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Teacher's scripts while teaching with information- and communication technology (ICT) in the subjects German, Mathematics and Computer Science

Objectives

This exploratory video study investigates teaching patterns when integrating Information and Communication Technology (ICT[1]) in lessons of Mathematics, Computer Science and German. Teachers' behaviour is analyzed with respect to didactic dimensions, e.g. direct teaching vs. student- and problem-centred teaching as well as to verbal interaction, e.g. questions provoking factual knowledge versus evaluative or meta-cognitive questions. In addition to careful descriptions of teachers' behaviour the study focuses on subject-specific differences as well as in developing a typology of teaching with ICT.

Theoretical Framework

Often, ICT is seen as a "change agent" that nearly automatically changes routines and habits on different levels (Cuban, 1993; Kerres, 2000; Olson, 1988; Ritter, 1994; Tulodziecki, 1999). On the instructional level it is assumed that ICT changes teaching methods since the presentation and examination of subject matter can be realized in a new and more effective manner. On the curriculum level ICT is expected to influence the curriculum development. Finally, on system level it is expected that the use of ICT promotes a change of the education system. However, this study focuses only on the instructional level.

Teaching patterns or teaching scripts[2] have received a lot of attention in instructional and educational research since the TIMSS-Video Study (Stigler et al., 1996). Focussing on teaching scripts can be understood as an adequate balance between laboratory-studies and the complexity in the concrete teaching and learning environment. Scripts can be used as a coherent model which can be applied to teachers' actions in complex teaching situations. Teaching scripts were described as general action modules (Stigler et al., 1999). They can also serve as predictors for student achievement (Klieme, 1999).

During school education one repeatedly experiences certain teaching patterns which eventually result in "teaching scripts". It is assumed that these scripts are only altered insignificantly during academic teacher training (Richardson & Placier, 2001; Wideen, Mayer-Smith & Moon, 1998). Furthermore, scripts stabilize during the teacher's professional practice.

[1] ICT is defined as computer-based digital Information- and Communication systems, -media, -techniques, -tools, and –products (Reusser, 2003).

[2] Schank & Abelson (1977) define scripts as mental representations of systematic action sequences which are comparable to routines. Even though, they never looked at scripts in education, they are well known for their *restaurant script*.

Nevertheless, there is no empirical research on how teaching scripts really occur.

Pedagogical studies concerning the implementation of ICT in classrooms are primarily evaluation studies of major pilot projects, e.g. Apple Classroom of Tomorrow (Dwyer, 1994), ImpaCT (Hammond, 1994) and SITES (Pelgrum, 2001). In general, these studies emphasize the notable potential of ICT to realize constructivist learning principles, to promote co-operative learning and a pedagogy of understanding. The assumption that ICT can support constructivist learning has been prevalent since the beginning of the 1990s (Chan et al., 2001; Hooper & Rieber, 1995; Kerres, 2000; Papert, 1998; Pelgrum, 2001). It is generally expected, that the use of ICT supports independent student work on complex assignments (Pelgrum, 2001; Tulodziecki, 1999; Scott et al., 1992) and advances social interaction between students (Kamke-Martasek, 2001; Chan et al., 2001). In addition, ICT can increase the level of authenticity of subject matters and student interaction (Kerres, 2000; Jonassen, 1996). Furthermore, Pelgrum (2001) postulates a changing role and activity of teachers and students in computer-based lessons. Finally, psychological research focuses mainly on the effectiveness of ICT under experimental conditions in learning laboratories and the effects on discrete aspects of ICT on teaching and learning (e.g. Chen & Looi, 1999; Duffy & McMahon, 1999; Fischer & Mandl, 2000; Hadley & Sheingold, 1993; Moreno & Mayer, 1999; Spiro et al., 1991).

Even if most studies give clear evidence for the potential of ICT in teaching and learning processes, it remains an open question if teachers make use of this potential. Critics of computer integration into instruction, such as Cuban (1993), suggest that all too often teachers merely integrate ICT into their traditional teaching patterns. Thus, two research questions were investigated in this study:

(1) How do teachers use ICT in instruction?

(2) Is there a connection between the use of ICT and the subject matter taught?

Methods and Data Source

The majority of existing results on the use of ICT in classroom is based on survey studies with students and teachers about their perceptions of ICT implementation in instruction. However, survey studies are always influenced by the subjective point of view. There exist only few analyses of teaching patterns with regard to ICT by independent observers (e.g. Schaumburg, 2003).

