamics visual language is in use for several activities with students in school and university [8]. It provides basic support for modelling and simulating system dynamic models. By using different types of relations, the flow of information and the current flow of values between the objects ("stock", "rate" and "constant") can be distinguished. A user interface for the simulation is integrated, containing buttons to control the simulation of the model.

Modelling is an important aspect of science learning that is often neglected in school lessons. One reason is a lack of motivation on the part of pupils that often can be observed caused by the models abstractness. The system dynamic language has been used under the topic "sustainable usage of resources". This topic is designated for secondary school students at the age of 18 in their 12th grade in biology courses.

Using modelling environments pupils can understand many mathematical models that natural sciences deal with. With the system dynamics language in Cool Modes the pupils additionally can construct models in a cooperative manner. Although they need further instruction for difficult models, the pupils were able to construct simple models on their own from the very beginning (Figure 1). To build up a model concerning a special problem they started with finding elements and their dependencies just by trying out different approaches. After this phase different models had been presented to the whole group and finally the pupils tried to construct a model in a collaborative session which fits best to the problem.

Compared to the fact that students of biology in secondary schools are usually not very interested in learning abstract models, they were very engaged during the modelling process with the system dynamics environment. Being asked about the benefit the students...
answered that they found constructing models collaboratively more motivating than simply reading about a model in a book or listening to the teacher explaining a model.

5. A visual language for studies of elementary probability

The visual language for stochastics has been developed in close cooperation with a secondary school teacher. It is designed for modelling experiments to explore a variety of perspectives and principles of probabilities. There are different types of urns representing possible data input, e.g. a dice, a calendar, numbered or coloured balls, etc. There are relations performing drawing with or without replacement, data collectors to store the results, and display elements as a table or a bar chart where the order of drawing can be considered or neglected. An experiment can be executed automatically (and optionally repeated several times). All types of stochastics problems based on urn models can be modelled and explored in an empirical way. To support collaboration results of experiments in stochastics can be displayed in a table shared by the pupils (Figure 3).

![Figure 2 Parts of the visual language for stochastics](image)

![Figure 3 Shared model for the "birthday experiment"](image)

In Cool Modes, we focus on the transformation of a concrete problem into an adequate model, i.e. from experimenting with real objects like urns or dices, a model can be explored and the experiment can be simulated. Creating and carrying out such virtual experiments the software supports handwritten notes, visualisation, organisation and sharing of the results. The children can prepare a discussion and reflection of their experiences to “solve” the original problem. This could be done by analysing the empirical data or by building up and formulating mathematical rules. During school lessons, the software is used as a tool to simulate a high amount of experiments, offering a visual language to construct and control the experiments, facilitating the exchange of the settings, the examination and the sharing of the results through common objects or workspaces.

The stochastics environment has been tested in a class of 9th graders. Beginning with easy models (throwing of dices, drawing coloured balls from an urn), the pupils got familiar with the software and could fresh up basic knowledge from further school years.

The main topic of the course has been the classic “birthday experiment”: »How often does the event “at least one common birthday” occurs in a group of n people?«. First the pupils had to elaborate an adequate model in Cool Modes to explore the problem. The stochastics environment provides a calendar urn, i.e. a representation of 365 days. A basic model was found using this urn and draw 24 times with put back.

The following experimental work was arranged in small groups. To share the outcomes between the groups we used a common object in form of a table for group wise reporting to prepare the computation of the relative frequency over all experiments.

In a second scenario we made use of the experiences with this “birthday-microworld”. The pupils had to modify it to explore the number of group members to which the probability for “at least one common birthday” is 50 percent. Now they had not only to analyse and count positive outcomes but decrease or increase the group size. This time the pupils should report their outcomes permanently via a shared table. So each group could make use of all reported outcomes and alter its proceedings. We tried to examine how this collaborative setting influences the proceedings of the groups or the class itself? Actually it was very difficult to observe such feedback effects – enough reason to do further research.

In an comprising lesson the empirical results were compared with the actual probability which was computed using the complementary event “no common birthday”. During the whole course we made constantly use of an interactive board to structure and document our
Further lessons will follow concerning “lotto problems”. Therefore adjustable objects to filter automatically the rare positive outcomes were added to the palette. Collaborative settings will enrich the self-determined exploration of the underlying mathematics.

6. Further classroom experiences in other domains

Based on Cool Modes and a similar more text-oriented tool “FreeStyler”, we have collected further experiences in classrooms with a group of teachers interested in exploring new forms of media use in their lesson practice [6].

