Towards a Conceptualization of Pedagogical Content Knowledge for Computer Science

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ABSTRACT
According to the current state of research, it seems uncontroversial that the Pedagogical Content Knowledge (PCK) of teachers is a crucial factor for the success of teaching and learning in the context of many school subjects. Yet, the research about PCK in the subject of computer science (CS) is still sparse. Thus, we are working on a conceptualization of PCK for computer science (CS) that is based on literature on the one hand and empirically validated on the other. As a first step towards this goal, we have developed a category system from a set of publications from general pedagogy as well as from educational research in other subjects. Additionally, we have compared this system with the outcomes of a former survey among teachers about the preparation of lessons. Currently, we are coding all curricula for teacher education in Germany with this category system and preparing interviews among experts, applying the Critical Incident Technique.

Categories and Subject Descriptors
K.3.2 [Computers and Education]: Computer and Information Science Education - Computer science education

General Terms
Human Factors

Keywords
Pedagogical Content Knowledge, Literature Survey, Empirical Validation.

1. INTRODUCTION
Recent activities in several countries give rise to hope that computer science (CS) is on its way to a regular subject in schools, see e.g. [39]. Yet, before this subject will be accepted as a “full member” in the “club of traditional subjects” like mathematics, physics, foreign languages or history, much educational research has to be conducted in order to reach the level that those subjects have accomplished, building on many decades of teaching. One of the most important questions of educational research asks for the factors that determine the learning success of the students. As recently shown by Hattie [13], the competencies, knowledge and beliefs of the teachers are likely to be the most crucial ones among those factors.

As proposed by Shulman [36], the required knowledge of teachers comprises parts that refer to subject matter (content), pedagogical issues and combinations of both, usually referred to as Pedagogical Content Knowledge (PCK). Particularly the latter is subject to recent research in subject-matter didactics, e.g. in mathematics [21], physics [29] as well as in computer science [30].

The German collaboration project KUI (Competencies for Teaching Computer Science, translated by the authors) aims to identify the competencies that are required to teach computer science with success. KUI is elaborated at the Universities of Paderborn (Niclas Schaper, project coordinator, and Johannes Magenheim), University of Siegen (Sigrid Schubert) and the Technische Universität München (Peter Hubwieser). It is funded by the German Federal Ministry of Education and Research.

The project goal is to design appropriate competency models and develop suitable measuring instruments for teacher competencies in the fields of (1) subject matter content knowledge, (2) pedagogical content knowledge and (3) non-cognitive skills and beliefs. The focus of this paper lies on the second field.

As defined by Weinert [41], competencies have several components including certain specific knowledge elements. Therefore, in recognition of the undoubtedly important role of knowledge, our first goal is to identify the knowledge elements of the relevant teaching competencies.

In order to derive the demanded PCK for teaching CS, we are performing the following steps:

1. content analysis of German curricula for computer science teacher education,
2. expert interviews according to the Critical Incident Technique [11],
3. design of competency models and
4. development of measuring instruments.

Initially, we had searched the websites of all German universities for teacher education curricula that comprised the teaching subject Informatics (understood synonymously to computer science in this paper), which resulted in 43 places of discovery.

The intended qualitative content analysis of those curricula will follow the methodology proposed by Mayring [25] and look for teacher competencies that would be addressed as educational goals. As this should be performed by several different coders, inductive coding would result in different category systems, which might be difficult to combine in the end. Therefore we decided to start this analysis from a common, theory-based category system.

After inspecting and comparing several recent conceptualizations of PCK (in general and for several other school subjects), we had to realize that it is not possible to simply transfer one of those to computer science. For example, it turned out that the conceptions of PCK for mathematics and physics were structurally very different from each other, according to the specific view that teachers have on the learning process and from specific teaching elements like assignments or experiments. On the other hand, the PCK conceptions for CS that were presented so far were restricted to programming and hence too narrow for our purpose, e.g. [30], [20].

As a consequence, we decided to perform a literature review on the inspected sources as well as on the most relevant publications that have been cited by those, looking for PCK conceptualizations that we could use as parts of our needed category system. We compiled a text corpus from several sources (see section 3), including very early “general” (not subject-specific) publications, e.g. [36], [37] or [6] as well as recent results from other subjects (mathematics, physics, biology, languages) and publications from CSE research, e.g. [10], [14]. Following this, we performed a qualitative content analysis “through the lens of CS” on this corpus, once again according to the methodology proposed by Mayring [24]. The outcome of this literature survey was a twodimensional category system (see section 4) that was in accordance with conceptualizations of other school subjects in many respects, but also showed some important differences.

