An academic experiment on the use of computers in elementary school mathematics classrooms

Silke Ladel, Schwäbisch Gmünd (Germany)

Abstract: *The role of computers in elementary school math classrooms is still being determined. Although computers are promised effective visual tools to promote independent work and study, many educators neglect to use them. Since there are varying points of view, individual teachers generally decide whether to incorporate computers into their methods. Purpose: My experiment analyzes and quantifies the value of computers in elementary school math classrooms. Method: Over a course of 11 weeks, my first grade class worked with the teaching software "Mathematikus 1" (Lorenz, 2000). Using both interpersonal and video observation, I completed written evaluations of each pair of my students' will and ability to cooperate, communicate and independently solve mathematical problems. Conclusion: My results show that it is generally beneficial to use computers in elementary school math lessons. However, some elements of said software leave room for improvement.*

Kurzreferat: *Die Rolle des Computers im Mathematikunterricht der Grundschule ist keineswegs geklärt. In vielen Klassen wird der Computer nie genutzt, obwohl er besondere Formen des Lernens wie entdeckendes Lernen und selbstständiges Arbeiten verspricht und besondere Möglichkeiten der Visualisierung, Veranschaulichung und differenzierenden Förderung bietet. In der pädagogisch-didaktischen Diskussion finden sich sehr unterschiedliche Positionen zum Computereinsatz in der Grundschule; und je nach Einstellung der Lehrenden kommt der Computer zum Einsatz oder ist in den Klassenzimmern erst gar nicht vorhanden. Im vorzustellenden Projekt wurde der Einsatz des Computers in der Grundschule konkret an Hand eines Beispiels untersucht und bewertet. Über den Zeitraum von 11 Wochen wurde in einer ersten Klasse mit der Lernsoftware „Mathematikus 1" (Lorenz, 2000) gearbeitet. Untersuchungsschwerpunkte betrafen die Kooperation, Kommunikation, Selbstständigkeit und Leistungsbereitschaft der Schülerinnen und Schüler vor dem Hintergrund der Bearbeitung der mathematischen Aufgaben und Themenbereiche. Als Methoden wurden u.a. Videoanalysen und die Methode der Schülerbeobachtung im Unterricht eingesetzt. Die Ergebnisse deuten auf Hinweise für einen geeigneten Computereinsatz in der Grundschule und auf Vor- und Nachteile von bestimmten Softwarekomponenten hin.*

ZDM-Classifikation: U70

1. Objective

The main emphasis of my experiment is on observing and analyzing how pupils relate to using computers and the math-specific software, "Mathematikus 1", as classroom learning tools.

Key questions were:

- Do the pupils *cooperate* with each other while working on the computer? How/in what way?
- Do the students *communicate* with eath other? Is the communication friendly or competitive? Do they discuss mathematical topics, and if so, what initiates their dialogue?
- Do the pupils work *independently*, or do they frequently ask their teacher for help? How do the children handle the PC, its software, and how do they proceed concerning objectives?
- Does working with computers influence the students' *commitment* to completing the lesson? How do their concentration and motivation develop over the duration of the full academic experiment?
- How successfully do the pupils grasp each core *mathematical topic:* number concepts, addition/subtraction, rules and legalities of sequences, word problems and multiplication tables? Which mathematical problems do they solve easily vs. which tasks create consistent confusion? Where is additional help requested? Do unusual features appear in the software, and if so, where?
- Does the exercise of using the computer or the repetitive nature of its software visibly improve or strengthen students' *mathematical abilities*, and if so, which ones?
- Do the pupils access the software's built-in *help* option, and if so, are they able to use it successfully?
- What attributes and drawbacks do the pupils and their teacher identify in the *program "Mathematikus 1,"* and would said instructor recommend it for future use?

2. Method

This academic experiment on the use of computers in elementary school math classes was conducted during the second semester (February 15th through May 3rd) of the 2005 school year.