6.1. The FreeStyler environment

FreeStyler tool [4] technically bases on the same platform as Cool Modes. It provides a modified user interface to support an organisational learning approach which puts the emphasis on creative meetings and its outcomes and the incremental building of a group memory. It serves primarily as an interface between face-to-face discussions and the documentation process, but it can be used during multiple working phases as preparation, creative meetings, presentation, post processing or wrapping up information. This is enabled by a cooperative visual language which offers a set of content objects to structure information. A content object combines a symbolic view with predefined interactions. It can be characterized as a template for a special type of information as ideas, concepts, decisions, addresses or internal and external links. Whereas several content objects rather define the category of information, others, i.e. the links, provide additional structural information and interaction features. Together with these content objects users can add handwritten input flexibly. Methods as concept mapping, mind mapping or MetaPlan are easy to perform with the FreeStyler. The external representations both enrich and influence the communication.

FreeStyler files are page-based “maps”. Internal links structure the common representation. User definable external hyperlinks can be used to point to and to access related files. To arrange the objects and to integrate handwriting comfortably, layers are available that can be faded out independently. Regarding to the documentation approach the system offers retrieval and indexing functions. Also keywords can be assigned to maps. The maps are stored in XML. In order to exchange the maps an integrated mail function can either send snapshots of the pages or the XML file as attachments. Built-in filters allow for separating types of information in order to focus on special aspects as decision or ideas.

6.2. Cooperative elaboration in drama analysis

To provide lessons about a German drama [2] a secondary school teacher has elaborated a scenario together with a member of our project team using the FreeStyler application. The topic is dedicated to pupils at the age of 16 years in their 10th grade.

Using the schools’ own computer room which is usually used by natural sciences this was an interesting new experience for the teacher and the pupils. After the drama had been introduced in former lessons, the teacher planned a whole day lesson for the computer supported scenario. In the first hour the pupils learnt to handle FreeStyler and solved a short task for practice. In the following two hours the pupils had to work on a task concerning the drama. The class was split into four main groups of approx. six pupils. Each main group was divided again to devise a strategy both for an accusation and a defence plea for the main characters in the drama. For every micro-task a separate cooperative workspace was opened in FreeStyler. Every group worked in their own workspace but had the possibility to watch the work of the others. This influenced the argumentation because “defence” and “accusation” teams knew each others arguments immediately. The teacher also took benefit from this scenario: Starting her own FreeStyler instance she was able to look into the workspaces of the different groups not only for information but also to decide whether a group needs help or not and how the different arguments were elaborated.

In the fourth hour the groups presented their carefully designed results to the whole class. In the plenary discussion their arguments were easy to understand and analyse because of the structured representation. Storing all the produced data on a central server made it easy to distribute and to re-use it for added value: The teacher herself was able to evaluate the results at home and she could easily assemble the most important results to continue with in the next lesson.

6.3. Teacher’s feedback

We try to elaborate and establish mechanisms to disseminate the experiences of our teacher community. Feedback is given permanently by the teachers concerning the usability of the tools which are developed and adapted for the teachers’ needs. Concrete scenarios are developed for the use of Cool Modes and FreeStyler in secondary schools. The teachers are supported technically and conceptually to implement the scenarios in their daily school life. In this way an empirical base for usability evaluation of the system can be created.
From the teachers’ point of view, it will be a problem to convince schools and responsible administration to establish hardware infrastructure needed for practical work with Cool Modes or FreeStyler. But the software can be used also with basic equipment, such as pen based input device, in an effective manner.

An alternative to a special computer room or a computer integrated classroom [5] is the use of Cool Modes or FreeStyler together with a notebook and a data projector in a normal classroom scenario. Pupils can alternate in creating models and representations and the results can be visualised for all participants in a suitable manner.

7. Conclusions and perspectives

Cool Modes as a tool to facilitate co-constructive modelling activities includes a wide range of visual languages that can be used in secondary school teaching (Figure 4), e.g. for stochastics, system dynamics, turtle graphic for learning Java, and Petri nets for synchronisation of parallel processes. Conventional modelling tools do not have the possibility of a synchronous information exchange between learners and teacher. The tools we presented in this paper are suited for a structured presentation of results and provide synchronous information exchange for collaboration based on a replicated architecture [11]. Another important advantage in comparison with the use of a conventional chalkboard is the reusability of results. Furthermore, all pupils can work with their own copy and complete it as desired.

Pedagogical innovation is found in facilitating a rich repertoire of learning styles and increasing engagement, motivation, and self-determination on the part of the students. The ability and the willingness of the students to work self-dependent and to support each other combined with detailed working material allows not only dealing with slightly different tasks but also the split of the class. While the one part experiments the other parts can discuss problems in detail or draw conclusions from their observations or results being supported and stimulated by the teacher.

In our future developments, we will support the associated teachers with new material in different subject areas. But even more importantly, we will support schools in setting up an intranet based infrastructure to exploit the full potential of distribution and reusability of digital material created.

References