Please note that we had aimed to develop a category system that could serve as a common starting point for the coding of the curricula, but we did not expect that this would be complete in any regard already at that time. As there would be several further empirical working steps, we were confident that the system would evolve and become more or less complete at the end of the whole agenda.

In order to achieve a first empirical validation, we compared this system with the outcomes of a set of 11 interviews that we had conducted in 2010 among practicing teachers, asking for their strategies and skills to prepare their teaching lessons. As we had followed the prescriptions of the CIT quite closely in those interviews, they can be regarded as a first proof of concept. It turned out that our conceptualization of PCK was highly consistent with the knowledge elements that were addressed by the teachers in those interviews. Even more surprisingly, in contradiction to our prior expectations, during the coding of the 43 teacher education curricula (see step 1 above) which was finished several days before the deadline for this paper no category had to be added to the upper two levels of the original system.

These are quite strong indicators that our system is quite complete at least as far as the exiting teaching practice is concerned, which gave us the motivation to publish our model already in its current preliminary stage. In this paper, we will present this category system that resulted from the literature review as well as the first validation of the resulting conceptualization of PCK, comparing it to the outcomes of the teacher interviews from 2010. The outcomes of the analysis of the teacher education curricula will be covered by subsequent publications.

2. METHODOLOGY

As explained e.g. by Schaper [31], the methodologies that could be applied to derive domain specific competency models (and conceptualizations of knowledge as parts of those) could follow different approaches: (1) inductive vs. deductive and (2) empirical vs. normative.

Yet, a closer look shows that those are closely related pairwise. On the one hand, inductive derivations have to be conducted based on empirical methods and thus are strongly connected with those. On the other hand, normative approaches refer to theoretically or pragmatically founded postulations or concepts, while deductive methodologies would start at already existing conceptualizations which will be based on theoretical models or assumptions. This reveals that theoretical and normative methodologies are closely related also (see [32]).

In summary, we end up with the choice between an empirical/inductive or a normative/deductive approach. Schaper argues that both would have their pros and cons [31]. On the one hand, a purely empirical approach would reflect exclusively the “existing” practice, neglecting that educational goals have to be set in a normative way to foster improvements or evolutions. On the other hand, deductively-normatively derived competencies or knowledge elements would lack any relationship to existing practice or to pragmatic limitations. Therefore, the solution lies in a combination of those two directions, e.g. by deriving a conceptualization deductively from literature and validating and fine-tuning it by empirical-inductive methods. This represents exactly the overall methodology we are following (see steps 1-4 in section 1 above).

2.1 Deductive Text Analysis

The deductive part of the work started with the collection of a set of publications that we have identified to be relevant for this issue. The resulting text corpus is described in detail in section 3. We performed a qualitative content analysis on it, driven by the following research questions: (1) “Which PCK is needed to teach CS in schools successfully according to the state of research?” and (2) “Which critical situations might be appropriate to be presented in expert interviews according to the Critical Incident Technique?” (see step 2 in section 1).

The main techniques of qualitative content analysis according to Mayring [24] are summarizing, explicating and structuring. The goal of ‘summarizing’ is to compress the text material. ‘Explication’ connects additional text material to those passages in the text that need further explanation. Finally, ‘structuring’ aims to construct a suitable category system. In [22] we have discussed an exemplary application of this methodology in detail. By this way, applying the software MaxQDA (www.maxqda.com), we developed a category system from the text corpus that
2.2 Empirical Research

We analyzed a set of 11 guide-line based interviews that we had collected during a large in-service teacher training course in July 2010 among experienced teachers. The interview partners were selected from the community of about 150 teachers who were attending our courses regularly, according to our impression of their competence and experience. Please note that all interviews were conducted in German language and all resulting categories and excerpts were translated by the authors. The guideline for the interviews was based on the Berlin Model that was proposed in 1962 by Heimann [15] and described in English by Uljens [40]. This model represents a set of categories for the most important aspects of educational design. It distinguishes between (1) the preconditions of learning, (2) the four decision fields (2a) intentions, e.g. learning objectives, (2b) learning content, e.g. topics or knowledge, (2c) teaching and learning methods and (2d) media and (3) the consequences of a certain learning situation. The preconditions as well as the consequences are sub-categorized as anthropogenic or socio-cultural. We have described the application of this model in teacher education in [5].

