Implementation of Computer Science in Context - a research perspective regarding teacher-training

Ira Diethelm, Claudia Hildebrandt and Larissa Krekeler
Carl von Ossietzky University
Computer Science Education
26111 Oldenburg, Germany
firstname.lastname@uni-oldenburg.de

ABSTRACT
In order to increase the number of students and professionals in computer science a context-oriented approach for teaching is often suggested, e.g. in [7]. But there is no structured approach to transfer the concept of computer science to its implementation at schools or universities, yet. This aspect is also not mentioned in current research. This paper aims to open a discussion by shifting the focus from the concept to its realization which requires teacher-training and teaching material. We present our initial steps for investigating the transfer of the symbiotic implementation strategy and how it was established for chemistry in context to the field of computer science.

Categories and Subject Descriptors
K.3.2 [Computers and Education]: Computer Science Education, Teacher Training

1. INTRODUCTION
Innovative teaching approaches have one problem in common: How to put them into practice. New approaches often sound very promising and helpful for students to learn more CS or motivate them for it. But studies like [6], already made in 1971, showed that top-down strategies are not enough to implement a new approach which aims to change the teaching practice of teachers.

In the case of CS in context this would be to motivate the teachers to rearrange their teaching concepts to a much more student-centered approach. It points out the relevance of the regarded contents in the context of their every day life. It also aims to enhance teaching methodology. Implementation of this concept appears to be a big amount of work. But we can learn from similar projects of natural sciences such as chemistry in context – ChiK. Therefore we start with a report on ChiK and its symbiotic implementation strategy in the following section. We also try to explain why we have so few students in our CS studies at universities.

In section 3 we discuss the special conditions of CS teachers that may influence the success of an implementation of CS in context. There we elaborate several factors which should be considered during a research project for the implementation of CS in context. The aspects discussed are also reasons why teacher training in CS is urgently required.

In section 4 we present our first ideas for research questions and research methodology including first items for a survey. We also report on our activities preparing for the survey and some expected results. We hope that our results will help to overcome the gap between theory and practice in teaching CS in context.

2. RELATED WORK
2.1 Computer Science in Context
The phrase CS in context is used in differing ways: CS in context is used for a courses at university that focuses on more practical aspects of computer science like information and application. Also, a context-oriented approach often means to use project-oriented teaching methodology.

Context-oriented approaches for schools like ChiK, see e.g. [9], are a bit different: They aim at the change of teaching practice for more “authentic science” in class and hence to make it more interesting for students. Therefore, teaching units have to be based on relevant contexts. These contexts should not only be used as a motivation at the beginning but also be present in all following parts of the teaching unit. ChiK-units aim to rise the variation of teaching methods and to point out basic concepts (like the relationship between behavior and structure). ChiK provides a pattern with 4 phases per unit [11]: 1. phase of contact (e.g. a question or debate); personal relevance, interest; 2. phase of curiosity and planning (e.g. a mind map): identify important questions; 3. phase of elaboration: inquiry, results, presentation; 4. phase of deepening and connecting: reflection, understanding, personal relevance.

We think that this pattern also might fit for CS courses. Koube et al. [8] suggested an approach of CS in context called in German “Informatik im Kontext - ImK” that derives from the other context projects. ImK also has three aims: 1. orientation on relevant contexts; 2. variety of teaching methods and 3. principles and standards. Some usable teaching units for this approach can already be found in [9].

2.2 Teachers’ perspective
Implementing a concept often means to modify the teach-
consisting of 2 teachers from each school, one researcher and is characterized by the foundation of learning communities, 2.3 Symbiotic implementation better than the old one, it has to be used.”

"already existing knowledge and problem-solving capacity time when they went to school and knowledge that comes perhaps a year later. But research has shown that an unreflected participation at isolated events is not leading to changes in the teaching behavior in classes. It leads to isolated knowledge only. It is shown already in 1971 by [6] that this relies on a misbelief: “It was assumed [...] that any professional teacher ‘worth his salt’ could read a document describing the innovation and then, on his own, radically change his behavior in ways that are congruent with the new role model.”

One main reason why this top-down strategies fail is that concept level and application level are regarded separately. As a result not enough attention is paid to the special needs of practice like those of the single teacher, see [1].

The fact that teachers’ attitudes in CS still lag behind and are difficult to change can be explained as follows: Teachers not only need knowledge of the subject they teach. They need knowledge about the complex activities in class and they need so called subjective theories about their work, see [2]. Most publications about teachers’ cognitions use some general assumptions that characterize the underlying conception of man. One of them is that teachers not only use knowledge from their formal studies, but from their own time when they went to school and knowledge that comes from their unreflected every-day work at school as a teacher.

