

## "LeActiveMath" – a new innovative European eLearning system for calculus contents

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**Abstract:** *This contribution gives an overview of the project "LeActiveMath". Within this project a new mathematics learning software has been developed.<sup>1</sup>*

*LeActiveMath is an innovative eLearning system for high school and college or university level classrooms which can also be used in informal contexts for self-learning, since it is adaptive to the learner and his or her learning context in many respects. Topics cover elements of basic knowledge like 'linear equations' as well as more sophisticated contents like 'differential calculus'. This article describes some of the innovative components of the software that are meant to support the students' self-regulated learning.*

*We conclude by reporting on the first evaluations in math classrooms in fall 2005.*

**ZDM-Classification: D34, C74, D64, I40**

### 1. Introduction

Significant efforts have been made in order to develop and improve learning technologies, whereas most of them attended to isolated tools. Among those are search and highlighting tools, exercise back-engines and even modelling or mind mapping tools<sup>2</sup>. Though this means that a wide variety of tools is offered to the user, many tools, such as computer algebra systems (e.g. Derive, Maple) or function plotter (e.g. maths online function plotter), are nevertheless restricted to the application in specific branches of mathematics. Therefore, other approaches deal with the integration of several tools in one system. Though those systems differ a lot from

each other on the first view, many of them have some common bases, e.g. they employ a hypertext structure and contain search facilities.

What are the benefits of such integrated systems?

One common aspect is that the presentation of contents in a non-linear hypertext-structure facilitates the integration of those contents into the cognitive structure in the learner's mind. This in turn is based on the perception that the organizational structure of the human memory is a semantic network, similar to the one underlying the learning environment (Tergan, 2002).

Other reasons for hypertext or hypermedia learning environments that do not refer to the learner and his cognitive structure relate to the domain (for further details see Tergan, 2002) or the target learning outcomes. Such learning environments are reasonable, when self-guided, open and constructive learning shall be offered, a multi-modal mental representation of knowledge as well as cognitive flexibility and knowledge transfer abilities shall be supported (Issing, 2002).

This statement has to be considered within its framework of a learning theory that values the acquisition of strategic knowledge, general problem-solving skills and especially the abilities to assure a successful life long learning a lot. Within this context, *adaptivity* and *interactivity* are considered to be important criteria for the quality of a software system.

Adaptive systems are able to take different situations, prerequisites and preferences of learners into account and thereby allow for an individualisation of learning processes. They allow for more efficient learning leading to a connected web of knowledge. This was shown for an adaptive choice of the difficulty of exercises as well as for an adaptive introduction of new concepts tied to previously acquired concepts (Leutner, 2002).

Interactivity is, as Jacobs (2005) elaborates, a requirement for following such principles as self-regulated learning and learner-initiative. "The ability to choose navigational sequences, interact with solutions, modify parameters, and create graphs are examples of an approach that encourages student-centred learning." (Jacobs, 2005, p 763).

<sup>1</sup> A demo-version is available: <http://learn-calculus.activemath.org/ActiveMath2/>

<sup>2</sup> <http://www.cognitive-tools.com/>

That the question of the ideal form of interactivity is not only a question of the quantity but also of the quality of interactions is stressed by the way Issing and Klimsa (2002) explain interactivity, as an altering dialogue initiative between human and computer as well as between humans via a computer network. Nevertheless this leaves many open questions such as, what the right way and degree of interactivity may look like. How little or how much guidance do students need?

Unfortunately most of the evaluations still today concern the effectiveness of specific tools in even more specific learning contexts only. Others aim at giving evidence to multimedia design principles.

Attempts to see whether findings that hold for non-interactive learning environments are transferable to interactive ones have been made by Mayer et al., (2003). They found evidence for the *interactivity principle*<sup>3</sup>, i.e. that students understand a multimedia explanation better, when they are able to control pace and order of the learning contents on their own and for the *self-explanation principle*, i.e. students learn better when they are prompted to provide explanations during learning. In an experiment some of the subjects were given prequestions to work on during the following session with a software whilst others were expected to explore the contents of the software freely. In a problem-solving transfer test conducted afterwards the prequestion group generated significantly more answers than the control group did.