According to the Critical Incident Technique (CIT), a critical incident could be described as an event or a problem, which stimulates or demands activities and operations by the interviewee [7], [9]. Usually, the interviews are structured according the following steps: (1) welcoming the interviewee and introducing the applied interview technique, (2) presenting a critical incident to the interviewee and encouraging him or her to give details of his/her approach to solve the presented problem, (3) conducting the interview by probing and clarifying remaining questions in order to agree about a common understanding of the underlying problems and issues (see [7], [22]). According to our guideline, the interviewers should start by asking the introductory, open question: “If you consider the preparation of CS lessons, how would you normally proceed, which problems would you face and how would you solve these problems?” Only in the case that the teachers would not mention one or more of the main categories of the Berlin Model, the interviewers should give a respective stimulus, addressing the following particularly relevant issues: the preconditions of your lesson, learning objectives, content, teaching methods, media, assessments, sources of information and collaboration with other teachers.

The interviews were recorded with mobile phones. In the end we had collected 11 interviews from 20 to 35 minutes from 4 female and 7 male teachers. The interviews were transcribed and coded inductively by two authors, again applying qualitative content analysis [24]. The resulting category system reflected the aspects that the interviewed teachers had regarded relevant for the planning of lessons in CS.

2.3 Comparison of Results

We mapped the results of the interviews from 2010 to our literature-based PCK model to find out if this would describe the pedagogical decision fields of CS teachers adequately. For this purpose, we tried to incorporate the categories that were obtained from the interviews into our PCK model. We are well aware that this does not represent a quantitative survey in any way. Nevertheless, we regard the results of the interviews as a first step to validate the category system that we propose for PCK in CS. The results are presented and discussed in detail in section 4.

3. THE TEXT CORPUS

As our project KUI (see section 1) aims to develop models and instruments in German language, we looked for publications in our language predominantly. We have to apologize to all English speaking readers for the frequent citation of German publications. Nevertheless we have to cite all analyzed publications here, striving for scientific sincerity.

As we aimed to develop a category system that would serve as starting point for coding the curricula, we looked for conceptualizations that might be relevant for PCK. For this purpose, we collected publications from different fields:

- general, subject-independent definitions and conceptualizations of PCK,
- definitions and conceptualizations of PCK for other school subjects,
- definitions and conceptualizations of PCK for CS,
- standards for teacher education,
- taxonomies of educational research in CS,
- publications and textbooks for subject-matter didactics for CS.

By this way, we intended to approach the problem from different directions.

3.1 Subject-independent Publications

We started at Shulman’s famous proposals for definition and scope of Pedagogical Content Knowledge and Curricular Knowledge [36], [37]. Based on Shulmans proposal, Carlsen [6] rearranged the knowledge components in order to adapt it to the required knowledge of science teachers, dividing Shulmans „curricular knowledge“ in a subject specific and an interdisciplinary component.

Figure 1: Carlsen’s domains of teacher knowledge [6]

By this way, he was able to separate the three knowledge areas Pedagogical Knowledge (PK), Subject Matter Knowledge (SMK) und Pedagogical Content Knowledge (PCK). Starting from this...
point, we focused on PCK, which was structured by Carlsen as follows: *Students’ Common Misconceptions, Specific Science Curricula, Topic-Specific Instructional Strategies and Purposes for Teaching Science* (see figure 1).

As a very important publication in respect of PCK we regarded the teaching standards proposed by Oser [26], particularly considering that the overall goal of our collaboration project is to identify teaching competencies for CS. Another set of standards was derived by Terhart [38].

In Germany, similar to the US, the 16 states are independent regarding educational affairs. The institution that is in charge for common regulations is the *Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany* (KMK). In 2004, this KMK had constituted a working group that built its report on those recommendations of Oser and Terhart [35], which we included in our text corpus also.

### 3.2 Other Subjects

Based on Shulman, the so called Michigan Group has proposed a subject specific knowledge framework for mathematics (see figure 2).

