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ABSTRACT

Since the early 1990s, laptop computers have repeatedly been suggested as a tool to improve instruction and student learning. Meanwhile, several evaluations have shown that laptops helped to increase the amount of independent and collaborative learning. Instruction with laptops was also found to be more student-centered in many cases. However, most of these studies are based on subjective data (interviews and questionnaires) exclusively. Observational data to confirm these findings is missing. This study examines 45 lessons (24 with and 21 without laptop use) that were videotaped over the course of two and a half years in a laptop program of a German high school. It is found that when laptops are used, the use of other instructional media, particularly notebooks and the blackboard, decreases significantly. The amount of independent work if found to increase significantly, while for other forms of instruction, such as teamwork, pair work, lectures and teacher-guided discussions, no differences can be determined. The results are discussed in relation to interview and survey data gathered in the same study. (Contains 23 references.) (Author/AEF)

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The Impact of Mobile Computers in the Classroom – Results From an Ongoing Video Study

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Abstract

Since the early 1990's, laptop computers have repeatedly been suggested as a tool to improve instruction and student learning. Meanwhile, several evaluations have shown that laptops helped to increase the amount of independent and collaborative learning. Instruction with laptops was also found to be more student-centered in many cases. However, most of these studies are based on subjective data (interviews and questionnaires) exclusively. Observational data to confirm these findings is missing. The present study examines 45 lessons (24 with and 21 without laptop use) that where videotaped over the course of 2 ½ years in a laptop program of a German high school. It is found that when laptops are used, the use of other instructional media, particularly notebooks and the blackboard, decreases significantly. The amount of independent work is found to increase significantly, while for other forms of instruction, such as teamwork, pair work, lectures and teacher-guided discussions no differences can be determined. The results are discussed in relation to interview and survey data gathered in the same study.

Introduction

Many studies have shown that computers at school can have a beneficial effect not only on student achievement but also on students' learning motivation, on classroom atmosphere, and on the teachers' willingness to experiment with new and innovative instructional approaches (Christmann, Badgett & Lucking, 1997; Dwyer, 1994; Kulik & Kulik, 1991; Liao, 1992; Losak & MacFarland, 1994; Sivin-Kachala & Bialo, 1996). Yet, it is often lamented that schools are reluctant and slow in integrating computers and in adapting to the needs of the information society (e. g. Peck & Dorricott, 1994). Studies found that the schools' computer equipment is often used inadequately or not at all (Marcinkiewicz, 1993). One reason for this might be that most school computers are desktop machines located in computer labs, which cannot be used flexibly when needed and cannot be used outside school (Fabry & Higgs, 1997). Obviously, in an arrangement like this, computers cannot become the natural tool for learning that is so often called for.

The use of mobile computers is often suggested as a possibility to solve this problem. Only if every student and every teacher had his/her own laptop computer, say proponents of mobile computers, information technology in education could be used to its full effect. Therefore, the introduction of laptops to the classroom is seen as a major catalyst for a profound change in learning and instruction in K-12 as well as in higher education (Owen & Lambert, 1996; Robertson, Calder, Fung, Jones & O'Shea, 1997; Stager, 1995).

Since the start of the Microsoft „Anytime, Anywhere Learning" initiative in 1996 (to name only one of numerous sponsoring programs), the use of mobile computers has spread worldwide and several extensive evaluations have been carried out (e. g. Bruck, et al., 1998; Fouts & Stuen, 1997; Hill & Reeves, 1999; Rockman et al., 1998; Stevenson, 1999). With regard to instruetional strategies and classroom practice, some of these studies found that phases of independent work as well as project work increased (Fouts & Stuen, 1997; Rockman et al. 1998) or that teachers felt that laptops were particularly suited to this kind of work (Bruck et al., 1998). Studies also repeatedly showed that there was more extensive collaborative learning in the laptop classrooms (Bruck et al., 1998; Fouts & Stuen, 1997; Rockman et al. 1998) and that students liked to help each other as well as their teachers with laptop problems (Bruck et al., 1998; Rockmann et al., 1998). On the other hand, it was also found that technical problems often hampered the successful use of laptops in the classroom (Bruck et al., 1998; Robertson et al., 1996, Rockman et al., 1997). In addition, Bruck et al. (1998) reported that some teachers deplored a high level of student distraction, as well as the loss of authority and control in the laptop classroom.

Overall, it seems that many of the positive expectations that are associated with the use of mobile computers in school could be confirmed in recent studies. However, the studies referred to above are tainted with various problems: First, the results are mainly based on questionnaire and interview data exclusively, which is known to be biased in several ways (Bortz & Döring, 1995). Behavioral and observational data to confirm the self reported data is missing in most studies. Also, many studies did not investigate control groups so that the effect of the laptop computers is not clear. Finally, results are sometimes based on rather short observation periods (ranging from a couple of weeks to 2 years at most) and small student samples.