In general, supportive effects of different media can only be expected in instances where the media are located close to each other with respect to time and place. In that case it is additionally supportive to guide the learner's attention. Quite generally, positive effects on the learning outcome turned out to depend a lot on the learner's familiarity with different representational formats. Under less favorable terms, addressing different modalities can as well result in a cognitive overload, for the balancing of the different sources of information may draw too much cognitive capacity from the learner and may thereby hinder his processing of

the new information (cognitive load theory, Sweller, 1994).

As explained by Tergan (2002), most problems appear as a lack of orientation (besides the just mentioned cognitive overload).

In this article we present the new innovative eLearning system LeActiveMath as one example of an integrated system. It aims at supporting students within different learning contexts, in classroom as well as in homework settings to deeply understand new concepts and to grasp procedures. To foster students' learning processes actively, self-guided and self-reflected learning is supported. We consider its pedagogical foundations and the underlying competency model<sup>4</sup>. In particular, we report on how conclusions drawn from the above mentioned issues on guidance and interactivity were incorporated in the development of the system. We conclude by reporting on the first evaluations in math classrooms in fall 2005.

## 2. The project "LeActiveMath"

### 2.1 Overview

The project LeActiveMath financed by the European Union<sup>5</sup> started in 2004 and terminates at the end of June 2007. Eight universities in Germany, the Netherlands, Spain and the UK and three private companies are working on the development and evaluation of a user-adaptive and interactive eLearning system for mathematics.

The technological approach to the pedagogical goals described above insists in the development and improvement of various components such as the advanced (open) student model or new interactive tools. Finally, these advanced tools are integrated into one open distributed system which is applying a semantic knowledge representation (Melis et al, 2003, 2006).

### 2.2 Workflow

The tasks in the project are organized in workpackages. In addition to six technological

<sup>3</sup> This term was used by Mayer et al., 2003. As this principle also applies to non-interactive multimedia environments a name as "self-control principle" would seem more appropriate.

<sup>4</sup> For a (detailed) description of competency models see Klieme (2004).

<sup>5</sup> LeActiveMath is one of the three Specific Targeted Research Projects selected in the first call of the 6th Framework Programme Information Society Technologies, key action Technology-Enhanced eLearning (FP6-507826).

packages, there is one workpackage on the production of content and an evaluation workpackage. There also is a dissemination and an administrative workpackage.

The former ActiveMath system served as a basis for developing the new system. Of course the work on LeActiveMath had not been enclosed by the time of the first evaluations in fall 2005. But a sufficient amount of content had already been authored and the development and implementation of the different novel components was already sophisticated enough for a first evaluation aiming at the improvement of the system and on questions about the overall acceptance etc.

### 3. The software "LeActiveMath"

The current version of the software already compasses most of the components that were planned to be integrated, such as interactive tools (function plotter, search facility, Computer algebra system), the user model or the tutorial component with the course generator (cf. Section 3.3). Altogether the contents compare to calculus textbooks of approximately 500 pages, in each of the available languages English, German, and Spanish.

#### 3.1 Theoretical background

The software LeActiveMath is based on a learning theory, which draws on modern brain and mind research (Issing, 2002; Weidenmann, 2001) and states that learning processes can only be initialized by learners themselves, i.e., by their active operation with certain topics or concepts (Duffy and Jonassen, 1992). Hence, the learner plays an active role in his own learning processes and is responsible for their outcome to a major extent. Therefore the LeActiveMath system aims at supporting students in structuring their learning activities and developing strategic competence. In other words, the various features and components have to serve the overall target that students become autonomous and self-regulated learners.

First of all, this framework affects the selection and especially the presentation of the content. Secondly the question arises, how the system itself should be designed to support individualized and self-regulated learning, e.g. how much guidance will still be necessary. This second issue has consequences for various system components, such as the course

generator (cf. Section 3.3) or the user interface (cf. Section 3.4).