2.1 The location and population

At the time of the experiment, the German elementary school, Greutschule Aalen in Ostalbkreis, had approximately 450 pupils, sectioned into three or four parallel classes per grades 1-4 respectively. The school is located in the town center and can be described as a focus school due to its catchment area. The first grade class in which the experiment took place originally consisted of 20 pupils. It was a partially integrated class, including six students with special needs who were taught separately for two topics --math and German-- only. In turn, the subjects of this experiment were limited to the remaining

14 math students, plus an additional pair: A second-grade girl, repeating first-grade math from the beginning of second semester 2005, worked in tandem with another female student who was borrowed from a parallel first-grade math class to participate during the hours of the experiment. In total, the 16 subjects included eight boys and eight girls. Prior to the experiment, the students' in-class exposure to computers was limited to three full-sized PCs, located at a work station in the back of the classroom. The teacher had incorporated said computers into the class' weekly schedule throughout the school year in an effort to lower the inhibitions of those students who did not have access to computers at home. For this experiment, however, each pair of pupils shared special laptop computers, selected specifically to foster cooperation and communication.

2.2 The laptop computers

Since 2004, the university, PH Schwäbisch Gmünd, has earmarked 31 laptop computers[1] for academic use, research and study in every subject. Today, several experiments document their application in repeated high-school drills (Kittel et al. 2005). Eight of these laptops, that are fast and easy to transport, served as the primary tools for this exercise. Their small keyboards proved very user-friendly for the young subjects. The laptop computers can also be operated via an external mouse, scaled down to fit smaller hands, or a pin as shown in figure 1. Other accessories included an attached CD drive and set of headphones with two earpieces for each student pair to share.

Figure 1. Laptop computer with pin function

2.3 The teaching software, "Mathematikus 1" (Lorenz, 2000)

The program starts automatically upon insertion of the CD-ROM. Students are initially asked whether to load a stored score or else begin a new game. When students are instructed to choose the later, a story begins:

"You are in the town of numbers. An old professor has invented a machine here which keeps the whole town running. One day, a chaotic goblin alters the machine so that the lights in the town of numbers go out, and nothing works." (Lorenz, 2000) (Translated)

The software subsequently enlists the students' help to restore the machine and save the town of numbers. Every building in the town of numbers (p. figure 2) corresponds to a mathematical lesson:

Figure 2. Town of numbers

Each button on the machine connects to a different one of the 14 total buildings by a corresponding cable. Students must click the specific buttons to select the following mathematical categories:

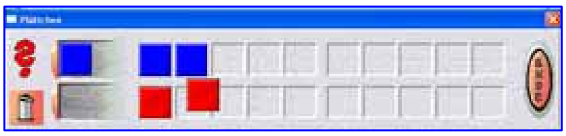
- Number ray
- Calculate with money
- The time
- Larger/lesser/same
- Amorous hearts
- Number pyramids
- Twenty pattern
- Circular slide rules
- Word problems
- Numbers and sample sequences
- Mini multiplication tables
- Number houses
- Fast mental arithmetic
- Reflections

Once the pupils solve five mathematical problems, the lights go back on in the corresponding building. If subjects successfully complete a full problem set for a building, then all of its lights will flash. The object of the game is to turn back on every light in the entire mathematical town.

A little professor assists students when needed in three steps: If a student gives a wrong answer for any given question, they will hear a special tone. The second time, a little professor appears to offer hints or the third time more detailed help towards the solution.

For some tasks, there are small plates available to aid in calculations (cf. figure 3).

Figure 3. Twenty pattern with helpful small plates



By a click a window opens and the red and blue small plates can be drawn on a twenty pattern. Through this the tasks can be visualized well. Lorenz, the software's author, explains in his accompanying book that it is better

[1] Fujitsu-Siemens Lifebook E7010, 15'' SXGA, IntelP4P-M, 1,7 GHz, 512 Mbyte RAM, 1x40Gbyte HD, DVD/CD-RW-LW, integriertes W-LAN-AC-Adapter, Maus

for children with difficulties to have at the disposal and to operate on selling these concrete putting materials. In addition, these small plates should be worked with also in the other course of the mathematics lesson so that the children know how they have to handle that.

There's a sheet of paper hanging on the right side of the machine. Students or teachers can click it to see, how many tasks they have already solved in each mathematical category.

Figure 4. Statistics newspaper in "Mathematikus 1"

Pupils can keep easy track of their progress by the number of blinking lights in each building.

3. Execution

This experiment started at the beginning of the primary school's second term, 2005, and spanned a course of 11 weeks. In respect to the importance of a first-grade routine, testing lessons took place once-a-week at a regularly-scheduled time: every Tuesday, after recess, from 9:35 to 10:20 am. In turn, the children could adapt and knew, just like the student R. said in the second test week:

"Right after recess, we may finally play with our laptop computers again!"