According to Dann, [2], p. 166, it takes three steps to change the cognition and subjective theories effectively: The "already existing knowledge and problem-solving capacity has to be activated, ... [then, the] individual subjective theories have to be confronted with new knowledge, [and, finally, to] guarantee that the newly generated knowledge becomes better than the old one, it has to be used.”

2.3 Symbiotic implementation

The symbiotic implementation strategy of ChiK, see [11], is characterized by the foundation of learning communities, consisting of 2 teachers from each school, one researcher and one school administrator. Every person in this group of 8-14 persons is regarded as an expert. This communities meet every 6 to 8 weeks. They aim to develop teaching material, try it in their own school and reflect their experiences. So, together they develop a solution that can be shared and fits with the specific conditions and needs of the participating teachers. The personal beliefs and attitudes of the teachers regarding the innovation are crucial.

Most of the groups started from teaching units or materials they already had and began to modify them so that they made an context-oriented unit of it (activation and confrontation according to Dann, above). Then some or all members of the groups tried this material on their own in their classes and evaluated it. In group they reflected on their experiences (to realize that the new teaching method is better than the old one).

Fey et al. evaluated the success of ChiK and summarized their results in [4] after the first year regarding the aims of the project: The perceived variety of teaching and learning methods increased. Co-operation with teachers of other subjects was enhanced within the participation schools. The perceived relevance of the group meetings correlates significantly with the enhancement of the feasibility of ChiK. The higher the perceived relevance of co-operation within these learning communities is, the higher is the perception of a teacher’s own growth of competence.

In general we can claim that their strategy was quite successful. In the meantime it became a common teaching approach for chemistry in Germany and it is implemented at school, in school books and embedded in the official curriculum. So we think this setting might produce similar results in CS.

3. CONDITIONS OF CS TEACHERS

For a successful transfer and design of a symbiotic implementation strategy for CS in context there are some factors which have to be discussed. Some conditions of CS teachers differ from those of chemistry teachers. But there are no publications known that focus on research of this conditions in CS teacher education or in CS teacher training. So we only can sum up some observations and statistics:

Comparing the number of chemistry or physics teachers we can only find a few CS teachers. There are many schools with only one CS teacher. As a consequence the co-operation and exchange of teaching material, new ideas and feedback among CS teachers is very restricted just because of the distance. This makes co-operation a very important aspect for a strategy for implementing CS in context.

Because CS is a quite young discipline the teaching material and curricula for CS at schools are not as uniformized as they are for the natural sciences. The consolidation, tradition in educational research and self-image of CS lags far behind those of natural sciences. Most CS teachers haven’t had CS as a subject at school when they were young. This is relevant for the subjective theories of CS of the teachers. So the perception of teachers for CS or CS teaching may be an interesting factor as well. We think that these perceptions differ a lot.

There are very different ways to become a CS teacher in Germany: a few studied CS education, some only CS and took no studies in pedagogy, some have been teachers for other subjects, mostly maths, and decided to take additional courses in CS when they were already working at school or
are self-taught. Knobelsdorf and Schulte showed in [7] that some of their students want to become a CS teacher because their own teacher was incompetent and that they had to learn CS on their own. This uncovers another requirement for the design of our implementation strategy: It has to deal with the differently qualified teachers and the resulting competences in CS.

An enhancement of teaching competency is shown when teachers try new teaching techniques and methods. And it is shown in the ability to cope with frequently changing conditions, see [5], p. 106. With respect to the fact that CS teachers have to deal very often with changing conditions – a change of tools and of computers they work with at least every 5 years – a perceived low competence becomes plausible.

As a first summary we can say that there are at least 3 important factors for CS teachers that may influence the implementation of new teaching concepts. For the implementation of CS in context we have to focus on these factors:

- missing communication and co-operation,
- perception of CS or CS teaching,
- perceived competences and qualification history.

Nevertheless it is another field of research to identify this influencing factors. So we use them as an assumption for our research project.

4. RESEARCH PERSPECTIVE

A transfer of the symbiotic implementation strategy from chemistry to CS seems worth trying and promising.

4.1 Research questions

We assume that the above mentioned factors influence the quality and the success of a symbiotic implementation of CS in context and CS teacher training in general. To prove this our research has to answer the following questions regarding teachers:

- What are the initial states of teachers for each factor and how do these values change during a testing period?
- How do teachers perceive the success and quality of the implementation itself?

