GERMANY

A German perspective

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Challenges

1. Lack of clear understanding of Computer science education /Informatics as a school subject.

In Germany, computer science has been available as an optional or mandatory-optional school subject throughout the country since some decades already, but only in few federal countries it has been implemented as a mandatory subject for all students. In 2016, the board of ministers of education and cultural affairs published a strategy document on "education in the digital word"[2], a 60-pages long document, which mostly focuses on digital literacy and competent usage of digital tools but does not include any considerations concerning computer science education in a separate subject. The only explicit connections drawn state that the competences to be acquired are "so important that they cannot be addressed in a single subject like computer science but have to be integrated in all subjects". The document, which is now discussed in all federal countries and used for implementing digital education strategies, does not show a clear understanding that learning in the digital age is not only about learning with and using digital technology, but also about learning about digitalization and the underlying concepts.

In this context, the need to strengthen 'computational thinking' (Wing, 2006) is always mentioned. However, the term is controversially discussed even at the academic level (see, e.g., Denning, 2017) and is interpreted in a completely different manner in the context of educational policy. Everyone interprets the term as they see fit it for their educational interests. The spectrum of interpretation of computational thinking ranges from modeling, coding, and programming to the understanding application of informatics systems. Based on these different concepts, the term is then also used to justify CSE as an independent school subject or as an integrative learning area, integrated into all subjects.

A few years ago, the earlier German Minister of Economic Affairs (Gabriel) suggested the introduction of a new subject called "Programming language". Among political and other stakeholders within the education systems, computer science is very often equated with "programming" or "programming language" or "using digital technology", which indicates limited or even misconceptions about the discipline. However, these persons are very often the ones who make or influence the political decisions concerning this field.

In 2016, the German Informatics association organized a workshop on "education in the digital networked world" and brought together around 30 experts from computer science, computer

[2] https://www.kmk.org/fileadmin/Dateien/pdf/PresseUndAktuelles/2017/KMK-Strategie_Bildung_in_der_digitalen_Welt_Zusammenfassung_en.pdf

science education, media education, secondary schools, and politics. In this workshop, a model was developed (the *Dagstuhl triangle*, see Brinda/Diethelm 2017), which was well recognized in the German speaking countries. It integrates learning with and about digital technologies and also reflection about its impact on the individual and society. This model and a number of presentations and discussions with stakeholders were fruitful and contributed to the awareness that computer science can contribute to understanding of and participating in the digital world.

The 2018 German National report to IFIP TC3 also addresses and summarizes these problems (Source).

2. ***Need for Computer Science/Informatics as a distinct subject in school curricula is controversial and poorly understood.***

The advantages and disadvantages of computer science as a separate subject, integration of computer science aspects into other subjects, and teaching computer science through projects or extracurricular activities were discussed in (Brinda 2017). The same argumentation was used in a comment paper of the German Informatics association answering to the above-mentioned strategy paper[3].

3. ***Computational thinking, a core component of Computer Science/Informatics this considered to be important in 21st century skills, but due to its complexity, it is difficult to implement in schools.***

In Germany, this does not seem to be an issue, because there are a number of successful implementations of computer science education from primary school projects to advanced classed in upper secondary education. However, most of these classes are optional. With only optional classes, the goal of school to prepare everybody for life and work also in the digital world cannot be reached by everybody, because it depends on decisions made throughout the school career. The main problem for the implementation in school seems to be the following: the school curriculum is already quite full with other subjects, so a new mandatory course would have to be added to that or something else would have to be reduced or even removed. If the time to be spent at school would be extended, political stakeholders fear discussions with parents, students and teachers. If any other subject would be reduced at school, the political stakeholders fear discussions with the representatives of the respective subject. The education administration also often argues that there is a lack of qualified informatics teachers (chicken and egg problem). To avoid any discussion, they abstractly delegate computer science-related competences to all other subjects, which cannot work for the majority of teachers.

4. ***The development of Computer Science/Informatics school curricula is impeded by insufficient empirical evidence of student learning in order to support content definition and sequencing.***

In Germany, this is not a problem. A number of successful curricula exist in the federal countries. Empirical research concerning various fields is progressing and made available to teachers for

[3] https://fb-iad.gi.de/fileadmin/FB/IAD/Dokumente/gi-fbiad-stellungnahme-kmk-strategie-digitale-bildung.pdf

ongoing improvement of learning and teaching computer science. However, empirical research on computer science education in schools is still relatively young and not as multi-faceted as in the other STEM subjects. There are relatively few well-founded studies. Existing studies often have low case numbers, are sometimes methodologically critical, and the impact on teacher training in CSE and the current practice of computer science teaching is probably still rather low.