Note: The second lesson reflected an advantage of experience. The instructor was able to more easily distribute and set up equipment without rushing during recess. The subjects did the cutback under the instruction of the teacher at the end of the lesson.

4. Observation

In principle, there is to make a note that, in all effort of objectivity, every oberservation is affected of subjective perception. A margin of error exists in the difficulty of the quick and complex events of an entire first-grade classroom. To correct for this obstacle, both teachers accessed select video recordings of each testing lesson to more accurately complete evaluations.

In keeping with the main emphases of the experiment, instructors conceived three cores of observation:

1) Drawing upon Bartnitzky and Christiani (1994, S. 54f), the teachers focused on observing each pair of students' cooperation; independence (via problem-solving skills); communication (be it verbal, involving a third party, and under what circumstances); and overall willingness (a.k.a., motivation, interest and concentration) to use computers in the classroom; i.e., Did pupils cooperate to complete tasks, or did one of the partners "keep everything to himself?" Instructors discerned whether each pair of pupils completed each task as a collaborative unit or else took alternating turns. Finally, teachers recorded all altercations between participants. In a written evaluation, observers used this four-step scale: "not applicable", "barely applicable", "somewhat applicable", or "strongly applicable", marking each answer with an X.

2) Following the "handouts for monitoring the solving of calculations in primary school" from Hamburg's Office for Education and Sport (2003), a second written assessment rated all 14 mathematical topics presented in the teaching software in five categories: "number concept, addition/subtraction, rules and legality of sequences, mini basics and word problems." The quality of each mathematical exercise is divided into three analyses (as shown in table 1):

Number concept				
	Make counting mistakes	Check every point one by one	Uses the structure of the crowd	Other:
Twenty pattern				

Table 1. Clipping from the second observation sheet to the mathematical learning effect

3) The third written evaluation surrounded the teaching software, which stored comprehensive statistics, including where students experienced problems with certain tasks.

5. Results

The following details the pointed observations, made from both interpersonal and videoed surveillance of the subjects, for each of this experiment's main emphases:

Computers

The pupils approached these new teaching aids without inhibition. After delivering brief instructions on correct laptop operation and use, the observers could notice very quickly, that children, which had prior computer experience, assisted the others. Logging on with a password caused minor confusion for some since asterisks appeared in the place of letters and numbers on the screen's display.

As is typically the case in children of first-grade age, the students approached their computers with unbridled curiosity. Originally, all 16 children chose to operate their laptops via the mouse. One team of subjects was quick to uncover the keyboard's air pad. While one child preferred using the mouse, the other one used the air pad. Once a different student discovered the function of the pen in the final phase of this experiment, several other students gradually followed.

The use of headphones varied more markedly. Although one pair of pupils worked best without them, headphones helped some subjects cooperate (see figure 5) while causing conflicts in other teams.

Figure 5. Help with the headphones

Cooperation

In general, the pupils cooperated just as well as in their everyday classes with occasional quarrels outweighing joint success. In particular, the male team I. (m) /P. (m) cooperated extremely well while the female team G. (f) /A.-T. (f) preferred to parallel-work instead of solving problems together. This could be a function of their new environment as the second-grader, G., and her partner, A.-T.–a pupil from a parallel first-grade class; both joined this pre-existing class as outsiders. Gender did not appear to be a contributing factor as mixed teams (m/f). M.-L. (f) /S. (m) collaborated quite well, while integrated groups M. (f) /T. (m) and J. (f) /M. (m) argued more frequently. In particular, partners P. (f) /R. (m) transcended initial difficulties and ultimately worked well. Female subject P. mentioned laughing with her partner through the second half of the project after their teacher mistook a playful interaction for an altercation. "We are arguing only in good fun," student P. explained, admitting that a friendship had developed.

Communication

In most cases, working on the computers fostered natural communication between partners (Exception: team G. (f) /A.-T. (f) as noted above), limited almost exclusively to navigating the laptops, software, and the mathematical problems presented. Little communication was required to quickly solve the easier mathematical tasks. Students tended to be most vocal when celebrating the completion of restoring all the lights in any given building and the computer animation that ensued. Other stimuli for audible discussion surrounded solving the more difficult mathematical tasks or if one of the team made a mistake. For example, team I. (m) /P. (m) discussed each solution very distinctive before it was entered. (Below, an excerpt from their problem-solving dialogue):

P: "…Look, this is three, and nine minus seven is two. Push less-than!"
(The partner selects the "less-than" sign. The PC reports their solution is wrong.)
P: "Oops, we are stupid. It's the same!"

