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TEACHERS AND COMPUTERS

THE 'COMPUTER CONCEPTS' OF GERMAN MATHEMATICS AND COMPUTER SCIENCE TEACHERS

Abstract:
This paper gives an overview of the results of a research project which was undertaken to analyse the 'computer concepts' or 'computer world views' of teachers. The topics in question concern the teachers' concepts of computer science as a scientific discipline and as a school subject, their concepts of good teaching, a change of teaching paradigms in German computer sciences classes, and the teachers' attitudes towards computers.

Introduction

In recent years, great efforts have been made to introduce computers and new media into schools. It is widely thought that the effective teaching of computer science is predominantly influenced by the teachers' cognitive skills, with emphasis on up-to-date technical knowledge. However, as a study by the author has revealed, a teacher's individual 'computer concept' or 'computer world view', i.e. a complex structure with cognitive, affective, and operational components, also influences the teaching process considerably.
The present paper gives an overview of some results of this study, i.e. a research project which analyses the computer world views of German mathematics and computer science teachers (cf. BERGER 1997b, 1997c, 1997d). This project is related to the international research program of the MAVI (mathematical views) group which has been initiated by G. Törner (Duisburg) and E. Pehkonen (Helsinki).[1] MAVI is undertaking research into the mathematical and related world views of teachers, pupils, scientists, and similar groups.
The computer world view (or computer science resp. mathematical world view) can be loosely described as an individual's view or philosophy of the 'world of computers' (of computer science resp. of mathematics). More precisely, it can be understood as a complex system ('belief system') of individual images, convictions, opinions, and attitudes towards a certain topic or context with a strong and, in part, subconscious influence on the manner in which the individual deals with this topic – on his thoughts, emotions, and behaviour, for example as a pupil or as a teacher. World views gain didactic relevance, not least in that they may play the part of a 'hidden curriculum', having a selective and directive impact on the teacher's performance. (For a survey of the concept of 'belief systems', see PEHKONEN 1994, TÖRNER 1995, PEHKONEN & TÖRNER 1996a, 1996b, and TÖRNER & PEHKONEN 1996.)
The central notion of *attitude* is defined by psychology as an acquired, not necessarily consciously performed, and long-lasting readiness of an individual to react in a consistent manner towards persons, objects, ideas, etc. (cf. SEIFFGE-KRENKE 1974). Attitudes allow an individual to tackle successfully unknown situations without each time having to construct new concepts of actions and explications. Attitudes consist of three components: a *cognitive* component (knowledge of the item), an *affective* one (emotional relationship to the item), and an *operative* one (disposition of behaviour towards the item). Attitudes affect the individual's mental

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constructs in a directive, selective, and consistent way, and they have a highlighting and structuring effect on the individual's view of reality (reduction of the multitude of environmental stimuli) and thus contribute to the forming of a schematised behaviour of the individual in a certain situation.

The study is methodologically based on instruments of modern qualitative social research (cf. LINCOLN & GUBA 1984 and TESCH 1990), which are, apart from participant observation, mainly characterised by detailed analyses of exemplary single cases with the help of intensive in-depth interviews. The analysis of the interviews followed the principles of modern hermeneutics (cf. BECK & MAIER 1994 and BERGER 1997a).

Qualitative methods in general seem to be more suitable for the exploration of attitudes than quantitative would, even if based on a large number of random tests. It could reasonably be argued that the actual conflict between quantitative and qualitative social research originates in two epistemologically different conceptions of what a theory for sociology should look like. The quantitative sociologist's concept of a 'logico-deductive theory', which is empirically proved only in retrospect, is opposed by the naturalist's concept of an inductive or 'grounded' theory, i.e. generated by induction grounded in empirical data. "The adequacy of a theory for sociology today cannot be divorced from the process by which it was generated – and we suggest that it is likely to be a better theory to the degree that it has been inductively developed from social research." (GLASER & STRAUSS 1967, p.5). That means that qualitative methods become emancipated from mere preliminaries to quantitative research – in order to achieve the status of important tools for the development of theories which, as they are grounded in empirical findings, will better fit to social reality.

