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Abstract:

Considering the dynamics of laptop implementation activities in secondary education in German-speaking countries, the lack of broadly-based research activities on the effects and critical success factors of laptop classrooms is remarkable. Particularly since the broad variety of studies that have been conducted in English-speaking nations for more than 20 years has not yet found general recognition. Therefore it is the objective of this paper to give a well-founded review of international research on the effects of notebook use for educational purposes.

1 Effects of new media: catalyst for reform vs. lever for reform

Before addressing the specific topic of notebooks in educational contexts, it is supportive to briefly introduce two opposing views on the innovation effects of new media as a framework of analysis: Two general patterns – the perspective of media as a catalyst for reform and that of a lever for reform – can be distinguished.

The *catalyst concept* implies that the introduction of new technologies causes an immediate, far-reaching change which exceeds initial intentions [1]. Exponents of this view regard new media as 'vehicles for didactic innovation' [2] as they do not only contribute to the acquisition of media competences but also to enhanced constructivist learning in schools.

In contrast, the perspective of *lever for reform* assumes a ‚lever function' of new technologies as they are tools for achieving specified goals that need to be clearly defined in advance. Whereas new technologies are regarded as initiators of change under the catalyst view, they solely fulfill the function of a tool according to the lever perspective [1]. Thus they only act, among various other factors, as instruments for school innovation processes [3].

These different approaches have particular practical relevance for the integration of new media as the design of implementation processes depends on the attitudes of decision-makers (e.g. head teachers). Followers of the catalyst view would primarily focus on the creation of IT infrastructure and ensure that teachers make use of media resources during lessons [1]. The supposed impact chain thus leads linearly from enhanced availability of media via increased use to better learning results [4]. This would suffice to induce extensive changes. On the other hand, if lever effects are expected, additional activities are crucial: Purposeful planning of the

change process and support systems become major factors [1]. This demonstrates that the effects of media projects are dependent on the attitudes and expectations of key persons within an organization. Starting from the potential which they ascribe to new media, they define an implementation strategy and thus exert indirect influence on effects.

2 A brief history of international laptop projects and related research

First attempts to integrate student notebooks in tertiary education were undertaken in the United States as of 1988 [5]. At the beginning of the 1990s, the use of laptops in school contexts was tested in pilot projects and disseminated increasingly in subsequent years [6]. Laptop integration gained further impetus due to resource-intensive support programs by hardware and software manufactures such as Microsoft with its *Anytime Anywhere Learning Program*, promoting initiatives in the US, Canada, Australia and UK [7]. Likewise, US education policy made substantial investments in technology programs, e.g. in South Carolina, California and New York [8]. The largest equipment initiative so far was launched in Maine: in 2002, 17,000 students at 240 schools received mobile computers. Two years later the program was extended to 34,000 students and 3,000 teachers [9].

In the course of the augmenting dissemination of laptop concepts a vast number of research projects with highly diverse methodical approaches commenced. The presumably most widely recognized studies in this field are the evaluations of the Microsoft program – so called Rockman reports – by Rockman, Walker & Chessler [10, 11, 12]. The high attention may be due to the relatively early publication date and to their longitudinal design. During a period of three years the progress at 53 US schools was monitored. The focus was – similar to most subsequent studies – broadly based: The adoption of new technologies and the changes in teaching and learning were to be captured, problem fields to be identified and suggestions for successful implementation strategies to be developed [10]. A combination of methods – student achievement tests, student and teacher surveys, telephone interviews with school partners, shadow studies (observation of students and teachers during an entire school day) and qualitative interviews in selected schools – was employed. The reports come to the conclusion that the commitment to participate in the notebook project was strong and remained constant over time. An increase in exploratory learning, project-based work and student presentations was observed. As effects of laptop use, higher problem-solving skills, enhanced faculty of speech in writing assignments and the capability of goal-oriented computer use were discovered [12]. In the third year of evaluation differences to a control group which did not use laptop computers were less consistent in the field of student performance (particularly when measured with standardized tests) and learning strategies [11].