Team J. (f) /M. (m) was also noteworthy. (The following quotations typify their collaborative work):

J: "…and now seven plus three is...?" *(J. counts with her fingers.)*
M: "You must calculate everything! Like 12 plus five are 17; 17 plus four equals 21; 21 plus six is 27; 27 plus 8…"
J: "There is no 27." *(J. points at the screen.)*
M: "Yes, yes, you can add it." *(M. points to the numbers 20 and 7 on the screen.)*

Trouble-shooting

All in all, good cooperation and communication precluded pupils from asking their teacher for frequent help. The partners worked independently, helping each other to resolve the problems. Primarily, they asked their partner and the help of the software respectively. At times, students even extended themselves to aid other teams (see figure 6). The most confusion surrounded the "mini-multiplication tables" section, prompting the teacher to briefly explain the connection between the icon's level (color the rectangular) and the symbol level (multiplication task) to several groups.

Figure 6. Cross-team cooperation

Goals

The more the children worked with the computers, the teachers could observe, that the more efficient teams began calling attention to their math game scores and setting goals for future sessions.

Per video analyses, some student quotations include:

P: "Yes, we have all this! Did we just make this?"
R: "We're missing this here!"
P: "We do have all lights on. We also have all the lights on here!"

Or:

M: "We have to solve every problem where the score still says zero. Select this here!"

Conversely, the less efficient teams (primarily team M. (f) /T. (m) and team G. (f) /A.-T. (f)) more frequently tended towards "jumping to and fro" aimlessly from between the buildings.

Motivation and commitment

The relatively long period of 11 weeks was ample time to accurately measure student commitment. At the beginning of the project, it was already above average. The children appeared very interested as evidenced by the pupil quoted below:

(Student S. was disturbed by F.'s and P.'s loud counting) S: "Be quiet; I can not concentrate at all!" *(F. and P. showed consideration for S.'s motivation surrounding the project and resumed counting in a whisper so that S. could remain focused himself.)*

As the experiment ensued, students grew accustomed to using the laptops that even seemed to lose their allure around the ninth or tenth week. However, the pupils appeared to regain interest in the final weeks of the exercise, perhaps out of an increased urgency to solve the most math problems possible before the lesson ended. In the end, regardless of varying team aptitude, the total group showed more interest in this experiment than in their more traditional lessons, despite the aforementioned aimless behaviour exhibited occasionally by the less efficient teams.

Effect of mathematical learning

It proved difficult to complete the second written observation sheet and quantify the amount of mathematics each subject had learned. The approximate 30-minute class, limited to meeting once-a-week, was too brief for two sole observers to reliably measure a learning curve for their respective 8-subject groups. In part, it became too unclear to account for the proportion of any given math problem solved by a particular pupil. For example, a seemingly capable student developed difficulty completing tasks when her partner became ill as well as one could notice that she didn't work effectively after all. A more accurate mode of evaluation would necessitate one observer per pair of pupils; however, it would still be a challenge to physically witness an increase in effective learning. For instance, the software's limited criteria for completing each of the 14 tasks allowed partners to complete multiple cycles of the same lessons. To document more detailed and meaningful results surrounding the qualitative effect of students working with computers dictates an empirical quantitative study with distinct test and control groups, plus corresponding initial and exit tests.

Mathematical subjects

The results admit some conclusions to particular mathematical subjects and buildings and partly to the mathematical communication, independent from the teams. Because of the possibility to resume a building, even if all tasks were already solved, there were some buildings, that the children did twice or three times (most commonly "the time", "reflections", "amorous hearts" or "number pyramids"). Unfortunately, this phenomenon was not reflected in the program's comprehensive statistics but rather discovered during the process by manually comparing each team's scores with those from the previous session.

Generally, the teams excelled in the buildings called "addition/subtraction," "amorous hearts" and "number pyramids". The striking 90% student average for "number pyramids" is not surprising as its method was already familiar and even well-liked by the students (especially team M.-L. (f) /S. (m)) from preceding classes. For fun, some pupils intentionally entered wrong numbers again and again to see and hear the building's plates break (cf. figure 7). However, this fascination was routinely short-lived; participants always re-gained motivation and continued to work diligently. Team (P. (f) /R. (m)) completed the number pyramid below (p. figure 8) in an unusual way by filling in the gaps from the bottom to the top, even though the exercise required other arithmetic to be done first. In the first row, they reasoned that if 3 + 2 = 5, then the middle row must have a 13 on the right. In turn, they erased the number 11 they had originally put there.