Background of the study

In March 1999, one of the first laptop programs in Germany started at the Evangelisch Stiftisches Gymnasium Guetersloh. More than 300 students of this high school and their teachers were gradually furnished with networked laptop computers. Students of four cohorts entered the program in grade 7 and are using laptops regularly at school and at home until the end of grade 10.

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The school's administrators, participating teachers and parents have developed an elaborate pedagogical concept for the integration of laptops, which is based on the school's three general assumptions about the benefits of incorporating media in instruction: Media are essential to foster students' media literacy, they can serve as a tool to connect the classroom to the authentic world outside school and they are a valuable means to improve instruction (Engelen, 2000; 2001a, b). With regard to the improvement of instruction, the concept draws from a reform-pedagogical framework that states that media should be used to

- foster the concreteness and vividness of instruction,
- facilitate individualized learning and intensify phases of student work
- strengthen teamwork and communication in the classroom
- increase the amount of independent learning and problem solving
- further students' responsibility and improve their attitude toward co-operation and sense of belonging to the school community

This framework provides the foundation for the school's concept of laptop learning. Teachers jointly develop instructional units based on these reform-pedagogical ideas, making sure that the computers are used to serve a sound didactic purpose. Important cornerstones of the concept are also that the computer is integrated into the regular curriculum from the very beginning and that the frequency of use of the laptops is increased step-by-step, starting with only one subject and gradually expanding to the whole curriculum within the first project year.

An extensive evaluation that is carried out by the Center for Media Research, Freie Universitaet Berlin accompanies the pilot project. The evaluation focuses on changes in instructional strategies and classroom practice, student achievement in selected subject areas and the acquisition of cross-curricular competencies (an extensive report will be published in 2002 by the Bertelsmann Foundation, one of the main sponsors of the project). This paper presents preliminary results regarding the first aspect, instructional strategies and classroom practice.

Method

To overcome the shortcomings of other studies pointed out above, observational data was gathered to investigate changes of teaching strategies and classroom practice. A randomly selected sample of lessons of the laptop classes was videotaped over the past 2½ years. The same classes and the same teachers were recorded repeatedly. As the laptop classes are not using their computers every day, lessons with and without laptop use could be recorded in the same classes with the same teachers. Confounding effects that result from comparing different classes or teachers with different teacher styles, could thus be reduced. Subjects covered are mathematics, German, and English.

A body of 45 lessons was videotaped. 24 of these were laptop lessons, 21 were lessons without laptop use. Table 1 provides an overview of the distribution of lessons.

Table 1: Distribution of lessons with and without laptops

			Grade			Total
Laptop			Grade 7	Grade 8	Grade 9	
With Laptop	Subject	English	4	3	1	8
		German	5	4	1	10
		Maths	3	2	1	6
	Total		12	9	3	24
Without Laptop	Subject	English	4	1	-	5
		German	5	3	1	9
		Maths	2	3	2	7
	Total		11	7	3	21

The lessons with and without laptops have so far been compared for use of instructional media and form of instruction. Every lesson was divided into a maximum of nine intervals of 5 minutes length. For each interval, two trained observers recorded the dominant media use and form of instruction. The inter-rater agreement, as determined with the intra-class coefficient, was .93 for the use of instructional media and .79 for the form of instruction.

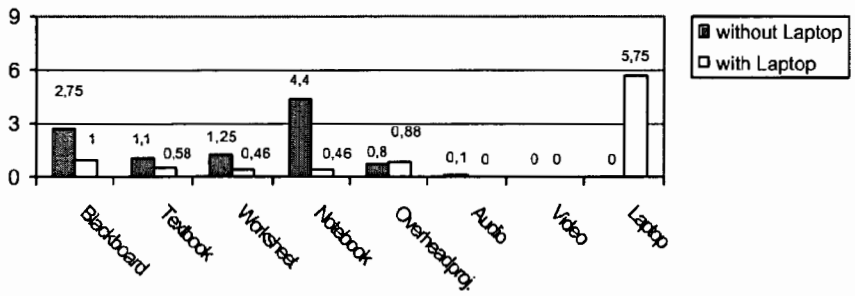
The results of the video study are discussed in the light of data gathered from student surveys and qualitative interviews with teachers and students in the last section of this paper.

Results

Use of Instructional Media

On a descriptive basis, it was found that the use of the laptop had a decreasing effect on the frequency of use of "traditional" instructional media, such as textbook and worksheets, blackboard and notebooks (see Fig. 1).