The investigation proceeded in two phases: the first being an exploratory preliminary study with open and non-standardised interviews, which was followed by the main study – designed on the basis of the outcomes of the preliminary study – with a questionnaire and open and standardised interviews. The empirical material consists of the video-taped interviews (1 – 2 hours each) of 28 computer science teachers and two computer scientists (in leading positions of the school administration) as well as the transcriptions of these interviews (250000 words). The teachers work in grammar schools and comprehensive schools in Northrhine-Westfalia, one of the 16 Federal States of Germany, and most of them teach mathematics as a second subject. 50% have degrees in computer science; another 39% have undergone a two-year intensive teacher training program in computer science.

An investigation of the computer world views of mathematics and computer science teachers should not regard teachers only as teachers. The individual acts in specifically different social roles: in the role of a *teacher,* in the role of an *expert* (on mathematics and computer science), and last but not least in the role of a *private person,* i.e. an active member of society. Corresponding to these social roles, there are three experiential domains forming a teacher's views of the computer, i.e. *school, science,* and *society*. Based on experiences in these domains, each social role separately may have shaped the computer world view of the individual, resulting in specific facets and in overlapping and sometimes even inconsistent partial views.

Corresponding to these domains of experience, the interviews and the questionnaire included three thematical domains, in which the partial views, analogous to the attitudinal components, were manifested and thus could be analysed as *opinions* (judgements on the truth or probability of statements about reality), as *affects* (feelings of attraction or rejection), and as *dispositions of behaviour* (predispositions for actions).

Concepts of computer science as a scientific discipline

As one result of the study, it turned out that the interviewed teachers actually do not see computer science predominantly as a ‘science of the computer’. The interview statements regarding computer science as a scientific discipline are thoroughly characterised by a distinct ‘computer distant’ point of view. This is also confirmed by a quantitative observation, i.e. in the statements describing the essentials of computer science as a scientific discipline, the frequency of the terms ‘computer’ (or German ‘Rechner’) and ‘machine’ is significantly low. More than 60% of the respondents do not use the term at all, or only once. If it is used, it is often done with the intention of restriction and distancing.

- ”[In computer science] everything has somehow got to do with computers. Nevertheless, computers are not the point, but all those theoretical foundations.”
- ”In my view, the computer is not really a characteristic feature of computer science.”
- ”The technical know-how, the machine, is one aspect. But *that* I would rather regard as engineering, not as computer science.”

Some of the interviewees have rather subjective conceptions of computer science, coming up with a broad spectrum of individual characterisations.

- ”Basically, computer science deals with the outside world in our heads. That’s actually the same as philosophy does.”
- ”Computer science is: Given a problem, how to find a solution?”
- ”Computer science is to handle complexity. It is itself complicated, and it must be, just because the world is complicated.”
- ”Computer science has become a rival to mathematics. Mathematics now is annexing subjects of computer science.”
- ”I think, the crux of the matter is, that we do not know exactly what we are actually doing and what sort of science that might really be, which is copying a little bit here and there [from other sciences].”

Computer science essentially is ...	No. of respondents
information science	5
structural science, as mathematics	3
computer science, oriented towards applications	3
theory of algorithms	3
computer science, oriented towards foundations	2
theory of formal languages and machines	1
system analysis (science of systematically solving problems)	1
formal philosophy	1
science of complexity	1
a ‘hotchpotch’ of other sciences	1

Table 1. Teachers’ characterisations of computer science as a scientific discipline.

For the most part, the teachers see computer science as a dominantly formal science. Even some who regard computer science as ‘science of the computer’ emphasise its foundational aspects (cf. Table 1).

Concepts of computer science as a school subject

Although the interviewed teachers for the most part are highly committed to their subject (without this commitment they would not have gone to so much trouble as to study computer science while already being employed as teachers), they do not seem to overestimate the rank of computer science within the scope of the other school subjects.

