Primary School Teachers' Opinions about Early Computer Science Education

Alexandra Funke, Katharina Geldreich, Peter Hubwieser
Technical University of Munich
TUM School of Education
Arcisstr. 21, 80333 Munich, Germany
{alexandra.funke, katharina.geldreich, peter.hubwieser}@tum.de

ABSTRACT

Schools and universities often have to deal with students' misconceptions and stereotypes towards computer science (CS). For example, CS is widely perceived as boring, not interesting and a masculine discipline. To prevent students from forming false and mostly negative attitudes one idea is to introduce computer science concepts like programming before this forming takes place, in other words at a very early stage in school. In consequence, the discussion about the necessity of CS in early childhood education rises more and more. To provide empirical background for this discussion, we interviewed six primary school teachers on their opinions towards computer science courses at primary schools. Based on this results, we are planning a computer science course for 3rd and 4th grade students.

CCS Concepts

•**Social and professional topics** → **Computer science education; Children;**

Keywords

Computer science education, primary school, teacher, interview

1. INTRODUCTION

In the last few years much research about misconceptions and stereotypes about computer science has been conducted [7] [18]. Although there are many different initiatives to remedy this drawback, the situation is still similar as it was 10 years ago. Unfortunately, these mostly negative attitudes already are developed at a very young age [13].

Because of this it seems to be necessary to act at an early stage in the students' live to change this situation. In this way it might be possible to foster a positive image of CS and to reduce stereotypes or negative attitudes. Several countries already show a high awareness concerning early computer science education [6], like the UK [3] which implemented computing to the primary school curriculum in 2013. Beyond this there exists a variety of courses for primary school students outside of the school environment, like summer camps [15] and online initiatives, for example code.org. However, these courses mostly take place on a voluntary basis and the participants are almost exclusively students with a high interest in computer science [4].

Our research group planned to create a computer science course for whole classes of primary schools. We want to show the students how interesting CS can be.

As a first step towards these objectives we conducted a study with primary school teachers. We asked them for their opinion about computer science in primary schools and how a CS course should be designed.

Our research questions for the interviews were:

- *What is the attitude of primary school teachers towards early computer science education?*

- *Which challenges do they see for teaching computer science in primary schools?*

- *What contents should a computer science course for primary school students provide?*

- *What is the current situation at primary schools regarding the integration of computer science?*

2. BACKGROUND AND RELATED WORK

Computer science as a subject is widely perceived as boring and not interesting [9]. Reasons leading to this are for example the mostly negative stereotypes and attitudes towards CS [2]. Furthermore, computer science is broadly perceived as a masculine discipline which is supported by the fact that the most computer scientists and CS teachers are male. The typical role model in this science is the male computer scientist. In contrast, there are almost no role models for girls [10]. Those stereotypes and conceptions are already developed at a young age [13]. For example, even students of computer science often do not know what CS really is [7] [2]. The problem with fixed misconceptions and attitudes is that it is hard and sometimes impossible to change them [5].

To deal with these challenges some researchers recommend the implementation of the subject computer science at primary school or even at kindergarten level [15]. With this it would be possible for the children to make own experiences with technology and computer science before misconceptions and attitudes can be formed. In addition, they learn to deal with computers not only as users but as creators [1]. This is

important to increase the childrens' self-confidence towards technology [15]. A major goal is to show them how much fun and interesting CS and programming can be.

Several countries, like the UK [3] and Poland [14], show already a high awareness concerning early computer science education and implemented computing to the primary school curriculum.

In Poland, there is a computer subject since the 90s. The new curriculum for all grades and levels was introduced in 2008 [14]. The Polish primary schools include the grades one to six. Every primary grade is taught *Informatics* or *Computer Activities* an hour a week.

During the first three years at the primary level, computer activities are fully integrated into other activities. The goal of grades four to six is to solid knowledge and skills regarding technology. In this case, computers are used as tools to support learning.