3 International findings on the potential of laptops in education

Due to space limitations and the broad basis of reports on educational use of personal computers in general (e.g. described by Schaumburg [6]), this paper intends to give an overview of the specific effects of laptop classrooms.

Computer use during lessons
A hardly surprising – but in most evaluation reports explicitly stated – result is that computer use in classrooms [6, 10] and – owing to the devices' portability – private use [13, 14] in-

crease substantially (for contrary conclusions see Petko & Knüsel 2006 [15]). Even though Stevenson [16] observed that particularly during the first years of a laptop project, the frequency of use might be below expectations as teachers themselves are subject to a learning process and thus have reservations towards the new setting. Moreover, differences in laptop adoption are due to media didactical competencies and computer-related attitudes of teachers [17].

Motivation
As a consistent result, an increase of overall school motivation, special interest in subjects and commitment can be found [10, 11, 15, 18, 19, 20]. A drop in absenteeism rates can be observed as well [21]. However, the sustainability of the motivational effect is not undisputed: While a merely short-term novelty effect of new media can be regarded in many cases [22], Ricci [23] reports pupils' constant interest in working with laptops after a project duration of two years. Unrealistic expectations which pupils or their parents address in the project can be a problematic issue. In these cases the risk emerges that initial motivation transforms into frustration [16].

Media literacy
Most evaluation reports arrive at the conclusion that – frequently substantial – gains in students' media literacy can occur [19, 24, 25]. These findings are mainly confided to user skills (such as working with hardware and software or creating media products), whose acquisition is frequently a 'by-product' of subject-related activities [26]. Most studies discuss technical skills whereas other constitutive aspects of media literacy – e.g. the reflection on computer use and media consumption or a critical evaluation of information obtained – attract less attention.

School achievement
Research in the United States that aims on the question of the 'effectiveness' of media-supported learning environments primarily focuses on increased school achievement [27], which is regularly used as a major indicator to legitimate resource-intensive educational initiatives [28, 29]. Findings concerning this aspect are ambiguous: While several authors arrive at positive conclusions [8, 18, 30, 31], in other cases results are inconsistent [23] but seldom negative [32]. In tests with essay tasks, Rockman et al. [12] observed that students who had been using laptops during lessons performed better than a control group; however, standardized tests did not yield significant differences. On the basis of tests, Stevenson [33] did not find performance-enhancing but stabilizing impacts of laptops: While a control group had declining achievement over time, the performance of 'laptop students' remained constant.

A possible reason for these contradictory findings are the diverse methods of data acquisition. Positive results can primarily be found in qualitative approaches [34]. Rockman [29] points out that measuring competence gains by conventional standardized tests may be misleading particularly when paper-and-pencil versions, which do not have the potential to capture computer-related skills, are used.

Teaching methods and didactic settings
The shift in didactics, which is stimulated by laptop integration, mostly corresponds to the constructivist learning paradigm. Lowther et al. [30] report a rise in student-centered activities and project work. Other researchers [10, 19, 20, 35] observe these – differently deep – changes as well. For instance, a decrease in direct instruction takes place while independent inquiry/research, group work and presentations by students gain in importance. After a program duration of three years, Rockman et al. [12] recognized a trend towards a more

constructivist teaching style. However, no significant differences between 'laptop teachers' and a control group in conventional settings could be found. In total, results in this field are inconsistent as well. Petko & Knüsel [15] state that traditional classroom work still dominates and open learning environments are seldom introduced. Schaumburg [6] gives an overview of research reports which estimate the increase in group work as marginal and place emphasis on the dominance of teacher-centered settings. However, during an evaluation of her own, she discovered that the share of direct instruction was reduced to 54 % of overall lesson time. On the other hand a rise in cooperative classroom work did not take place; differences primarily arouse from diverse attitudes of teachers.

Changes in teacher roles
The changes in teaching methods are closely connected with different roles. Teachers define themselves increasingly as 'facilitators' [23] of learning processes than as instructors. Moreover, the relationship to students is positively affected by this new role model [31]. Schaumburg & Issing [26] point out that such changes do not occur immediately at project start – in the beginning even tendencies of augmented teacher orientation are possible.