Concerning the first issue, the content ideally contains exploratory tasks and allows for sensible (inter-)activity. As not only concepts but also strategies (metacognition skills, etc.) have to be acquired, the selected topics must be presented in a way that takes this aspect into account. The following quotation is almost in line with this direction but adds the idea to emphasize on contextualized knowledge:

“The intention is to encourage an approach to teaching and learning mathematics that gives strong emphasis to the processes associated with confronting problems in real-world contexts, making these problems amenable to mathematical treatment, using the relevant mathematical knowledge to solve problems, and evaluating the solution in the original problem context. If students can learn to do these things, they will be better equipped to make use of their mathematical knowledge and skills throughout life. They will be mathematically literate.” (OECD, 2004, p 40)

To follow this approach we developed and applied a competency model, geared to the one of the PISA consortium. This model consists of eight competencies and four competency levels. The competencies are (see also Niss, 2002 and Klieme et al., 2004):

- Think mathematically
- Argue mathematically
- Solve problems mathematically
- Model mathematically
- Use mathematical representations
- Deal with symbolic and formal elements of mathematics
- Communicate and
- Use aids and tools

Two of these competencies may serve as examples and are therefore described in more detail (for characterizations of the other ones see Niss, 2002):

*Think mathematically* includes the ability to

- pose questions that are characteristic for mathematics (“Are there ...?”, “How does ... change?”, “Are there exceptions?”)
- understand and handle the scope and limitations of a given concept
- make assumptions (e.g. extend the scope by changing conditions, generalize or specify, with reasons)

- distinguish between different kinds of mathematical statements (e.g. conditional assertions, propositional logic)

*Model mathematically* includes the ability to

- translate special areas and contents into mathematical terms
- work in the model
- interpret and verify the results in the situational context
- point out the difference between the situation and the model

Similarly we defined the competency levels

- L I: Computation at an elementary level
- L II: Simple conceptual solutions
- L III: Challenging multi-step-solutions
- L IV: Complex processings.

### 3.2 Foundations of the adaptive and adaptable features of the system

In order to allow for an adaptable, resp., adaptive selection and presentation of learning materials, the content in LeActiveMath was not designed and written as a complete course with a fixed number and order of learning objects. Instead, the whole content is a priori a (huge) database of learning objects (the *knowledge base* of LeActiveMath, cf. Fig. 2). In order to enable the system to extract from this database a reasonable number of learning objects and present them to the learner in a meaningful order, every learning object needs to be characterized by metadata<sup>6</sup>.

Instances of metadata are the type of the learning object (e.g., definition, theorem, example, or exercise), its presentation form (e.g., verbal or visual), the typical learning time, and the difficulty (where appropriate, i.e., for examples and exercises). Besides, we also introduced pedagogical metadata such as the intended learning context (e.g., high school), the field of interest, and the aforementioned competencies trained by examples and exercises as well as their competency levels. In order to allow for an assembly of learning objects in a reasonable order, the metadata also compass relations between learning objects, e.g., conceptual or pedagogical dependencies, like the fact that in calculus, the sum rule should be

introduced before the product rule. Using all these metadata in the knowledge base, the system is able to react adaptively on learner requests, e.g., for material according to a certain competency or field of interest. The system can suggest the learner which steps to do next, etc.

All the metadata were rated by another person, independent from the author, and are verified continuously through the number of processings and judgements of the element in the sessions.

Nevertheless, being designed as a flexible system with a wide range of usage, LeActiveMath is not only an adaptive but also an adaptable system. In particular, certain possibilities to adapt it, such as the facility to choose only certain parts of the content or to modify parameters on the learning context, were implemented. Such adaptation leads to a reduced clearer content and thus increases the efficiency.

The content can be obtained in the form of predefined books or of individually generated courses (cf. the next section), whereas the latter is the adaptive version. Those courses are arranged clearly, oriented on certain learning situations and goals the users are aware of. Pedagogical rules stipulate the structure of the course, e.g. the place to put an example. As examples have the potential to foster self-explanations (cf. Renkl, 2001) this is a prominent place. Furthermore the courses prompt the learner to look up his user model and to reflect on his learning process. Within some of the courses tools and features are introduced step by step and systematically in the contexts of their reasonable applications. According to the cognitive load theory (cf. Sweller, 1994) the separate application of tools may save the student's resources such that he/she can concentrate fully on understanding that specific tool or the concept he/she is expected to learn. The exercises and examples are chosen automatically and individually with information drawn from their metadata and the user model.