Therefore, this videotape study analyzes in detail the *behaviour* of 18 teachers (in one lesson each) according to core categories of instructional quality. A teacher-centered camera is used in their lessons of Mathematics (n=12), Computer Science (n=4) and German (n=2). These Teachers instruct

high school classes (grade 11 to 13) in 16 different schools in 6 federal states of Germany. All teachers participated voluntarily.

With reference to other video studies (Stigler et al., 1996; Clausen, Reusser & Klieme, 2003; Pelgrum, 2001) a detailed *low*-inference coding scheme was developed for this analysis. It includes the observation of the interaction between teacher and class (e.g. complexity of questions, teacher and student role) and didactic dimensions (e.g. complexity of tasks, type of ICT use) in time sampling. Except for the verbal interaction categories, a one-minute-time code is used. The verbal interaction is analyzed using a five-second time code to capture the complexity of the verbal interaction between teacher and class. Based on the coding of three independent observers the exact inter-rater agreement is computed (Cohen's kappa). The agreement ranges between good and very good ($.68 \leq \kappa \geq .92$).

Results

The video codings are analyzed using a cluster centroid analysis to identify different teaching scripts. On the basis of empirical findings and theoretical considerations regarding learning environments a *three* cluster solution is favoured. The solution is replicated by a discriminant analysis. All teachers are classified correct on the basis of the relevant characteristics (variables) to one out of three groups. There is a 100% concordance between the results of the cluster centroid analysis and the discriminante analysis. Furthermore, the three cluster solution is replicated by a factor analysis[3]. The solution with three factors explains approx 74% of variance. The identified factors replicate exactly the three different clusters.

The *three* teaching scripts can be described as follows:

- "traditional ICT-teaching script"[4] (n=5) with ICT used in a cram-like kind of instruction,
- innovative ICT-teaching script" (n=8) to promote student- and problem-centered learning, and
- "modern traditional ICT-teaching script" (n=5) with ICT used in a mixed kind of instruction.

Teachers with a "traditional ICT teaching script" use the computer more often to present content than the other teachers. In approx 76% of the lesson the teacher plays the active part dominating the communication with directive statements (60% of lesson). Furthermore, the proportion of complex assignments is low. These teachers rarely apply tasks of a high didactic quality, such as evaluation tasks or complex problems. They use whole-class work as dominant instructional pattern. A high proportion of class work is teacher-directed class

[3] Basis for the factor analysis was a transposed data matrix in which the cases (teachers) serve as variables and the variables serve as cases.

[4] Not to be mixed with an instructional teaching style that can also have a high instructional quality like direct instruction (Brophy & Good, 1986; Bereiter & Kurland, 1981; Helmke, 1988; Good, Grows & Ebmeier, 1983).

discourse (80%). During half of the time the teachers in this group control the computer.

Teachers with an "innovative ICT teaching script" realize the highest proportion of student demonstration in classroom. The teacher is not the main actor (39% of lesson) but students play the active role during the lesson (approx 50% of lesson). In this group teachers do not dominate the communication (only 27%). They show the highest task quality by employing a high number of complex tasks. Class discourse is used in only 19% of the lesson time. The time in which the teacher controls the computer is minimal (7% of lesson time). If presentations occur, they are often given by students. ICT is used as a tool[5] for task performance more often than in the other two groups.

Finally, with regard to their activity teachers of the "modern traditional ICT teaching script" rank in between the other two groups. They dominate the communication (32%) a little bit more than the innovative type and much less than the traditional type. This group is also mid-range regarding the activity of students (30% of lesson time). Complex tasks are less often used compared to the innovative type (34% of lesson time). Nearly half of the lesson all students of the class work together. Almost the same time is spent in class discourse guided by the teacher. Like the innovative type teachers of this group use ICT intensively as a tool and much less for presentation purposes. Figure 1 summarizes the results.