The learning goals in the computer science curriculum of the UK are divided into three categories: *Computer Science*[1], *Information Technology*[2] and *Digital Literacy*[3] [3]. Like in Poland, the UK primary level includes the grades one to six. The CS curriculum which was implemented in 2013 describes the learning goals for every grade in a very detailed way. Table 1 shows a summary of the leaning goals for keystage 1 (grades 1-3) and table 2 for keystage 2 (grades 4-6).

Table 1: Summary of the learning goals for Keystage 1 in the computer science curriculum of the UK [3]

category	learning goal
Computer Science	**U**nderstand what algorithms are / how they are implemented **U**nderstand that programs execute by following instructions **C**reate and debug simple programs **P**redict the behavior of simple programs
Information Technology	**C**reate, organize, store, manipulate and retrieve digital content
Digital Literacy	**I**dentify where to go for help and support **U**se technology safely and respectfully, keeping personal information private **R**ecognise common uses of IT beyond school

One example for a computer science course for primary schools students is presented in [4]. The authors of this work described a pilot study of a curriculum which based on computational thinking. They implemented a CS class which took place an hour per week. Over 600 students were taught during the study. The students' age ranged from 11 to 12 years in the first study 2014 and from 5 to 12 years in the second study 2015. By designing a computer science

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[1] *"All pupils can understand and apply the fundamental principles and concepts of CS [...] All pupils can analyze problems in computational terms [...]."*

[2] *"All pupils can evaluate and apply information technology [...] analytically to solve problems."*

[3] *"All pupils can be responsible, competent, confident and creative users of information and communication technology."*

Table 2: Summary of the learning goals for Keystage 2 in the computer science curriculum of the UK [3]

category	learning goal
Computer Science	**D**esign, write and debug programs that accomplish specific goals **U**se sequence, selection, and repetition in programs **W**ork with variables and various forms of input and output **E**xplain how simple algorithms work **D**etect and correct errors in algorithms and programs **U**nderstand computer networks including the internet
Information Technology	**S**elect, use and combine a variety of software **U**se search technologies effectively
Digital Literacy	**B**e discerning in evaluating digital content **U**nderstand the opportunities offer for communication and collaboration **U**se technology safely, respectfully and responsibly **R**ecogniseacceptable / unacceptable behavior

course for younger students their goals are, amongst others, that the students engage with the presented content and enjoy the classes. Furthermore the students should become familiar with the basic concepts of programming, rather than just learning to use a specific programming language. During these courses the students use the programming language *Scratch* and at the end of the courses all participants had to solve two programming main quizzes with it. Most of the children enjoyed using Scratch (55% of the girls and 72% of the boys). 39% girls and 65% boys want continue learning about CS. The researchers found no statistically significant difference between the average achievement of girls and boys. However, girls were not as good as boys at predicting their own ability. Despite doing as well as the boys, they didn't seem to be aware of this. The teacher made the observation that girls seemed to take slightly longer than the boys to understand concepts. Furthermore, girls needed more encouragement to try out new activities and boys tried things out more independently.

In [16] the authors implemented an in-school computer science course for 5th grade students. They co-designed this with an primary school teacher who had prior knowledge in technology but no explicit CS background. The course was then offered as a 30 hour course during the regular school year. To analyze the effectiveness of this collaborative developed curriculum the researchers collected data with interviews before and after the course, videos of the working students, screen recordings and student-created material like short essays and storyboards. During the class the students completed two programming projects with *Scratch* and worked almost all in pairs (18 pairs in total). They found that female-female pairs worked very well together and were creative. However their product missed many re-

quirements. One male-male pair had a great interest and enthusiasm for programming. They tried out many things on their own and had a similar line of thinking. Nevertheless, the product of the boys got low scores for usability and consistency. In summary the authors listed important observations for future courses. One key finding from this research is the usefulness of supportive collaborative work.

3. METHODOLOGY

The opinions about early computer science education of primary school teachers were gathered in form of interviews. The guideline for the interviews based on the Berlin Model that was proposed in 1962 by Heimann [8] and described in English by Uljens [17]. This model represents a set of categories for the most important aspects of educational design. It distinguishes between the preconditions of learning, the four decision fields (intentions, content, methods, media) and the consequences of a certain learning situation. The preconditions as well as the consequences are sub-categorized as anthropogenic or socio-cultural. Regarding this, we separated our questions into the four decisional factors *intentions / competences*, *content*, *methods* and *challenges*. We replaced the factor media with challenges, because asking for media is not very informative in our case.