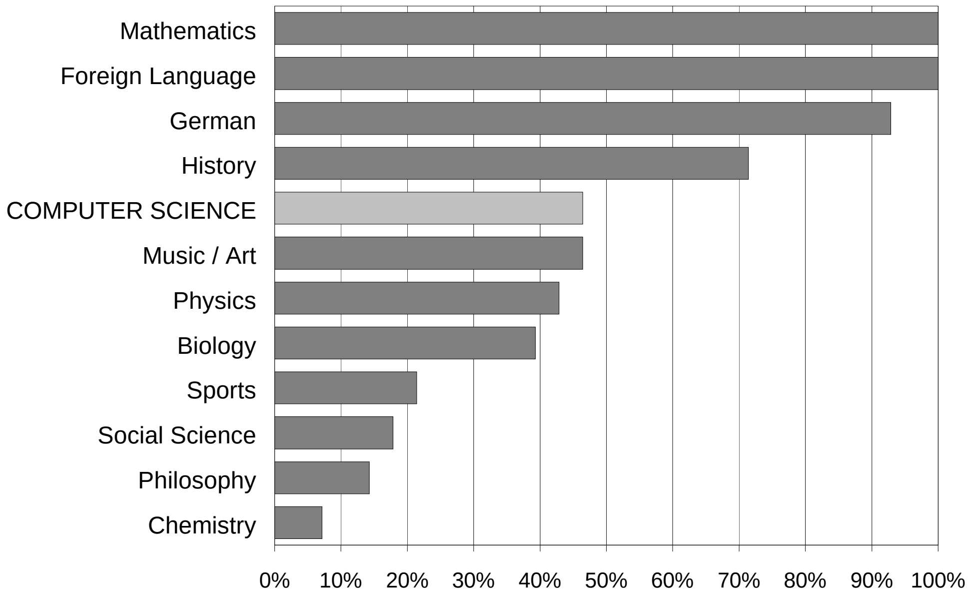

Diagram 2. Teachers' assessments of the rank of computer science as a school subject.

On the one hand, most of the interviewees state that in the future computer science should play the important role of a fundamental school subject, emphasising that computer science will be able to develop the students' skills of solving complex problems better than other subjects would (even better than mathematics). On the other hand, they answer rather conservatively to the hypothetical question of which subjects they would prescribe for senior students if a set of six compulsory subjects had to be decided upon (see Diagram 2). Everybody chooses mathematics and a foreign language, almost everybody German and 70% history, but only half of them choose computer science. Computer science, however, like music and art, is being ranked higher than natural science.

In the preliminary study, three aspects of computer science have been named as the most central ones at school: namely 'computer', 'programming language', and 'algorithm'. Diagram 3 shows how the teachers assess the centrality of these aspects and how this assessment changed during their years of teaching experience. The answers (distribution of 100 points to the three items) are represented by barycentric co-ordinates, where the pin-heads show the present and the pin-points the former positions. The diagram shows a distinct orientation towards *algorithm* which, on the basis of a detailed analysis of the interviews, may be understood as a general tendency *from phenomena towards essentials*, i.e. as a didactic concentration on the fundamental aspects. This turning away from the engineer's fascination with hardware and software aspects, which had been accentuated in prior times, and the turning towards the concept of algorithm, which is regarded as fundamental nowadays, is especially prominent among computer science teachers with an academic background.

While the period of introducing computers into schools was shaped by a ‘pioneering spirit’ which quite uncritically accepted the challenge of the new medium, most of the interviewed teachers today show a more sceptical attitude. The acceleration of hardware and software innovations is experienced as an inflationary process, rapidly rendering technical knowledge outdated. As an answer to this ‘race for innovation’, the interviewees tend to favour fundamental aspects as the basis of a long-term computer literacy.

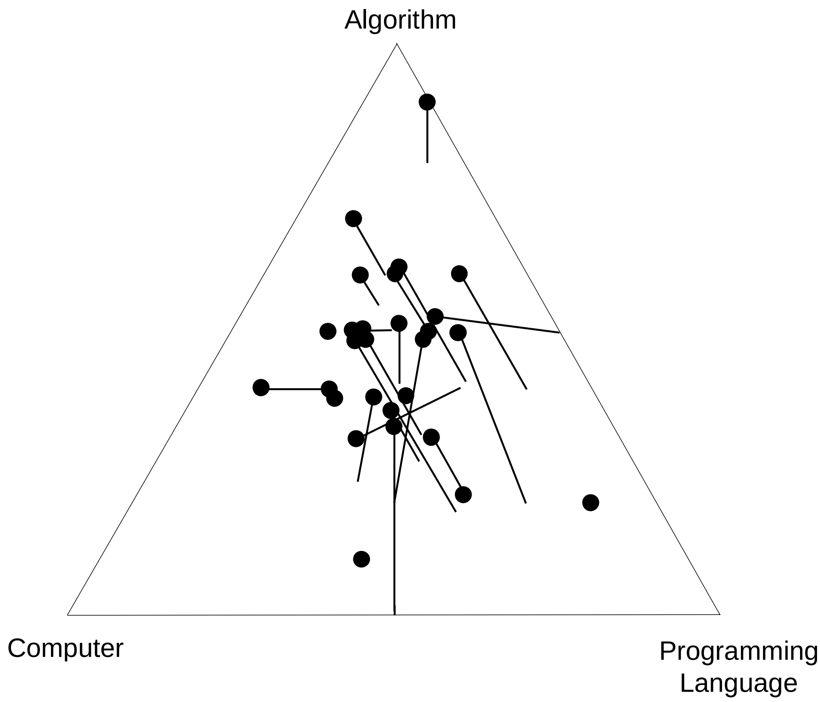

Diagram 3. The view of central concepts of computer science.