A frequent observation is that technophile students act as IT experts and assist their teachers in cases of technical difficulties [4, 29, 31]. Furthermore, new technologies have influence on cooperation among teachers as initial problems with the equipment demand mutual support and the new classroom situation stimulates exchange of experience [10].

Further desired effects
Reports point toward positive impacts on disadvantaged populations: In laptop classrooms underachieving students and students with lower socio-economic status have the highest gains in performance [19, 33]. In several cases, improvements in extrafunctional competences such as problem-solving or analytical skills were identified [11, 25]. Research on positive effects that does not solely focus on changes in classroom activities and student skills but on school level is rare. Single results indicate that laptop classrooms are suitable means to improve a school's external presentation; for instance, Light et al. [31] observed higher enrolment of high-performing students.

Undesired effects
Literature on laptop research emphasizes various problematic issues which can arise as a consequence of laptop work during lessons. Such side effects are

- an increase in undesired non-school related activities of students (e.g. internet surfing or chatting) along with less possibilities for teachers to monitor these actions [24, 29].
- consumption of problematic web content by students [18].
- physical complaints in the neck and shoulder region caused by the weight of the devices on transport to school and the – compared with desktop computers – unnatural posture during laptop work [13, 36].
- more time needed during lessons to clarify organizational matters and to resolve technical problems [19, 26].
- tendencies of social selection in cases where participation in laptop projects is dependent on the financial situation of parents to purchase the laptops and no compensatory measures are being taken [21, 37].
- difficulties for schools to raise the financial resources required for acquiring and extending IT infrastructure [10].

4 Research insights into Austrian laptop initiatives

After outlining the international state of research on student laptops, a more detailed exploration of these approaches, methodology and results appears fruitful. For this purpose, the resource-intensive Austrian implementation programs, which are supported by education policy since 1996, shall be examined more closely.

During the approximately last ten years, ICT as a strategy of modernizing school education has gained importance. In 2000 the ministry of education launched a broad initiative to stimulate bottom-up projects at various schools [38]. Consequently, school-specific concepts developed heterogeneously [39]. The following years were characterized by rapid growth – in the school year 2004/05 150 schools in upper secondary education had already established laptop classrooms with 10,200 students (www.efit.at).

In a first research project on laptop integration in Austria, Bruck et al. [40] evaluated the pilot program 'Innovative technology in education' one year after its launch. Central message of the report is that the program objective could not be fulfilled. Due to the technical efforts required, the initiative remained a 'technology project' while further implementation activities such as teacher training, convincing teachers, exchange of experience and technical support were underrepresented. As a positive effect, enhanced computer skills were observed, whereas no increase in subject-specific performance occurred. Problematic aspects were the different interaction between teachers and students, increased opportunities of distraction and the dependence on the functional capability of the infrastructure. In course of the school year, initial enthusiasm among teachers was substituted by more realistic estimations of the potential [40]. The report comes to a critical, differentiated assessment and declares its position against technology euphoria.

In a project described by Baumgartner [2], a team of experts accompanied the introduction of student laptops in a Viennese college for tourism. A case study reflects the implementation process and emphasizes the importance of a steering committee, participative management style and feedback culture as crucial factors of success. The areas content development, teacher training and didactics were rated as inadequate. An assumption is that the actual classroom work is not visible for external interest groups, whereas tangible novelties such as laptops are evident and are thus in the focus of implementation activities. Baumgartner [2] criticizes the implicit assumptions of most studies in which media integration is viewed as a sufficient condition for innovative education. He suggests regarding this causality reversely: Not the notebook is responsible for the empirically observed innovations but innovative schools and teachers who consider laptop classrooms as a challenge for their educational practice.