### 3.3 Course Generation

In order to outline the process of course generation we focus on two of the components of LeActiveMath: the *course generator* with its pedagogical basis and the *user model*, cf. Fig. 1 (for further information on the other components see Melis et al, 2001).

<sup>6</sup> A set of metadata is a set of data to characterize an object. E.g. topic, element type, presentation type and difficulty could make such a set.

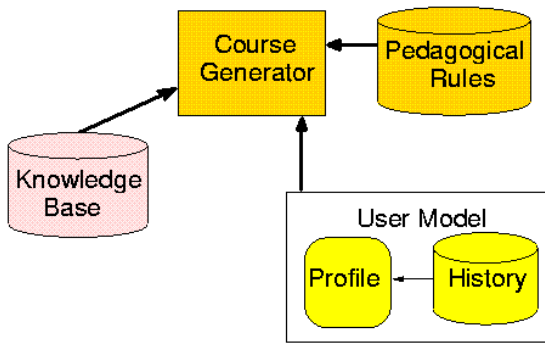


Fig. 1: A part of the LeActiveMath architecture

The *user model* has to draw a precise picture of the learner and serves as storage for all the data concerning the user. When a learner logs in for the first time, prior to all other steps, he/she has to enter the registration page and answer some questions, e.g. on his/her learning context and familiarity with the application of computers in general. This information (the *user profile*) is

used to initialize the user model. Through the learner's sessions the user model stores data about the pages that have already been visited by the learner, on his/her success or failure with solving exercises, and on the time needed for each task. This whole data collection, the *user history*, supplements the profile to complete the user model. Obviously, the metadata of the corresponding learning objects play an important role here: e.g., the impact on the user model from a successfully solved exercise differs with the difficulty of this exercise.

After the registration the learner is directed to the main menu of LeActiveMath. It contains a table of contents where all available prerecorded "books" are listed. Alternatively, the user can enter the course generation process and create own adaptable books. This process includes several steps where the student has to decide on the concepts he/she wants to learn and on the *scenario* (cf. Fig. 2).

Le Math Active

Main Page | Search | Notes | My Profile | Tools | Print | Logout | Help

Book Creation: [Area](#) ⇨ [Type](#) ⇨ [Topics](#) ⇨ [Summary](#)

Step 2 of 4: Type

Please **select the type of book** you want ActiveMath to create for you. Whether you want to prepare for an exam or discover a topic in depth – choose the type of book from the list that best suits your needs.

Type of book:

- Discover:** This kind of book will contain content that **helps you to understand** the selected topics in depth. It will contain the prerequisites you still need to understand and it will be adapted to your knowledge state.
- Rehearse:** This kind of book **tackles your weak points** and will train your knowledge in these areas.
- Connect:** This kind of book **illustrates the connections** between the selected topics, adapted to your knowledge.
- Workbook:** This kind of book **contains exercises** that aim at increasing your current knowledge state.
- Train competencies:** This kind of book contains exercises that **train specific competencies**.
- Simulate an exam:** This kind of book contains **exercises that can be solved within a timeframe** selected by you. Like a real exam, the exercises will have different difficulty levels.
  - Simulate an exam, 30 minutes;
  - Simulate an exam, 45 minutes;
  - Simulate an exam, 60 minutes;
  - Simulate an exam, 90 minutes.

Fig. 2: Screenshot of the 2<sup>nd</sup> step of the course generation: selection of a scenario

Technically a scenario is a collection of rules causing a certain order of appearance of the types of content elements or inhibiting certain

types respectively in the generated course. E.g. a course *Connect* puts definitions and theorems central and applies a concept map tool to stress

on the relations between the objects. A course *Workbook* does not include any definitions or theorems but does only present the user examples and exercises. The rules in the scenarios are the operationalized version of the pedagogical rules. As was said previously, all the content elements are annotated with certain metadata like the difficulty or the representation type for exercises. The selection of content elements is based on those metadata. Thus, simplified, the pedagogical rules - and consequently also the operationalized rules - are as good as the metadata is. From the learner's perspective the result of the course generation is a course with some content elements adapted and structured according to the learner's needs and especially to his/her level of ability.