Following an increasingly intensive didactic reflection on the actual situation of computer science as a school subject and highlighting its contribution to the aims of general education, the basis for a confident and competent handling of the medium computer is increasingly seen to lie in the *emancipation of the human from the machine*. The teaching of local tactics (e.g. detailed knowledge of a certain programming language) recedes in favour of the teaching of global strategies (problem solving, thinking in complex structures of processes and systems).

Even the academically trained computer science teachers emphasise that the gap between computer users and developers of hardware and software is today nearly unbridgeable. While during the pioneering period the computer science teachers, for the most part, saw themselves as specialists with an up-to-date technical knowledge who wanted their students to acquire the same expertise, nowadays the teachers aim at making themselves and their students confident and competent computer users provided with a sound background knowledge, at least in the ideal case. In present-day computer science classes, the computer is no longer seen as a ‘magic machine’ placed at the centre of teaching and learning activities. It is, rather, from the perspective of the fundamental aspect of algorithms, seen at a relativised position.

Concepts of teaching computer science – innovation vs. tradition

Within the interview context concerning the teaching of computer science, we asked the question ”Are you a different type of teacher in computer science classes (compared to math or other subjects)?”. The spontaneous individual answers given in the interviews are, in a standardised form, shown in Diagram 4. By far the majority of the respondents see their role in computer science classes as different from that in their other subjects, especially in mathematics.

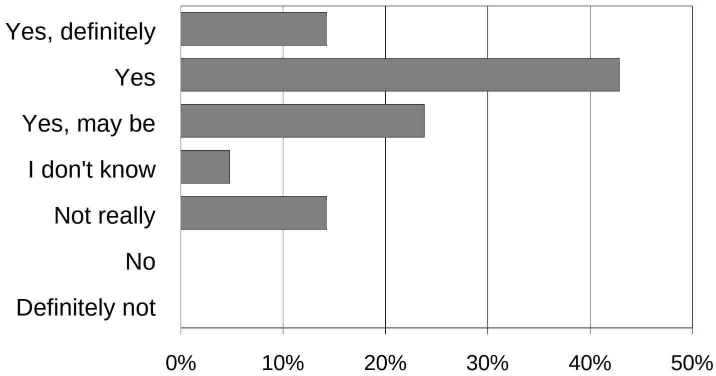

Diagram 4. Are you a different type of teacher in computer science classes?

How do the interviewees describe the roles of a computer science teacher in detail? If we extract each ‘meaning unit’ (statement or term) referring to the description of a teacher role from the totality of the interview transcripts, we find a clear grouping of nine main roles. Some teachers focus on one or two aspects. Most name several different roles. In detail, they refer to the roles of a ...

- *lecturer:* ”gives a lecture”; ”imparts knowledge”; ”carries knowledge over to students”; ”says what things are like”;
- *distributor of marks:* ”makes assessments of students’ achievements”; ”gives marks”;
- *mediator:* ”trouble-shooter”; ”mediator of conflicts between students”;
- *problem designer:* ”stimulator”; ”presents problems”; ”brings up problems”; ”invests much time to find problems, in co-operation with students”;
- *serviceman:* ”net administrator”; ”provides the technical environment”; ”has to take care that it works”;
- *teamwork manager:* ”planner of projects and teamwork”; ”project manager”; ”organiser of the working process, planned along with or by the students”; ”moderator of teamwork”; ”helps students to make a product”;
- *consultant/coach:* ”I’d like best to be a mere answerer of questions”; ”provider of information”; ”like a coach”; ”walking around or just sitting down until the students come to ask”; ”plays the part of a consultant, not of a ‘pusher’, an expert, being at the students’ disposal, but keeping out of the way most of the time”;
- *chairman:* ”chairman”; ”moderator of discussions”;
- *member of a team:* ”after overcoming the first difficulties, I see myself rather as a member of different teams”.