In 2002 the Centre for Education and Media at the Donau University Krems published various reports which arouse from the consulting process of the Austrian laptop initiative of the ministry of education. At eight schools in upper secondary education surveys with teachers, students and school managers were conducted. Additionally, lesson observations, qualitative interviews and online surveys with selected students were carried out [41]. In the light of the – even by international standards – sophisticated design, the results are only partially informative: For instance, with the question 'Did you look forward to the implementation of notebooks?' the information was obtained that 80 % of the students were enthusiastic at project start [41]. Motivation was therefore rated as 'overwhelming' [42]. The report indicates positive impact on the teaching style of teachers and on the quality of lessons. Furthermore students' work was more practice-oriented and 'professional' and an increase in collaborative

work was observed. As problem fields, technical difficulties and poor computer skills on the part of teachers were identified [41, 43]. A critical point is that the report's choice of words implies a lack of distance to the research topic – the university itself was involved in the evaluated model project.

A further evaluation study by Spiel & Popper [39] focused on the acquisition of key competences. Students of 25 classes participated in assignments and self-assessments. It was observed that laptop students performed better in the aspects of information management, team work and competence self-belief, whereas no difference was found concerning self-organization and learning motivation, which is – with regard to the international findings described above – surprising. Additionally three potential problem fields (concentration, computer addiction and performance decline) were examined; compared with a control group, no differences could be found [39]. Although the report contains notable insights into extra-functional qualifications, its significance is restricted due to methodical reasons: In the assignments (whose construction is undoubtedly difficile), several dimensions of key competences were operationalized in an elusive way. For instance, the capability of working in teams was measured with a knowledge test in which students had to mention criteria of successful group work.

Altrichter et al. [44, 45] chose another approach by analyzing the profiles of three schools with ICT focus (among them two schools with laptop classrooms). One case study describes how schools utilize laptops as a marketing strategy to succeed in a competitive environment by creating attractive curricula for their clientele. However, school-internal competition may arise when laptops are perceived as status symbols and students define themselves as an 'elite class' [46]. In a second example the lack of financial remuneration for dedicated teachers, a shortage of qualified ICT staff and missing didactic concepts are outlined as problematic aspects. Significant differences in teaching scenarios could not be observed, also in notebook classrooms direct instruction dominated [47]. In conclusion a ‚persistence of traditional patterns of education' [44] was detected.

In an own survey conducted by the author [48, 49], data from 101 head teachers of Austrian schools in upper secondary education were used to analyze whether decision-makers regard laptops as a resource for innovative classroom scenarios. The study, in which 71.1 % of Austrian schools with laptop classrooms participated, indicates that Kerres's [50] 'treatment hypothesis' applies for the majority of participants of this study: Laptops together with tangible adjustments in the school building (e.g. IT infrastructure) seem to be considered as a 'treatment' for the education system and thus as such substantial innovations themselves so that further changes in the didactical field are partially neglected. It became evident that schools primarily focus rather on technical than on pedagogical issues. High priority is given to establishing the hardware for laptop use, whereas lower attention is paid to didactic measures. Deficits concerning internal (technical) support and external support by experts can be observed. By contrast, the availability of training courses for general computer skills as well as for subject-specific didactics was rated as good. Media concepts or media curricula are frequently vague and often do not include precise statements on the intentions, conditions and desired effects of classroom work with mobile computers. Although alteration of specific classroom practices was not in the focus of this study, results show that the desired shift from traditional didactics to a 'new' learning approach did not take place. In many cases the high expectations could not be fulfilled during the project.

5 Laptops as catalysts of change?

Chapter 3 and 4 have demonstrated that during the last years significant gains in knowledge on the educational impacts of student laptops could be achieved. Yet – as the contradictory findings indicate – a definite assessment of the changes stimulated by laptop integration is not feasible. Accordingly, the scientific discourse, which oscillates between criticism of conceptless computer integration [4] and euphoria about a new learning culture in schools, is diffuse.

The synopsis of research reports leads to the conclusion that laptops primarily seem to act as a *lever for reform*. They are a – potentially powerful – instrument to achieve specific targets set in advance. In order to deploy their potential it is not sufficient to solely introduce new media in classrooms; moreover, technology needs to be embedded in a general pedagogic concept. A catalyst function of laptops is assumed in single studies – for instance, Rockman et al. [12] state: '*Computers themselves, then, may be acting as a catalyst for change.'* – but cannot be proved on a broad basis. Carlsen et al. [3] come to the conclusion that new media do not act 'automatically' as catalysts; however, they have the potential provided that they are integrated in an innovative *pedagogic* scenario (whereby, in turn, media are assigned the part of powerful tools).