For the current iteration, we recruited six primary school teachers (five female and one male) from our circle of acquaintances. Two female primary school teachers were also principals of their school. None of them had prior experiences in teaching CS, but all teach math.

At the beginning of each interview we told them that we work on a project about *Computer Science in Primary Schools*. They were not given any further information prior to the interview. After asking the teachers about their opinion about early computer science education in the first part of the interview, we asked them how they could imagine a programming introduction course for students at the age of 8 to 10. In detail they were supposed to think about which skills the students should learn, what content is needed for this and what could be appropriate methods for this from their experience. Afterwards we wanted to know which possible challenges they see for teaching computer science to primary school students. In the second part we wanted to know if their schools offer computer science courses for their students and what technical equipment is provided.

The interviews were recorded and transcribed. To analyze the transcripts, we performed a qualitative text analysis according to Mayring [11]. In a first step, the interviews were divided into sentences. These sentences were rewritten in an abstract way and assigned to appropriate categories. This was done independently by two researchers. The resulting category system was then merged. Afterwards the final categories were used by the two persons who both coded the entire data set again. This was the basis for the investigation of an intercoder-agreement, where no significant differences were found.

4. RESULTS

In the following section we describe the answers of the primary school teachers regarding our four decisional factors *competences*, *contents*, *methods* and *challenges*. The survey was conducted in German language. The items as well as the quotes presented here are translated by the authors.

4.1 Competences

To figure out which learning goals a computer science course should pursue, and thus which competences the students should learn, we asked the six teachers: *What competences should students learn in a CS course?* As central competence they named the improvement of working independently. At the same time, teamwork should be possible and supported in a CS course.

Because some students still have a low self-efficacy, teachers would like the students to create something meaningful, they can be proud of afterwards. And thus to make their own experiences with technology. Regarding to this, one teacher commented:

> They should get the chance to do something and experience their own efficacy by realizing the ways in which something works and how they can influence the process.

Almost all teachers expressed the importance that their students learn to evaluate computers and technology critical:

> For me, an ethical aspect would be important - a critical-constructive approach without a negative predisposition. The students should realize that not everything is feasible and there are things in life that cannot be solved with such a system. I would consider this an important point even if it is very philosophical and maybe can not be understood by all children. We should foster an impulse in children to ponder this.

Furthermore, students have to learn how to use the computer or software and work in an accurate and structured way. Also a computer science course fosters logical thinking and creativity:

> I assume it trains logical thinking and can be combined with creativity. Something new and creative gets built and you do so with logical methods.

By appropriate programs and tasks the skills of spatial thinking can be trained beyond.

4.2 Contents

On the question: *What kinds of content should be taught in a CS course?* all teachers answered that the course should not only be a user training. The children should rather understand the structure and functioning of computers:

> I think learning to take a look behind the curtains is very important - for example how does a computer game work. It would be good if the kids could try to understand and discover CS knowledge from something they are familiar with.

Important computer science specific topics include programming, data security / privacy and the handling of hardware. Moreover, the teachers also see an important link with mathematics and the use of mathematical concepts in the course.

All tasks should have a reference to the everyday life of the students and an activity reference, since the children can empathize more quickly and easily in a task:

> It would be great for the children to have the aha-experience that they can use computer science

in everyday life and that it is needed for many things. The new knowledge should be brought together with the real world.

In the 4th grade some students already have a smartphone and use the Internet regularly [12]. Because of that a computer science course should educate about dangers of the Internet and its boundaries, as well as to teach the children a responsible handling of technology.

4.3 Methods

Apart from the usual teaching methods, discussion groups were perceived as very useful to discuss dangers and limits of technology. The course should enable students to create and develop things on their own:

Primary school children should always be able to act. It could be interesting to give them tasks in which they have to develop something following certain specifications of the system.