Diagram 5 shows how many teachers mentioned each particular role. While some of these roles (lecturer, distributor of marks, mediator) are traditional teacher roles, some are distinctly innovative (teamwork manager, consultant/coach, chairman, member of a team). Some roles are situated in the border zone between innovation and tradition (problem designer, serviceman). However, according to the characterisations of these roles given in the interview, they rather tend towards the innovative side.

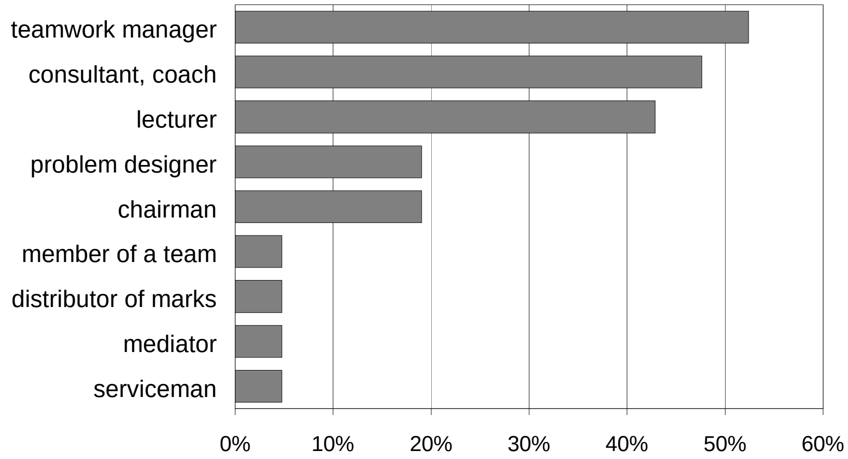

Diagram 5. Roles of a computer science teacher.

It is remarkable that there are more innovative roles than traditional ones and, moreover, that innovative roles are significantly mentioned more frequently. Only in the third place do we find the first traditional role of a lecturer. The two most frequently named roles (teamwork manager and consultant, coach) are innovative; more than 75% named at least one of these two roles. Only three teachers did not refer to an innovative role at all.

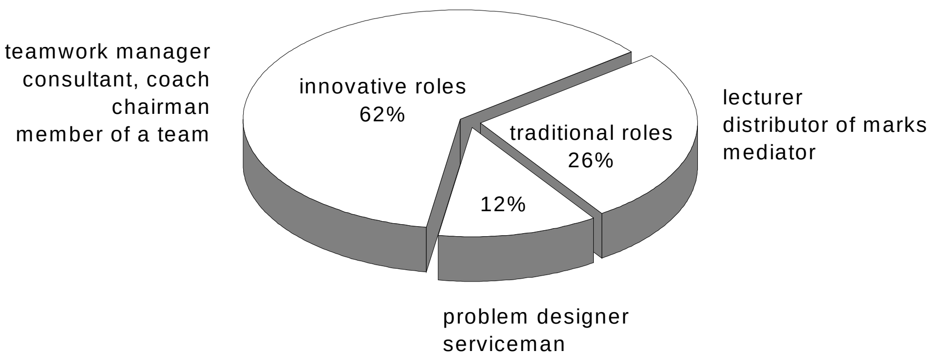

Diagram 6. Innovative vs. traditional teacher roles.

If the frequencies of the teacher roles are counted not on the basis of the totality of teachers, but on the totality of comments on teacher roles, the outcome is as shown in Diagram 6. In the spectrum of teacher roles, a dominant part of all comments (62%) refer to innovative roles.

Computer science versus mathematics – contrasting views and attitudes

As a thorough analysis of the interview statements reveals, this orientation towards innovation may not be understood as a general attitude applying also to the teachers’ other subjects. It is, rather, closely connected to some specific aspects of the teachers’ conceptions of computer science, which is seen to be in remarkable contrast to the case of mathematics. In the following, this will be illustrated by some typical quotations referring to three main aspects, i.e. the *educational essentials of mathematics and computer science*, the *styles of teaching and learning*, and the *'evolutionary status'* of both subjects. The interview questions did not explicitly ask about teaching mathematics. However, an average of about 8% of all interview texts are comments on mathematics, brought up by the teachers of their own accord.