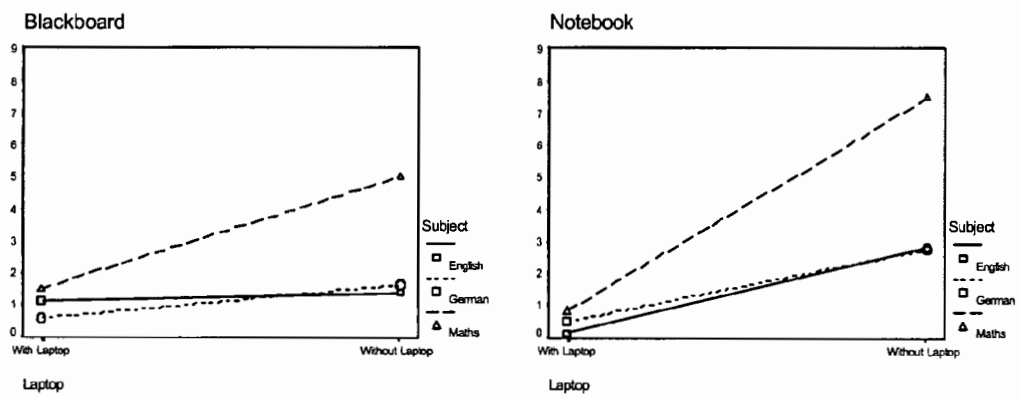
Fig. 1: Media use (number of 5-minute intervals) in lessons with and without laptops



The difference between laptop and non-laptop lessons was tested with a multivariate two-factorial analysis of variance with laptop use and school subject as fixed factors. The dependent variables were the frequencies of instructional media use. A significant main effect was found for the factor laptop use (Wilks's Lambda = .10; $F(7,32) = 40.04$; $p < .01$). An analysis at the univariate level showed that the frequency of use of the blackboard ($F(1,38) = 9.62$; $p = .04$), notebook ($F(1,38) = 52.37$; $p < .01$) and of course laptop ($F(1,38) = 214.48$; $p < .01$) was significantly different between laptop and non-laptop lessons. The frequency of use of worksheets tended to be significant ($F(1,38) = 3.72$; $p = .06$).

The interaction of laptop use and school subject tended to be significant at the multivariate level (Wilks's Lambda = .53; $F(14,64) = 1.69$; $p = .08$). A subsequent univariate test indicated that there was a significant interaction for the use of the blackboard ($F(2,38) = 3.32$; $p = .05$) and notebook ($F(2,38) = 6.60$; $p = .03$). The interaction plot is depicted in Fig. 2. It can be seen that there is a particularly sharp decrease in the use of the blackboard and of notebooks in mathematics, while the difference is much less distinct in the two other subjects.

Fig. 2: Interaction plots for blackboard and notebook



Form of Instruction

For the form of instruction, the descriptive analysis showed that guided discussions are the most prominent form of instructional activity both in laptop as well as in non-laptop lessons (see Fig 3). Laptop lessons differed most strongly from non-laptop lessons in that students work individually more frequently. Qualitatively, it was interesting to note that phases of individual work were often longer when the laptop was used than in non-laptop lessons. Group activities were also observed slightly more often in laptop lessons than in non-laptop lessons and tended to be more project-based, while group activities in traditional lessons were shorter exercises that could be solved in a limited amount of time, typically within the respective lesson. The frequency of lecture and pair work is almost identical in laptop and non-laptop lessons.

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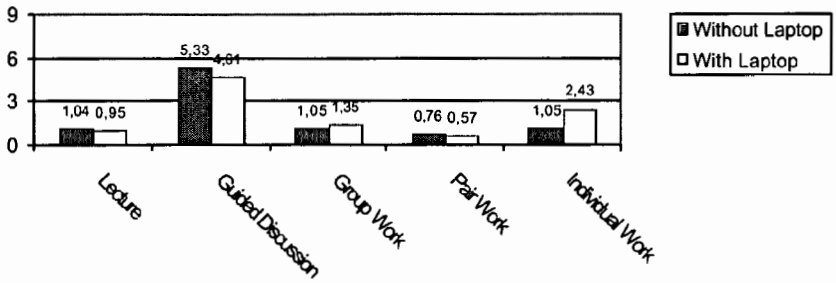
Fig. 3: Form of instruction (number of 5-minute intervals) in lessons with and without laptops



The difference between lessons with and without laptop use was again tested with a two-factorial analysis of variance with laptop use and school subject as fixed factors and the five forms of instruction as dependent variables. A significant main effect was found for the factor laptop use (Wilks's Lambda = .71; $F(5,34) = 2.82$; $p = .03$). At the univariate level, only the frequency of individual work was found to be significant ($F(1,38) = 10.82$; $p < .01$) while the other differences could not be statistically confirmed. The interaction of laptop use and school subject was not significant (Wilks's Lambda = .73; $F(10,68) = 1.16$; $p = .33$).