Figure 7. Computer animation upon entering a wrong solution in the building "number pyramids"

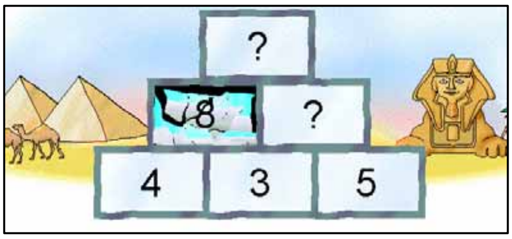


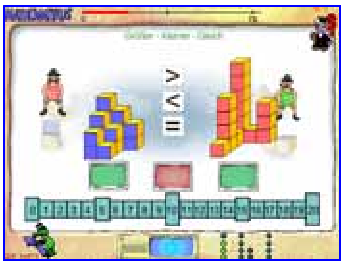
Figure 8. Variation of the number pyramid

The building named "amorous hearts" particularly stands out with a student average of 138%. The concept was very popular for its format and the players only need to solve ten math problems to close-out the topic. The next-to-lowest average score of 44% was in the area addition/subtraction, in the building "circular slide rules", where students often responded to difficulties with random guessing. Upon observing a wrong answer, the electronic help function simply suggested that if the problems were too difficult, the children should select another topic and then return to this one later. The program could be improved here to better exploit the computer as a vehicle to help students see the key connections between numbers.

The topic "larger/lesser/same" produced the lowest student average of 19% in relation to number concept. The children frequently struggled with the building's complex cubes, which they typically counted out one-by-one instead of grouping. In addition, the difficulty of hidden cubes quickly discouraged pupils into switching the topic completely. The following common statement illustrates this scenario:

P: “These *(tasks with numbers)* are much simpler than the others *(tasks with little blocks).*”

Figure 9. Complicated cube buildings



The concept behind “twenty pattern” --where pupils averaged 56%-- was already familiar from many of their regular lessons. Moreover, despite their teacher’s concerns regarding the more challenging game “number ray”, student’s scored an even higher average of 67%.

The students enjoyed “the time” and therefore repeated this category often, averaging 127%, perhaps a function of their having studied the topic in regular class during the same weeks as the experiment. The same holds true for “calculate with money” which garnered a student average of 81%. Conversely, the building “word problems” gleaned the lowest average of 17%. Its fault was surely not in the young subjects’ limitations as new readers since each problem was simultaneously presented audialy. However, the section merits criticism for requiring students to merely select one number to successfully arrive at a solution when there are clear openings within its construct to ask additional questions. For example:

“Christa has 14 euros. Klaus has half”.

Instead of stopping with the expected question, “How many euros does Klaus have?” it would be thinkable that a pupil asks: How many euros do Christa and Klaus have combined?

In addition, this word problem appeared to expose a bug in the program:

“Tom has 9 euros. Klaus has half.”

Here, the software required students to use the decimal point (stands for non-answerable question). But already first-grade pupils can calculate half of nine, as evidenced by the recorded conversation below:

R: “Huh? What is half of 9?“
P: “I know!”
R: “4.5”
P: “Yes 4.5!”
R: “But this is not possible!” *(There were only integer numbers available to select on the screen.)*

(After some time experimenting, R. gives up and decides to try a different topic.)

While it is ok to challenge students beyond their grade level, it is also necessary to afford them the proper answer.

Scenarios such as these produce the kind of uncertainty that can cause difficulties or even intimidate teams into sticking with the easier topics. The programme here remains a good support guiltily just like at the “circular slide rules”.

The geometric tasks for the section “rules and legalities at sequences” proved primarily easy for the children. Pupils preferred the entirely geometric building “reflections”, where they averaged 113%, over the “arithmetical geometric building” “numbers and sample sequences” where the number sequences confused some of the subjects.

Participants performed surprisingly well at “mini-multiplication tables,” averaging 30%. Initially, the teacher had to explain its concepts quite frequently, but many students enjoyed the challenge of completing its particular painting tasks.