Additional research questions are similar to those from ChiK [11]:

- Did the teaching behavior change in the designated way?
- What changes are reported by teachers and students as compared with prior teaching and learning experiences regarding context orientation and the variety of teaching methodologies?
- Did the motivation of the students for CS increase?

4.2 Research Methods

To answer these questions we are developing questionnaires for teachers and students. We decided to use online questionnaires that will be used at the beginning of next school year and at the end of each school year for the next 3 years.

To analyze the isolated factors for the teachers from section 3 we will have to find items regarding the following questions:

- How do they describe their exchange with colleagues of CS and other subjects?
- What is their history of qualification for CS teaching?
- How do they perceive their competences?
- What’s their teaching practice like?
- How do they deal with the frequent change of conditions of teaching CS?
- Is CS an established subject at their school?
- How many CS teacher colleagues do they have at their school?
- Do teachers perceive an enhancement of their teaching methodologies during the project and do their students perceive this also?

For the research questions regarding the variety of teaching methods and the co-operation in the groups we will use similar tools like ChiK used. Some sample items could be:

```
In my CS lessons I use a wide variety of teaching methods

My CS lessons is based on questions of topical interest or questions from social or private life.

My CS lessons pass like planned

I am able to identify the problems in my lessons.

I am able to cope with them.
```

The questionnaires will be followed up by an interview study and one study with repertory grids of Kelly to confirm the outcome of the survey more in detail and to be able to get a closer view to the teachers’ personality.

For the students’ perspective we’ll try to evaluate if the interest in CS is increasing and if students want to choose a profession in CS related fields. Sample items for this may be:

```
I enjoy my CS lessons.

When I find something about CS in newspapers or books I read it through.

I hope to find a job where I have to do with CS every day.
```

We’ll question the students that belong to the teachers of our study and comparable classes that have no CS lessons. We also like to ask students with CS but no CS in context in addition to that.

4.3 Sets of teachers

We already set up groups of teachers that take part in our research, so called teacher sets. Now, we will introduce them shortly.

First, we formed a set of 8 teachers of different schools and different school types (from secondary and vocational schools) who want to develop new teaching material and teaching units for the context “energy” in CS classes, see [3]. They meet every 8 weeks and currently they have decided to start with the objective of energy consumption of hardware systems. Their students are 16 years or older.

A second initiative focuses on the technical aspects of CS. Here there are about 20 teachers from 13 schools cooperating to create teaching materials and units for the 7th
grade (13 years old). Most of the teachers want to start planning their units with the context “robotics” and with Lego Mindstorms.

For these two sets the bigger context (energy or technical aspects) was given because they also belong to other research projects regarding these topics. The teachers have just met a few times to organize themselves in the group and to decide which topics to work on first. The third initiative will start in November when secondary school teachers will meet and create teaching units in context of a free choice.

All teachers that we met where asked for their motivation to join our projects and all answered that they want to cooperate and exchange material with other colleagues.

4.4 Expected results
We regard this research project as an initial shot in a set of projects. Due to the fact that we use similar settings and similar research questions like ChaK to some points the results may be similar in those questions. But regarding the factors that separate teachers of chemistry from those in CS, we hope to be able to explain differing data with these factors. And we might find a correlation of the cooperation and the perceived competences of the teachers. Besides that we are curious about a connection between the perceived competences and the qualification history.

Altogether, we expect to show that teachers of the sets describe their co-operation with teachers from other schools as helpful. We think that the co-operation of CS teachers relate to the perceived quality of the work in the set and the implementation of new teaching methods. We also expect to find that students in context-oriented CS classes are a bit more motivated for studying CS or related topics than in the comparing groups of students who had no context-oriented lessons in CS.

5. CONCLUSIONS
The results of research to this questions will effect the design of teacher training units for CS in context and the design of the practical phase of teacher education as well. The results may be also helpful for the design of school curricula and study programs at school or universities. If we use the results maybe we can manage to reduce the obstacles and raise the motivation level to study CS or CS related topics. And teachers may be able to handle the different pre-knowledge level of students much better and use them for the work on a certain context.

On the long run we hope to initiate some more effects: We hope to support teacher training in CS in general and to support the development of basic concepts for CS that can be used to augment CS lessons in the future like it did in chemistry or physics. Teachers who have joined the teacher sets of a symbiotic implementation could create new sets on their own.

We also think that the symbiotic implementation strategy can help to give CS more weight at school just because teachers teach interesting things that help students to understand the phenomena of their every day life.

6. REFERENCES