### 3.4 The Interface

Once the user has chosen some (predefined or individually created) book, he/she is lead to the content interface. The screenshot (Fig. 3) shows a sample page. On the left hand side (underneath

the logo and the book title "Highschool Content of ...") there is a content navigation bar with chapters and foldable sections and subsections. The small squares underneath the titles of the chapters and sections indicate the number of sections and subsections of the next layer respectively. The colours carry additional information about the learner's progress on that specific page. The colours range from red to green in a five point scale, which used to be a three point scale and thus applied the symbolic meaning of traffic lights. Due to students' complaints during the evaluations in fall 2005 that it took too long to get the colours changed, so this was revised. Grey boxes indicate that the user model has no information on the user's performance, e.g. because he/she has not visited that specific page yet.

Above the main window in the green bar there is a suggestion button in the form of a light bulb, appearing either yellow (suggestions for the next steps are available) or grey (no suggestions available).

The screenshot displays the LeActiveMath interface. On the left is a navigation sidebar titled "Le Math Active" with a "Highschool Content of LeAM\_calculus" section. The sidebar lists various topics, with "4.4 Derivatives of various functions" expanded to show sub-topics like "Computing the derivatives of various functions" and "Derivatives of various functions". The main content area is titled "Derivatives of various functions" and shows a lesson titled "The derivative of a triangle wave function". It features two graphs: the top one shows a triangle wave function  $y = f(x)$  on a coordinate system, and the bottom one shows its derivative  $y = f'(x)$ , which is a square wave function. Below the graphs, a text box explains: "We already know that the triangle wave function  $f$  drawn here is not differentiable at any even  $x \in \mathbb{Z}$ . In all other places, this function behaves like a linear function with slope  $m = +1.5$ , resp.,  $m = -1.5$ . Hence we obtain the following derivative function  $f'$ ." The interface also includes a top navigation bar with options like "Main Page", "Search", "Notes", "My Profile", "Tools", "Print", "Logout", and "Help".

Fig. 3: Screenshot of LeActiveMath "Derivative a various functions"

Further to the right (in white letters) there is the system's navigation bar. From there a learner can enter the semantic search, look up his profile or apply different tools, e.g. the function plotter. Still another line supports the orientation within the content containing the page title and the page number; here it is page 99 in a book consisting of 165 pages. And finally the main window provides the user with the content. The elements are separated by a thin horizontal line and are annotated with some symbols. Triangles with capital letters indicate the element type, e.g., E means "example". Clicking on the pencil symbol (resp., on the title of the element) opens an item menu in a new window, offering the opportunity to remove this element, to add a similar one, or to take a note, etc. The two stars indicate that this example is of difficulty "easy" on a five point scale from "very easy" to "very difficult". Finally, with the button "Your Opinion", available at the bottom of each exercise and example, the learner has access to a set of questions to judge this exercise or example.

### 3.5 Summary of the user's adaptive and adaptable options

The above sections have illustrated LeActive-Math as being a flexible system and we have given a brief outline on the adaptable and adaptive features of the system. Let us sum up some of the user options to adapt the system to his/her needs and to take advantage of the offered adaptivity, especially when creating own courses. Firstly, the course generation itself is adaptable, since the learner can, e.g., choose the type of book and its topic(s). But the course generation is also adaptive because it chooses the actual learning objects for this book according to the data in the user model. The user's book as the outcome of this process is again adaptable: the user can delete or add learning objects, he/she can change the format of the book (e.g., html or pdf, if he/she wants to print it), etc. Moreover, most of the books are even adaptive since they contain a number of dynamic learning objects that are inserted on the fly depending on the user model data at the time the learner first opens the according page.

Also, many of the other components (the search function, etc.) are both adaptable and adaptive. The objective behind is of course to help the learner to become a more self-guided learner via his/her continuous interaction with

the system.

## 4. Evaluation

As mentioned before two evaluation phases are planned in this project. The midterm evaluation was conducted in fall 2005 in schools and still endures in universities. In the school evaluation 107 students of five classes in three Bavarian schools took part. All subjects were 11<sup>th</sup> graders and therefore beginners in differential calculus. The final evaluation is planned for fall/winter 2006 and is planned as a larger assessment.