On the whole, pupils adopted the strategy of jumping between tasks to assess their difficulty. As a result, the less efficient teams often completed fewer tasks or else spent time repeating the same easier buildings. More efficient teams opted to quickly complete the easier tasks and then use their remaining time to try and solve some harder problems. Using a computer made this technique increasingly easier than with more conventional methods where students must follow a fixed order. With computers, participants could choose freely which tasks they wanted to solve. More importantly, the absence of negative repercussions rendered subjects less intimidated to try challenging topics, and they appeared to do so more often. Partners also felt less pressure by having the increased ability to manage their own time.

Because of the close connection between the handling of the tasks and the cooperation and communication in the team with the capability of the pupils, these things will be interpreted together in the following. There were three teams out of eight who scored a total of less than 50% on their tasks. The reasons varied and are discussed in the analysis below.

Teams

Team G. (f) /A.-T. (f):

Team G./A.-T. completed a mere 33% of their tasks. While they worked on a total of eleven buildings, they were only able to fully solve just two. This low score could be a function of poor cooperation and communication between the two girls. Although they each worked on both tasks, they did not work together but rather adopted an “every-man-for-himself” strategy. At first, the more efficient girl, A.-T. neglected to help her team-mate G., withholding explanations and allowing her partner to struggle through math problems without success. In a single session when subject A.-T. was absent from illness, her partner spent close to her entire allotted hour hopping aimlessly from building to building without stopping to solve the respective math problems.

Team I. (m) /P. (m):
Poor scoring students I. and P. were arguably too precise. Limiting their work to only eight buildings, they could only complete four. The two boys took extreme care to take turns using the mouse to solve problems. However, unlike team A.-T. /G. described above, they did not work separately but rather engaged in lengthy conversations regarding their ultimate approach to each task.

Team M. (f) /T. (m):
The cooperation between M. and T. varied markedly. In certain sessions, they worked well together, helping each other to solve tasks. Conversely, on other days, working effectively proved impossible. Despite their position as one of the weaker teams, they managed to score an average of 43%. Their erratic work pattern reflected a joint interest in three easier and more popular buildings, “the time”, “reflections”, and “amorous hearts”, all of which they visited twice, while neglecting other buildings completely.

Team J. (f) /M. (m):
Team J. (f) /M. (m) also focused on repeatedly completing a mere three houses: “the time”, “number pyramids” and “amorous hearts”. The last one they even solved three times!

Efficiency of teams
There wasn’t any twin-work on the buildings from the three qualitativ best teams, with the exception of one. These are also the teams, which excelled from the start -- cooperating effectively, communicating clearly, and working independently with a strong level of commitment. Despite their difficulties with particular buildings, they did not switch to other topics but rather made an effort to finish what they had started. However, their perseverance was not always effective. For example, team P. (f) /R. (m). R. tried to illuminate the building “numbers and sample sequences” in five different sessions but always ended up getting stumped by the same number sequence: 0-5-4-9-8-13. Clearly, said team found it difficult to detect patterns, but they did not give up.

i.e., a scenario from April 26th:
R: “The same pattern pops up again and again! 0-5-4-9-8-13! We must finish this now!”

Conversely, the less efficient teams never focused on a single task for long and as a result “jumped to and fro” the buildings. They never stayed a long time in one building whereby they worked on fewer tasks in total. Still, even these teams attempted a difficult task now and then after realizing there was no negative consequence for trying.

Animation
The computer animation did not appear to distinctly affect teams but rather provided constant and equal amusement for all (p. figure 10). All told, it was an effective tool to motivated pupils who had a lot of fun trying to illuminate as many buildings as they could.

Figure 10. Computer animation for the fully illuminated building, “reflections”

6. Conclusion

In the following I will summarize the main results of the research, formulate the open questions and give an outlook on future research programs.

In this scientific elaboration the use of computers was examined in the mathematics lesson of first graders. The main emphasis was put on select aspects in the context of the possibilities. The organisational effort was in an appropriate frame due to the use of laptops. The learning software used was “Mathematikus 1”, which is an exercise program in accordance to mathematical contents of the first grade.

As a result of the smaller keyboard and mouse the laptops were very child-friendly. The children utilized all given handling options like mouse, keyboard, touchpad and pin with pleasure. They approached the “new” tools of work unrestrained and investigated and discovered much single-handedly.