Discussion

The differences in the use of instructional media in laptop and non-laptop lessons show that the computer primarily takes over the function of the notebook. This finding corresponds with the statement of students and teachers in questionnaires and interviews that the laptops are most frequently used as a writing tool. However, this does not mean that the laptops are simply used as an "electronic notebook". In fact, especially in the teacher interviews it is emphasized that using an electronic writing tool enhances the use of the traditional notebooks in several ways: Most importantly, the possibility to easily change and edit text is seen as a tremendous advantage of the laptops for introducing students to the process of writing. It helps to encourage them to critically analyze their own and their classmates' texts and improve them by revising and re-writing them multiple times. Also, some teachers say that writing electronically motivates reluctant writers and many students stated that writing with the laptops was fun and one of their favorite activities. In addition, the laptops are used to create archives for certain subject matter (e. g. an English grammar archive or a Mathematics archive) with entries that are electronically linked. These archives are continually expanded throughout the years. Both, teachers and students said that the archives have many advantages in comparison to traditional notebooks, as they have a more transparent structure, new entries can easily be connected to existing entries, they do not get lost and some students found that they are better suited for revision and learning. Finally, teachers and students stated that co-operative writing tasks could be carried out much easier with computers.

Another remarkable difference in the use of instructional media is that the blackboard was used less often in laptop than in non-laptop lessons. This may indicate that instruction in the laptop lessons is less teacher-centered as the blackboard is typically used in teacher-guided phases. The teacher interviews confirm this interpretation as teachers said that when they teach with laptops they often do not teach the whole class but interact with individual students while the class is working on a problem individually or in groups. However, the analysis of the frequency of lectures and teacher-led discussions in laptop and non-laptop lessons weakens this assertion (see below).

Regarding the school subjects, the clearest difference in the use of instructional media was found in mathematics. Mathematics was found to be the subject that makes most extensive use of the traditional media notebook and blackboard in non-laptop lessons. Thus, in terms of instructional media use, it is impacted most profoundly. However, subjectively, the change is felt similarly in all subjects, as the observations from the interviews referred to above were comparable across subjects.

Regarding the form of instruction, the differences between lessons with and without laptop use are less clear. Phases of individual work increased. This corresponds to the pedagogical concept of the school on the one hand, as the laptops were to be used to facilitate individualized learning and intensify phases of student work and to increase the amount of independent learning and problem solving. It also confirms the statement of the teachers in teacher interviews that they use the laptops to activate the students and often employ them for individual work to make sure that every student acquires computer literacy, which is one of the main goals of the project.

The frequency of teacher-led discussion decreased in laptop lessons. However, the difference in comparison to non-laptop lessons was not significant. This difference was felt to be much stronger in the teacher interviews, where a majority of teachers stated that instruction is becoming considerably less teacher-centered when laptops are used. The video observation shows that just like in traditional lessons, guided class discussions are still the most prominent form of instruction in laptop lessons. Also, the amount of lectures was almost identical in laptop and non-laptop lessons.

Moreover, the frequency of group work did not differ strongly between laptop and non-laptop lessons. This result is partly confirmed by student surveys as two of the three cohorts reported only a slight increase of group work or even a decrease of

group work. Teachers held varied opinions on whether they had students do more group work when laptops were used. Especially some teachers of the first cohort experimented extensively with teamwork and carried out several student projects. Experiences were mixed, as students were partly overwhelmed when they worked on projects in multiple subjects at the same time. In the following years, project work was therefore reduced. Some teachers of the second and third cohort reported that they do not use group work more often than in regular instruction. Yet, students as well as teachers unanimously reported that they felt that laptops are a valuable tool for teamwork and that working collaboratively is easier with laptops than with traditional media.

Conclusion

The results show that the major change in the laptop classroom is an increase in individual work. Students work more often independently, which according to many teachers, results in a higher degree of activation than in traditional lessons. In contrast to other evaluations mentioned earlier, this study could not unequivocally confirm that using laptops led to more collaborative classroom activities. Even though strengthening teamwork and communication in the classroom is one of the declared pedagogical goals of the project, there was no clear general increase in group work. It seems that while extensive group projects have been carried out with the laptops, this was rather the exception than the rule. If only subjective data had been gathered, these projects could have easily been overemphasized. The same is true for the change from teacher- to student-centered instruction. While there are clear indications that the laptop classroom is becoming more student-centered, the video analysis also shows that the change is less profound than only looking at the subjective data might have suggested.

The use of video proves to be a helpful tool to corroborate findings that are based on subjective data. Results, which were derived from questionnaires and interviews, could be confirmed through observation in many cases, thus raising their credibility. While it should not be concluded that one source of data has more value than the other, this study shows that combining observational and survey/interview data is worthwhile to enhance the validity of a study's results. It reduces the danger of misinterpreting findings and helps to detect possible biases in subjective reports.

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