Too much theory should be avoided by a high practical relevance of the tasks. To create meaningful results, ideas and suggestions of the children should be taken up. To show that even in computer science teamwork is very important, the students should not only work on their own. One teacher also suggested to let the children initially working without computers.

4.4 Challenges

When developing and implementing a computer science course for students between 8 and 10 years, a number of challenges arise. For example even at this young age, children have very different knowledge regarding the use of technology:

No matter which topic there is always the question of how to reach all children and pick them up where they stand. You will have children who already have experience from home and need more challenging exercises than children who have no idea yet. And to deal with these different experiences is definitely a challenge. I really believe that all children can reach an entry-level of knowledge and for the ones with more previous knowledge or interest, a variety of tasks on different levels should be prepared.

Often the students are not very independent and have a low frustration threshold. Especially if course contents are too theoretical, they quickly lose the interest in the course topics. On the other hand, if the content is too heavy, students can be overwhelmed easily. Because of this, it is important to break down the contents to an easier level and prepare tasks accordingly to this age group. Materials should also be understandable for children who can only read more slowly or for children with less experience. Terms have to be explained adequately and have to be translated from foreign languages if necessary.

A challenge for the primary schools is that there are too few teachers for computer science in school or the current teachers are insufficient trained:

I guess you have to be very competent to conduct such a course. If you work with 20 children and every child has a question or has accidentally pushed a button and something happened

and while you answer that one question the other children come up with more questions or use the time to make all kinds of nonsense - that is a particular challenge in primary school. For such a course the groups should be small and should be led by competent teachers - maybe two.

4.5 Further answers

Although all six interviewed teachers have almost no experiences in CS, they mentioned that computer science would be an enrichment for children in primary schools. They see the relevance for more initiatives towards the introduction of CS in primary schools:

It is an important topic in our society and it should also become a topic in primary schools. To what extent has yet to be discussed - but it is definitely too late to start computer science in secondary schools. It should be part of the primary school curriculum for many reasons.

It was hard for them to explain what computer science is and they expressed the need of trainings for teachers to enhance their knowledge and experience in computer science:

It is essential to train teachers in this field. Unless someone studied technology by chance, they usually do not have any knowledge in this area. We do not have the necessary qualifications in primary schools and therefore we need an appropriate training program. I believe there is a lot of interest and it would be great to get support.

All of them uses computers in their own lessons to support the topics of the lessons with videos and learning platforms. They express also some philosophical thoughts about early computer science education. It is important for them that students become creators and not only learn how to use computers or technology. They should recognize that computer science is more than just the individual programs which are running on a machine.

We want to end this section with a very interesting quote of one teacher:

Even in musical education, not every child becomes a musician and that is also not my expectation. But nevertheless certain rhythmic structures and ways of thinking are important for the kid's development. I think this is very similar in computer science. There will be children who are very interested and CS is their thing. And for the others it is also enriching because they learn ways of thinking without having to become a computer scientist.

5. CONCLUSION AND FUTURE WORK

In summary, the six teachers have no concrete image of computer science in primary schools. They all would like to participate at CS courses with their classes and highlighted the importance of implementing a CS subject already in early educational stages. Most of them think that it is important for students to learn how they can create things with computers not only how to use them. Topics they addressed in the field of CS in primary schools were dangers of the world wide web, the functionality of computers and

computers in society. They do not feel capable of teaching computer science on their own and express the need for teacher trainings or further teachers for the subject.

We described the answers which were given for the four decisional factors *competences*, *content*, *methods* and *challenges*. The teachers see the importance of computer science for learning specific programs and getting a more accurate working method. They express the wish that students learn how to reflect things in the world more critical and to become responsible citizens. All have the opinion that digital media and a basic understanding of computer science will become more important in the future.

Based on the results of the interviews and our findings from the literature we want to design a computer science course for primary school students at the age of 8 to 10 years. It will initially be an extracurricular offer for 3rd and 4th grade classes. Due to the limited knowledge and the poor concepts of the teachers in the computer science field it is important to improve the awareness of primary school teachers towards CS. It is conceivable to develop a training for teachers simultaneously with a course for their students.

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