In the following sections we present results of the midterm evaluation.

### 4.1 Purpose and Design

The main purposes of the midterm evaluation were the following points:

- debugging of content and system
- check of the ease of usage
- investigation on issues of acceptance
- data collection on motivation with respect to the application of the system.

The design therefore consisted of different tests and questionnaires part of which were paper & pencil and others were online sheets.

We designed a questionnaire comprising sets of statements which examined the students' self-concept with respect to mathematics achievement, motivation and interest in mathematics as a paper & pencil instrument. The items, e.g. "I am good in solving math exercises" or "Because math is important to me, I like to do well in this subject", employed a four point Likert-style response format, ranging from *exactly to not at all*.

The students filled in this questionnaire before they had worked with LeActiveMath in the first approx. 10 minutes of their introductory lesson for the system. This questionnaire was filled again after the application of the software in five to ten math lessons<sup>7</sup>.

Three types of optional online sheets were applied. The exercise and example questionnaires were available during the session via the mentioned button "Your Opinion" placed at the right bottom corner of the specific object. Each of the questionnaires contained a set of

<sup>7</sup> This second questionnaire differed slightly from the first one: the last section asking students about their interest in other subjects/fields was omitted.

questions specific to the content elements "exercise" and "example". In addition, the first included questions on the input editor and the latter also addressed java applets. Examples of those items were "Using the editor was easy" or "The symbols I needed were hidden" and in case of an example "I liked this applet" or "I didn't really know what to do with this applet". Again the Likert-style had been used but in this case it was a five point scale.

We chose questionnaires especially on examples and exercise because we believed these to be those two types of content that are most significant to the process of understanding new concepts. In addition, from an author's perspective, exercises and examples may be designed in different ways with respect to their presentation and their complexity.

Finally a survey to be filled after the log-out was designed with a five point Likert-style response format, containing statements on the single components of the system to be judged, e.g. "readability of the texts" or "hints and assistance" (to be judged between *very bad* and *very good*), general statements as "The system is easy to use" (with answer options between *not correct at all* and *absolutely correct*) and again a section about the input editor.

In all online sheets space was provided for further comments. This was especially important for the detection of bugs and (qualitatively) for the investigation of the users' acceptance.

**4.2 Results**

The paper & pencil questionnaire prior to the intervention was answered by 107 school

students of grade 11. The means of the judgement of some of the questions are presented in Table 1 as standardized z-values - with 0 = disagreement and 1 = agreement.

In math lessons I especially like ...	M	S D
..., when a large amount of time is spent on understanding the topic.	.74	.252
..., when our teacher proceeds in very small steps.	.69	.256
..., when we do many similar exercises.	.62	.273
..., when we work on personal computers.	.60	.353
..... to do such exercises, where one can try something on ones own.	.49	.301
..., when we are informed of the development of computation schemes or the life of famous mathematicians.	.43	.287

Table 1: Means of students' interests in different activities in math lessons

Interesting points of that table are the slight dislike of "such exercises, where one can try something on ones own" and the comparatively big standard deviation for the computer item and the "explorative tasks item" mentioned before.

The results of the pre- and post-intervention judgements are presented in Fig. 4, whereas the table contains the means and standard deviations (in brackets), N=33.

Item	Pre	Post
spent time on understanding	0,75 (.250)	0,75 (.277)
proceeding in small steps.	0,69 (.249)	0,7 (.337)
many similar exercises.	0,58 (.292)	0,37 (.298)
try something on ones own.	0,48 (.313)	0,45 (.331)
personal computers	0,64 (.347)	0,47 (.373)
about life of mathematicians	0,42 (.315)	0,42 (304)