The cooperation of the students turned out different. Even if there were small differences now and then they were outweighed by joined work and interaction. Particularly with mixed teams (m/f) a development of interaction was seen.

The communication between the students was more active than in the traditional lesson. Also the program and laptop were part of the discussions. There was a considerable increase of discussions especially with the difficult tasks. Overall an active exchange could be recognized between the students.

Due to the good cooperation and communication of the teams the children could independently work on the PCs. The program “Mathematikus 1” is suitable for first-grade students. It is self explanatory and easy to use. In case of difficulties the help button of the program was used first, secondly class-mates were questioned, the teacher was only asked occasionally for advice. The question whether the methodical special features of the computer are used and offered with regards to interaction and help would have to be examined in an additional research.

Depending on their capabilities the teams defined objectives and handled the tasks in different ways. The more efficient teams worked very goal-oriented, they checked their statistics or the lights at the buildings. The not so efficient teams went also in the statistics of the program however; they were unable to pursue consequently the aims, arising from it. Due to the difficulties that occurred with some tasks, they frequently jumped aimless between the buildings “to and fro”. Simpler tasks were solved twice and more difficult tasks were left out by the not so efficient students. In comparison to the traditional lesson the pupils showed more motivation to approach difficult tasks.

A systematization and expansion of the gained experiences by this project on a larger experiment group is in work. Primarily the communication via mathematics, the argumentation of the children as well as possible developments will be examined in this process. A systematic examination with regards to the increase of mathematical competences was not carried out in the context of this work. To gain that knowledge additional research, based on empirical data is already planned. However, in respect to the individual mathematical topics some observations could be made which are especially helpful for the development of learning software. E.g. there could be stated deficits in the help of the “circular slide rules” (recognize connections between the numbers) or the “word problems”. The arithmetic with “the time” as well as “amorous hearts” were task types e.g. of great popularity.

The computer effects in the programme “Mathematikus 1” are in an adequate frame so that they do not lead to any considerable diversion. They are even designed to motivate the pupils and aerate the work with the computer.

In continuation of this work another study regarding the actual learning-software, is going to give more information about how the children work with different types of tasks, which they prefer and where problems occur. The examination and accordingly the development of a learning-software for mathematics with regard to didactic principles, like discovering study or the natural distinction is in work. Furthermore, starting from mathematical topics, it will be examined which are suitable particularly for an operative and discovering use of computers and in which way computer surroundings could be realized.

The motivation and commitment of the efficient as well as the not so efficient pupils was high. Altogether, pupils with studying problems worked more concentrated than in the conventional lesson and with more endurance on the different tasks. Definitely the more difficult tasks gave reason for increased communication and demanded arguing mathematically. The work on the computer was higher than at independent work in the conventional lesson. A more broadly comparison of the use of computers with conventional lessons and methods of the mathematics lesson with theoretical analysis and empirical comparison of contents and methods of the mathematics lesson should be striven for.

References

Bartnitzky, H. & Christiani, R. (1994). *Zeugnisschreiben in der Grundschule*. Heinsberg: Agentur Dieck.

Kittel, A., Beckmann, A., Hole, V. & Ladel, S. (2005). Der Computer als Übungs- und Wiederholungsmedium im Mathematikunterricht – eine unterrichtliche Erprobung mit Tablet-PCs. In G. Graumann (Hrsg.), B*eiträge zum Mathematikunterricht 2005* (S. 299-302). Hildesheim: Franzbecker.

Ladel, S. (2006): Eine unterrichtliche Erprobung zum Computereinsatz im Mathematikunterricht der ersten Grundschulklasse. In A. Beckmann (Hrsg.), *Ausgewählte Unterrichtskonzepte im Mathematikunterricht in unterrichtlicher Erprobung 2006* (S. 5-38). Hildesheim: Franzbecker.

Lorenz, J. (2000). *Mathematikus 1*. Braunschweig: Westermann-Verlag.

Behörde für Bildung und Sport, Amt für Bildung, Hamburg (Hrsg.) (2003): *Beobachtungen des Lösungsweges beim Rechnen in der Grundschule*. Hamburg: BBS.

Author

Ladel, Silke, Pädagogische Hochschule Schwäbisch Gmünd, Oberbettringer Str. 200, D-73525 Schwäbisch Gmünd, Germany.
Email: silke.ladel@ph-gmuend.de