The following quotations, by different teachers, manifest a general difference in their views of mathematics and computer science with regard to *educational essentials*. While mathematics is seen to be oriented towards theory and formalism, computer science is characterised as 'practical', 'concrete', 'interdisciplinary', oriented towards applications, projects, and problem solving:

- ”To me, the problem with math is that the questions are normally not as practical as they are in computer science. In math, many problems do not come to that point of everyday life. That's more distant.”
- ”Of course, there is theory in computer science, too. But, here, even theory is somehow different to math. In computer science things simply get more relaxed.”
- ”A good project for math? Hard to find – what should it be like?”
- ”Math is too dry. In computer science, what I can do with math, is to try it out and take a look at it. Algorithms and so on.”
- ”Well, I feel the teaching of math and computer science are totally different. Of course, I'd like to teach math in a problem-oriented way as well. However, the problems are not as comprehensive and complex as they are in computer science classes.”
- ”As I see it, computer science is oriented towards applications. Theory, here, is developed along with the process of problem solving. Perhaps a mathematician would say that it's the same with mathematics. To me, computer science, first of all, is application; application for solving problems and making practical things much easier.”
- ”I see no other school subject as such a good opportunity for interdisciplinary work: I've got a practical problem which I'm going to solve by means of computer science; I may use mathematics as well, but I have to take into account as well a lot of totally different aspects. I think it is a fantastic school subject to recreate those synopses which we have lost through a narrow specialist thinking. In mathematics, problems mostly are artificial; in computer science, I actually can tackle real problems.”

This contrast is also reflected in the teachers' different conceptions regarding *the styles of teaching and learning* in mathematics compared with computer science classes. Teaching mathematics is characterised as 'frontal', 'teacher-centred', and 'dogmatic', whereas teaching computer science is associated with keywords such as 'teamwork', 'creative', 'active', 'co-operative', 'co-determined', as the following quotations show:

- ”Teamwork is much more often involved in computer science classes than in math classes, where most teaching is done on the blackboard. In computer science things are easier and more relaxed.”
- ”There is a small chance to use teamwork even in math classes, but mainly in computer science you can let students manage things in their own way.”
- ”In computer science classes, more often than in math classes, I am a moderator: Someone, who is initialising certain processes, which will then run by themselves.”
- ”Teaching math is more formal. Teaching computer science is oriented towards teamwork.”
- ”Learning objectives are never simple in computer science. Almost everything is aimed at problem solving, creative work and something new. Of course, this requires

a different kind of teaching, whereas certain math topics can be taught rather dogmatically."

- "In math we fall back on class teaching. Other social forms, teamwork for example, can only be realised in computer science."
- "In computer science, I mostly keep back myself. Math lessons are much more teacher-centred."
- "Computer science is taught in a considerably more teacher-centred way, which in math I cannot realise and perhaps do not even want to realise, because of the great amount of material that is to teach at math. In computer science, I take the liberty to respond to students' problems much more often."
- "In computer science classes one should keep out as far as possible. In math classes the teacher's role is much more dominant, and I need more class teaching. When carrying specialised knowledge over to the students, even in computer science I need that, but not when I have students create ideas. That is just where they can get active, and that's missing in math."
- "I feel considerably more insecure in computer science. However, I feel more relaxed because I think that I can have much more confidence in the students than I could have in math."
- "In computer science you are rather 'a peer amongst his peers' and sometimes you have to take care not to be too close friends with your students: this might happen frequently in computer science, whereas in math you still tend to a teacher-centred lecturing."

Some teachers explain their contrasting concepts of mathematics as opposed to computer science by the different '*evolutionary status'* of both subjects. They regard mathematics as 'old', 'completed', 'formalised', and 'inflexible' and in contrast to this, computer science as 'new', 'in a state of flow', and 'open-ended'. The fact that in computer science 'things are changing and still developing' is seen as a 'chance to try out new things', while in math 'old teaching patterns and methods are irresistible'.

- "In computer science, there is always a kind of change and evolution. There is always something new that makes me work more for computer science than for math, where all is like stiffness, inflexibility."
- "In computer science, one is engaged in developing things further, whereas in math one sticks to didactic concepts which have been used a thousand times."
- "Computer science is more in a state of flux than mathematics is, both as a science and in its effects on society and education."
- "The fact that computer science is not yet that definitive and is still changing and turning upside down, is actually a chance to try out new things. You know that the math curriculum is not given by God, but you are always tempted to stick to it and to say 'who cares, I simply carry on like this, so it's printed in the book'."