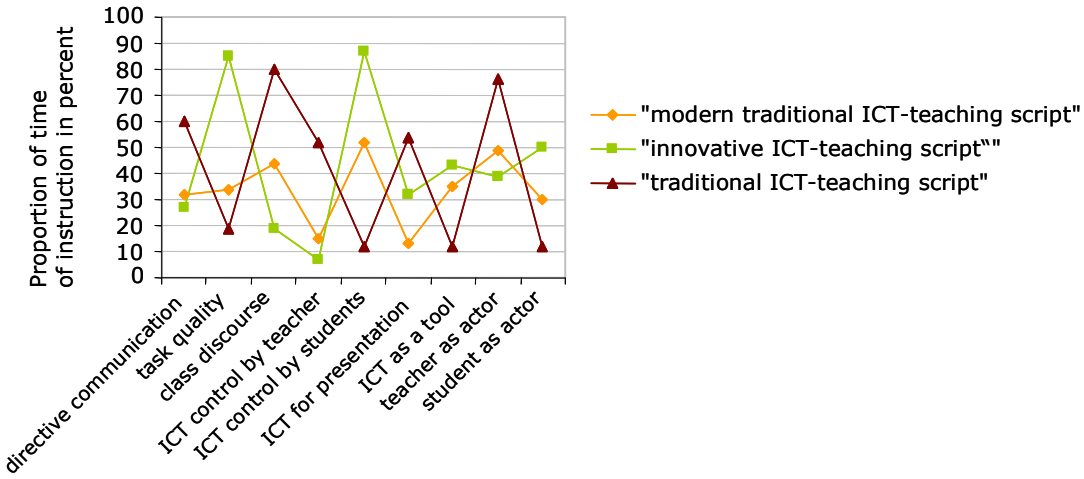

Figure 1: Teaching scripts while teaching ICT in Mathematic, Computer Science and German classes.

Regarding our second research question the data is analyzed using a cross classified table to determine if there are differences between the subjects taught. The result confirms a relation between the subject matter taught and the use of ICT ($\chi^2_{(4,\ 18)}$=14.87; p_{exact}=.003). The "traditional ICT teaching script" is only

[5] Tool use is defined as software use which is neutral with respect to the content and didactic dimensions, e.g. Excel, Word, Macro Media.

observed in the group of Mathematics teachers (n=4). In contrast, the innovative type mostly occurs in the group of Computer Science teachers (n=4) and only one Mathematics teacher shows an "innovative ICT teaching script" (n=1). All examined German teachers (n=2) and seven Mathematics teachers use ICT in a modern traditional way. To sum up, the results of this sample show that Mathematics teachers have a higher affinity to the "traditional ICT teaching script" than their colleagues in Computer Science and German.

Discussion and Conclusion

The presented study yields interesting insights in ICT integration in instruction, even though, the number of lessons analyzed is rather small. Nevertheless, three distinguishable ICT teaching patterns are identified: the "innovative ICT teaching script" which is student- and problem-centered, the "traditional ICT teaching script" with great vicinity to a cram-like kind of teaching and the "modern traditional ICT teaching script" which can be located between these two different teaching scripts. The identified types of ICT use can be classified on the dimension "linear directive teaching"[6] and "student- and problem-centered teaching". These teaching patterns are well established in instructional research while the presented study extends these findings to ICT usage.

Empirical research shows that teachers with characteristics like those described in the "traditional ICT teaching script" have a relatively low instructional quality (Brophy, 2000; Klieme, Schümer & Knoll, 2001; Mariage, 1995). Teachers with characteristics like those described in the "innovative ICT teaching script" use complex tasks and support self directed- and problem-centered learning. These dimensions correspond to indicators of high instruction quality and effective teaching (Brophy, 2000; Cohen, 1994; Gutiérrez & Slavin, 1992; Helmke & Jäger, 2002).

Studies which expect a nearly automatical change through ICT integration (see above) to achieve constructivist teaching could not be confirmed by this study. It seems that teachers do not use the full potential of ICT. Most of the teachers show teacher-directed use of ICT ("traditional and modern traditional type"). Only a small group of teachers use ICT in a more student-centered environment ("innovative ICT teaching script"). But, even these teachers do not use ICT in its full extend. They rarely apply ICT for communication and documentation purposes or as a source of information. The various possibilities do neither occur in the subgroup "innovative ICT users" nor in the whole sample. To sum up, it can be said that teachers do not use ICT automatically in the sense of constructivist teaching. Furthermore, they do not achieve a high level of quality of instruction while using ICT. This is even more surprising since this sample is a positively selected sample of teachers who volunteered to participate.

[6] Step-by-step classroom discourse is the dominant teaching pattern.

From the perspective of the three examined subjects taught the results of the presented study suggests that Mathematics teachers integrate ICT in their traditional linear concept of instruction. Only few use the possibilities of ICT for a high instructional quality. In fact, it seems that this group simply substitutes e.g. Power Point presentations for black board lessons. Additionally, the results point to further evidence for different teaching cultures (Feiman-Nemser & Floden, 1986) and confirm the influence of subjects on the use of ICT (Jones, 1999).

Finally, it can be said that the results of this research significantly contribute to what teacher trainers, teachers and researchers know about the use of ICT in instruction. This knowledge might be valuable to instructional research as well as research on computer-based teaching and learning.

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