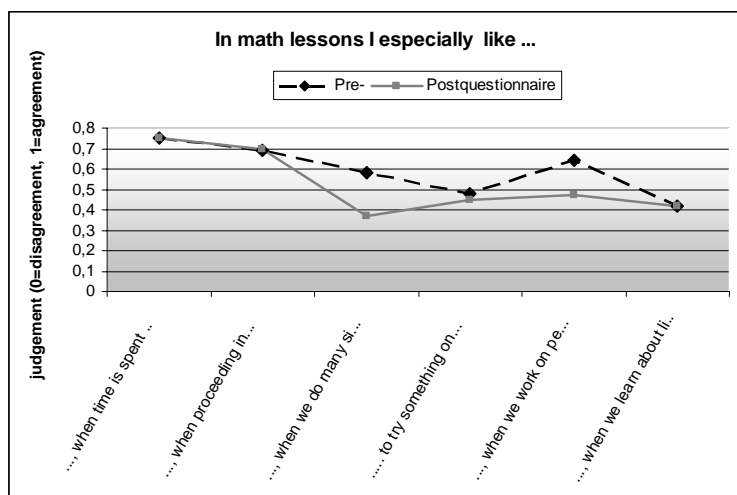


Fig 4: Comparison of means before and after the application of LeActiveMath

Two aspects are quite obvious. After having worked with the system for several lessons, the students consider doing innumerable similar exercises less interesting. But the interest in computer-based instruction decreases as well from pre- to post-questionnaire. To try something on ones own is not appreciated either.

The online survey generally resulted in the figures in Table 2. Due to the questionnaire being optional the number of responses was quite low and differs from item to item. The first two aspects *user-friendliness* and *contents* are summaries of sets of items, e.g. texts, pictures and applets in the case of the latter. Here especially pictures were judged good (mean 0.73). With respect to user-friendliness the ease of usage was appreciated but the system's reaction on input errors was not regarded to be tolerantly.

aspect	M	N	SD
user-friendliness	0,5 – 0,75	31/32	.250 – .300
contents	0,52 – 0,73	29 - 33	.200 – .300
assistance	0,31	32	.310
fun	0,55	33	.250
efficiency	0,4	33	.280

Table 2: Means of judgements for single components

For additional student statements see Groß and Moormann (2006).

### 4.3 Discussion and future prospects

As the standard deviations are relatively high in many cases the results have to be considered with care.

Regarding the results of the paper & pencil questionnaire a certain picture of the students' preferences in math can be drawn. E.g. it is noticeable that proceeding in small steps is valued considerably higher than trying something on ones own (explorative tasks). The assumption that possibly not all the subjects had a clear idea of the latter one is supported by the high standard deviation (.301). Nevertheless this could indicate a type of math instruction which

does not emphasize exploratory tasks. This result is also in line with findings from Jahnke-Klein (2001), that school students express a strong need for 'handholds' such as proceeding in very small steps or doing standard tasks again and again in math classes.

The disliking of *trying something out on ones own* still afterwards may be due to some problems with the systems stability during the sessions, e.g. the java applets were affected. The decrease in the interest to apply the personal computer in math class may be caused by similar problems. As an analysis confirmed this decrease had mainly appeared in only one of the classes, which was the one that had the most technical obstacles to handle.

We were pleased to see that *doing many similar exercises* lost importance for the students. It would be interesting to focus on the picture students develop about mathematics. A shift in the role of standard exercises induced by computer use has already been shown by Stewart et al. (2005). In a two-year experiment with a CAS supported university course the students' attitudes to computer use have changed from the first to the second years. According to their answers, the students tended to apply the computer more frequently in the second year and also the tasks changed from checking the results with the computer to doing standard exercises with it (Stewart et al., 2005).

The judgements of the systems components conducted by the school students uncovered two issues. The first one referred to the assistance. Our scaffolded hint system, which is supposed to provide the student with hints that include more and more details at every new request, had not been integrated by the time of the evaluation. Therefore students only received a general advice which was obviously not satisfying. In the final evaluation we expect better results for this component.

The other point is the individually perceived efficiency, which is quite low (0.4, between 0 = *very bad* and 1 = *very good*). A user manual within the system and a teacher training besides the application of the course generation are different approaches we follow now.

Though the results of this intermediate evaluation phase discovered the necessity of improvements on the system, it would be wrong to speak of the student as a general type with respect to his response behaviour. As the standard deviation indicates in many cases, there

are various types. And it will be quite interesting to address the different conditions and connexions within the response patterns with additional test instruments in the final evaluations.

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