In order to understand the causal connection between the teachers' readiness for innovation on the one hand and the circumstances of computer science as a school subject on the other hand, we may consider two basic approaches, two models of interpretation:

- *Model 1* Computer science teachers *a priori* are innovative. Only innovative teachers will choose computer science as a new subject and will be motivated to undergo the trouble of lengthy in-service training programs or university studies of this subject, as most German computer science teachers actually did.

But if this interpretation is applied, the innovational attitude of computer science teachers should be manifest also in their other subjects. However, from the interviews it became evident that for most of the interviewed teachers innovation is confined to their activities in computer science. On the basis of the interview material, along with an analysis of the situation of a computer science teacher in Germany, the following model can claim more validity:

- *Model 2* Computer science teachers *a posteriori* are innovative. Teaching computer science 'makes' a teacher innovative. Computer science as a school subject is not yet supplied with a sound background of didactic orientation and specific teaching methods. In this situation, and in contrast to math, teachers are forced – and free – to search for suitable models, even outside traditional schooling.

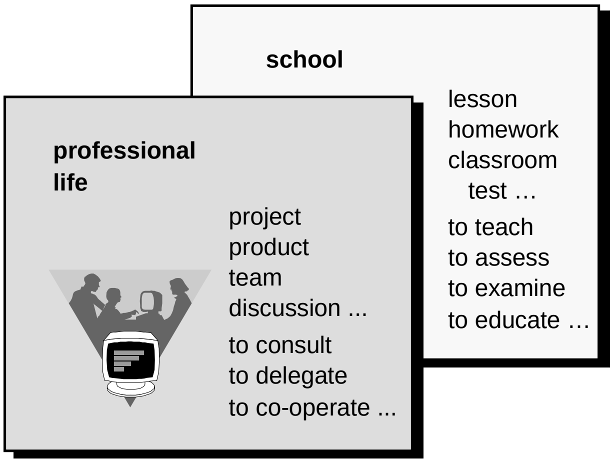

Figure 7. Two paradigms of teaching computer science.

At present, we can observe a change of teaching paradigms in German computer science classes. The traditional paradigm 'school' – characterised by keywords such as 'lesson', 'homework', 'classroom test', 'teaching', 'assessing', 'examining', 'educating' etc. – has not yet been replaced, but is increasingly paralleled and superposed by the new paradigm of 'professional life' with the leading concepts of 'project', 'product', 'team', 'discussion', 'consulting', 'delegating', and 'co-operating' (cf. Figure 7).

This ongoing change, however, follows a process of intentional didactic innovation and purposeful development of a new teaching style only in particular cases. More often, it occurs by adopting a ready-made system of approved social patterns from a domain outside school. This domain is the world of computer and software professionals, which has (consciously or subconsciously), in most teachers' views, obtained the status of a role model. The orientation of a school subject towards a model from outside school is a feature specific for computer science, revealing one characteristic aspect of the nature of 'computer world views'.

Even in computer science as an innovative school subject, innovation appears not to be achieved by the innovative teacher, who creates a new paradigm of teaching – but rather by a new paradigm that makes a traditional teacher act in an increasingly innovative style.

Computers and affectivity

Whereas the interview statements concerning *computer science as a scientific discipline* are characterised by a distinct 'computer distant' perspective, the role of the computer in the domain '*school*' is mostly seen in a reduced, but still central position, as mentioned above.

However, the statements concerning *computers and society* in many ways form a reasonable contrast to this. Most of the teachers attach great importance to the computer in this domain and see its role here as central. Significantly, frequent individual assessments are made and the comments are often emotionally charged.

The assessments are highly individual, forming a wide range from euphoric agreement to vehement disapproval, from confidence to extreme worry. As an illustration, we quote from different interviews:

- ”The computer is the central medium – it secures our standard of living.”
- ”I think we could not survive without the computer.”
- ”At the moment we are living in a time where the computer is being overestimated, simply because it is a time of radical change. In 50 years, it would be a dead-normal thing, like a kitchen appliance today.”
- ”The technological instrument computer has infiltrated us.”
- ”A radical change is going on. How it will develop – there are so many tendencies – it’s a horror. One could barely describe it in words – it will crash.”
- ”It depends on what man makes from it, it’s another kind of atomic bomb coming our way.”