An automatism of media causing a variety of initially not explicitly intended changes towards constructivist learning [51] is rarely encountered in practice: '*No miracles derive from the mere presence of ICT in a school'* [1]. However, notebooks can support a change in learning culture supposing that pedagogic media concepts are the basis of systematic implementation measures [1, 31]. Consequently, the creation of a didactic framework and the adaption of surrounding conditions are vital [52, 53]. Becker [54] points out that that for a constructivist change in classroom work, teachers' characteristics (e.g. their attitudes, ICT skills and own patterns of computer use) are as important as aspects on school level (such as IT infrastructure and strategies of school development). These results demonstrate that the treatment hypothesis is not representative for real situations: The potential of laptops needs to be activated by extensive accompanying measures [55].

Although it can be proofed that laptops do not act as catalysts, the survey of Austrian school managers [48, 49] clearly indicates that the majority of decision-makers give them the *status* of such powerful resources which are expected to stimulate far-reaching changes in traditional classroom work. This attitude can be insofar problematic as it has immediate consequences on the implementation process: In many cases didactic issues are poorly reflected and comprehensive strategies for laptop implementation and use are not introduced on school level; it is left to the individual initiative of teachers to develop appropriate practices [49].

6 A critical appraisal of the state of research

Findings of laptop research need to be seen in a nuanced light. For instance, Willis [56] questions the methodological approaches selected in most studies on the effectiveness of computer use. According to him, research questions are frequently worded in the style of *'Does it work?'* and lead to inappropriate simplifications. Furthermore, most reports focusing on an identical area of research cannot be compared without restrictions due to the inconsistent use of terminology in media research. Thus, generalization of results is under discussion – inter alia because of the variety of context variables with which most studies only deal superficially [25, 56]. This allows a broad range of interpretation [32].

Additionally the *objectiveness* of pseudo-scientific publications which are financed by hardware or software manufacturers and presented on their websites as a case for media use in schools needs to be questioned. Willis [56] instances a study on the effectiveness of ICT which claims to give a compulsory overview of the state of research but works selectively and quotes exclusively positive results.

The findings on hand are furthermore subject to restrictions caused by *methodical problems*. Numerous research projects are based on self-disclosure by students or teachers [37] and do not apply experimental designs, consequently distortions of responses are likely. As most evaluations are resource-intensive pilot projects, Hawthorne effects and a tendency towards social desirability may emerge [20, 57]. Such distortions can even occur in lesson observations when researchers are being demonstrated an 'ideal' scenario of technology use instead of everyday situations (e.g. in the case of Stevenson [16]).

Moreover the question of *transferability* of findings gained in Anglo-American school systems (with different structures as well as learning cultures) to German-speaking nations needs further clarification [6].

As a consequence of the fast *technological development*, which subjects media learning arrangements to permanent change, the up-to-dateness of most studies is confined to a short time period. Older publications thus only have limited validity [58].

7 Suggestions on future research activities

Among the topics of laptop research which – according to various authors – should be given priority are

- the specific advantages of mobile computers compared to desktops. Many reports describe effects which can also be achieved with desktop computers. Particularly relevant are the impacts which derive from the portability of the devices [6].
- data collection on ICT initiatives on a broad basis, which has so far been only possible in single research projects due to high costs [58]. This might contribute to the identification of the specific differences between prestigious pilot projects and 'everyday laptop work'.
- the segregation of effects which arise from the availability of laptops during lessons. In most studies, no analytical distinction between the introduction of new technologies and the – in most cases simultaneous – adoption of alternative didactics, which could be applied even without new media, takes place [22].
- matters of educational policy such as the role of laptops as marketing instruments [46] or school-internal competition and selection mechanism caused by the (un)intended creation of 'elite classes' whose students depend on the financial capabilities of their parents to bear the increased costs of education [44, 46].

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