5. ***Previous ICT curricula deliveries poorly prepared students for Computer Science/Informatics in further/higher education or professional employment.***

The integration of ICT in various subjects has also been tried out in Germany in the last decades. The results of the ICILS study 2013 have shown that the development of computer and information literacy was below average in comparison to other participating countries. These results were a main motivator for the above-mentioned strategy paper of German educational politicians.

6. ***Integrating Computer Science/Informatics across other subjects in school curricula has been ineffective.***

see 5.

7. ***Teacher professional development in a newly introduced Computer Science/Informatics subject is a challenge in quality and quantity.***

Teacher qualification is a huge challenge. In Germany, teachers with a wide range of qualifications teach (about) computer science. In this context, a distinction should be made between three groups of teachers:

1. teachers who teach computer science (mostly at Gymnasium or in higher secondary schools).
2. teachers who teach computer science as an elective subject and who often do so without any specialist or didactic qualification. We simply do not know what is taught regarding content (possibly only user software training?)
3. teachers of all subjects who are expected to teach computer science education in their respective subjects in an integrated manner

There are teachers from other subjects, who follow material (such as provided by code.org) in projects or optional courses, others who have been qualified more or less in in-service certification courses (one to two years with few days per week), and those who studied a regular teaching degree program at a university (5-years program). The resulting qualification spectrum leads presumably to a wide spectrum of more or less elaborated computer science-related learning offers in class. Until now, there has not been any empirical research investigating this in Germany. Individual reports however indicate that sometimes “computer science” classes just focus on using application software and in other cases computer science is purely taught with blackboard and chalk. The introduction of computer science as a new subject in some of Germany’s federal countries was prepared with in-service training of teachers of other subjects combined with an expansion of the teacher education in computer science at the universities of the respective federal country.

Regarding group 3, a huge (quantitative) need for teacher training arises if something like a `media pass´ or integrative informatics education is to be implemented in all subjects, although such concepts failed grandiosely in Germany in the 1980s and 1990s. This would create a massive need for teacher training, which would have to relate to both the scientific fundamentals of computer science and its didactic teaching in the context of the respective subject. Unfortunately, it is becoming apparent that this need for teachers' qualifications is not taken into account by the educational administration and that it is expected that the experienced teachers will 'somehow' implement it.

Considering the design of the UNESCO Curriculum Guidelines, the question arises in this context as to what extent these various competency requirements of teachers should be referred to at least in a brief form. The qualification requirements should then also be described with regard to corresponding theoretical concepts of teacher competences at a general level (PCK, TPCK; e.g. Mishra/Köhler 2006) and specific competences for computer science teachers (e.g. Informatics PCK; Bender et al. 2015).

8. ***Identifying and allocating the additional resources for teaching Computer Science/Informatics is a challenge.***

see 3.

To cope with the problem of available time for a curriculum, a solution could be a combination of several actions:

- reduction of the lesson length by a few minutes, collection of this time to create space for the needed subject
- moderate extension of the time at school
- Germany provides hours for the curriculum, which schools can fill with individual content (for example for fostering mathematical and language competencies) → use part of such hours to extend computer science education

Additional Challenges

- Media education representatives are better networked with educational politics than representatives from the computer science education community
- Media education representatives have key positions in the ministries of education and thereby presumably prevent the extension of computer science education at school
- Lack of understanding, what Informatics/CS is among educational politicians
- Individual (mis-)conceptions about computer science among educational politicians
- Tendency to avoid conflicts among educational politicians -> competencies abstractly delegated into other subjects
- Many stakeholders: other stuff is more important (reading, writing, maths, …); CSE should only be part of vocational training; Students learn a lot about the use of informatics systems during their spare time with peers – why therefore waste lessons in schools

Lessons learnt and Recommendations

- Make sure, Ministers are reached with recommendations
- Provide some concrete recommendations, how to overcome the problem of limited resources concerning time etc.

- Decide on a qualification framework for teachers, who teach computer science. Maybe also for those, who have to integrate CS aspects in the ordinary teaching of their subjects: Fundamental CS competences for teachers (→ PCK, TPCK see 7. above)
- Write a paper from the educational politicians' perspective: what are the benefits for them, …, how to avoid conflict, …
- Make recommendations available in different languages
- The organizational and content-related linking of formal and informal educational offers (learning laboratories, museum pedagogy, extracurricular projects of schools, computer science competitions (in Germany BWINF, Biber,..) leisure pedagogy (boot camps) which offer CSE-related educational programs with and without schools is also of great importance for computer science education.

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The description of the German situation was published in a report, which is available on:
https://www.ifip-tc3.org/working-groups/task-force-curriculum/

Coding, Programming and the Changing Curriculum for Computing in Schools

Report of UNESCO/IFIP TC3 Meeting at OCCE – Wednesday 27th of June 2018, Linz, Austria
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