There is a widely held opinion that having been familiar with computers for a long time, a computer science teacher’s attitude towards computers could not be characterised by fear nor fascination. Some of the interviews and the quotations above, however, reveal a totally different view. On the one hand, some teachers describe their attitudes toward computers from a subliminal perspective of fear:

- ” ... people could blame me for things that I couldn’t do. ... But that I don’t fear now. ... However, yesterday I was in the computer centre, and I acted a little bit stupid. I only needed some information, and I immediately said that I am totally stupid, because the person there always acts a little bit arrogant and so. So I didn’t necessarily want him to know that I had studied computer science. I fear that somebody would blame me for not being able to work with MS-DOS or Unix commands ... ”

On the other hand, teachers with many years of computer experience are revealing their high-flying expectancy of the skills of a next generation of computers, exposing contrary positions of both euphoric agreement and extreme worry within a narrow context.

- ” ... a crazy possibility to communicate with a gigantic public. Global village – a fascinating thing ... When it breaks free, it would become a gigantic danger of totally losing yourself ... that is a gigantic danger – a gigantic danger ... you are separated. We
  ould no longer communicate with all those non-verbal signals, but only by computers. That’s a gigantic danger ... the computer would become an instrument damaging the whole society. On the other hand, I can fully understand that naively euphoric usage. ... It is a totally new experience, you can discover some totally new aspects of your own personality. Thus, it is a widening of one’s own self – definitely. ... I find it a fascinating thing. It is fun. ... This central communicating-machine, I think, will come ... yes, that will be fun.”

	fields of experience		
	science	**school**	**society**
role of the computer	peripheral	central, but qualified	central
importance assigned to the computer	little	medium	high
frequency of assessments	low	medium	high
affectivity of the statements	none to low	medium	medium to very high
	expert	**teacher**	**private person**
	social roles		

Table 8. Global interview profile.

If analysis of the interviews with respect to the computer concepts is done by applying the parameters *contents* (what does the interviewee say about the computers' role in the specific field?), *assessments* (how, and how often, does she or he assess this role?), and *affectivity* (what is the extent of emotion in the presentation of this role?), it turns out that there is essentially one global interview-profile which characterises all interviews (see Table 8).
There is a significant qualitative correlation between the importance assigned to the computer, the frequency of assessments, and the affectivity colouring the corresponding statements.

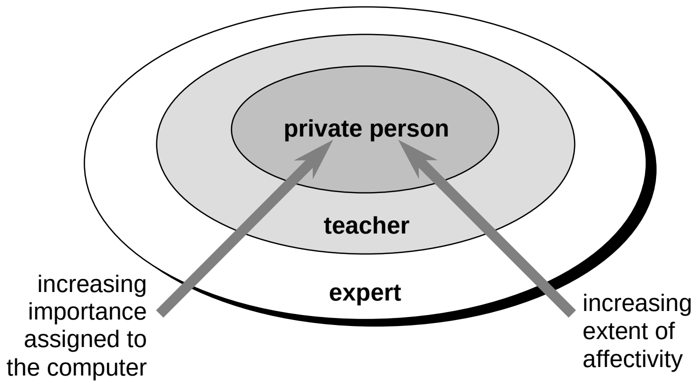

Figure 9. 'Shell model'.

From *science* via *school* to *society*, the computer views of each interviewee take a more and more emotionally charged perspective, while the role of the computer is increasingly considered as central and relevant. According to the hypothesis that higher affectivity refers to deeper layers of personality, we may depict the situation in a 'shell model' as shown in Figure 9. The more the theoretically specialised character of the field declines and social aspects and everyday experiences become determining, the greater the importance (approving or disapproving) attached to the role of computers becomes. The more the human being is involved, the more the phenomenon computer is seen as 'explosive'. The view of the *expert* is not, as one would expect, computer-centred, but the view of the *private person* is.

Conclusions

As the study revealed, a teacher's individual computer world view or computer concept, i.e. her or his attitudes towards computers and the context in which they appear, represent a decisive factor in the teaching (and learning) process. The cognitive components constitute only a part of these computer concepts, the other parts being the affective and the operational components. The study showed that it is first and foremost the affective component which has a selective and directive impact on the teachers' performance.

Even young teachers who on the surface seem to be well-equipped for their jobs as mathematics and computer science teachers did not altogether prove to be without an apprehension of computers, if subconsciously. Such observations gain even more importance, as the outcomes of the study indicate that a teacher's computer concept may constitute a 'hidden curriculum'.

In order to contribute to an adequate training of mathematics and computer science teachers, an analysis of their computer concepts should be integrated into current research, and especially so on an intercultural level. Further studies should be undertaken to allow a deeper insight into the affective aspects of teaching and learning processes in the realm of mathematics and the new media.

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