![Figure 2. “Mathematical Knowledge for Teaching”](image)

During the last decade, in Germany two prominent, high-quality studies investigated the effects of the knowledge facets of mathematics teachers on their teaching success: COACTIV and MT21. Each one has presented a certain structure of PCK, see [3], [4]. Finally, there was a very comprehensive dissertation about PCK in mathematics, presented by Lindmeier [21]. She has summarized the state of the art regarding PCK as shown in figure 2. Regarding the PCK of physics teachers, Magnusson et al. have presented a specific model [23]. Furthermore, recently Riese has presented his dissertation that was focused on PCK for physics [28]. We have added his conceptualization (p. 82) to the text corpus. For biology, Schmelzing has developed another categorization [33], see [1]. For the subject of English language, Grossman (1989) has posed a set of questions in order to perform a qualitative analysis of the PCK of teachers of English language.

### 3.3 Computer Science

As already mentioned above, the state of research regarding PCK for CS is a quite preliminary one in our opinion. Nevertheless, there are several explicit conceptualizations of teacher knowledge that might be regarded as a starting point, e.g. by Saeli [30] respectively Koppelman [20].

In 2008, the KMK (see section 3.1) decided common standards for teacher education for all 16 German states. Those comprise the subject of *Informatik* (understood nearly synonymously to computer science) and were included in our text corpus also. The next conceptualization we included was the dimension of educational relevant areas of the Darmstadt Model, which was developed by a working group at the ACM ITiCSE conference 2011 in Darmstadt [17]. As the research question that had led to this category system was “which factors are relevant for computer science education in schools”, we regarded the result also as relevant for PCK of teachers.

Recently Diethelm et al. [8] have developed a model for didactical reconstruction of lessons that is based on the model of [18]. As this is one of the most important tasks that teachers are performing in their professional work, we suggest that those categories should be considered also as a part of their PCK.

Assuming that teachers should be educated as researchers also, we have looked for categorizations of CSE research. We found two of them that could be relevant for PCK in our eyes. The first was the list of categories of Fincher and Pete [10]. The second was presented by Kinnunen [19], which was picked up again by Randolph et al. [27].

Finally, we analyzed the four textbooks for teaching computer science that we regarded the most important and influencing in Germany: [14] (Israel), [16] (Germany), [34] (Germany) and [12] (Switzerland). It turned out that the category system was already quite saturated at this point, because no additional category had to be added on the two upper levels, despite the comprehensiveness of those books.

### 4. THE RESULTING MODEL OF PCK

The deductive part of the work resulted in a two-dimensional category system with 18 categories on the first level of the dimensions and a substantial larger number of subcategories on the lower levels, which resulted from an intensive discussion among the engaged researchers and a subsequent process of aggregation.

As already mentioned in section 2.1, we found 3 top-level categories to be in a certain sense orthogonal to the remaining 15. On the one hand those could be considered as pedagogical operations that correspond to certain stages of a teaching process, on the other hand, they seemed to be closely related to the other 15. Thus we split the 18 top-level categories in two different dimensions, regarding the model as a matrix, where the three *Fields of Pedagogical Operation* (FPO, see section 4.1) represent the columns and the 15 *Aspects of Teaching and Learning* (ATL, see section 4.2) form the lines.

<table>
<thead>
<tr>
<th></th>
<th>FPO 1</th>
<th>FPO 2</th>
<th>FPO 3</th>
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<tbody>
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<td>ATL 1</td>
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<td>ATL 2</td>
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The mutual relevance of the *Fields of Pedagogical Operation* and the *Aspects of Teaching and Learning* will be subject to future research, which might detect knowledge elements that are relevant to the respective column as well as to the row. In a certain sense, the comparison of our model with outcomes of the teacher interviews from 2010 (see section 2.3) represents the first
empirical validation of the first column *Planning and design of learning situations* (FPO 1), as greyed in table 1.

### 4.1 Fields of Pedagogical Operation

The first dimension comprises the *Fields of Pedagogical Operation* (FPO). It structures and describes the phases of the process of teaching and learning in the classroom, where the teachers must manage certain critical incidents by making decisions and taking action (see table 2).

**Table 2. Fields of Pedagogical Operation (FPO)**

<table>
<thead>
<tr>
<th>Cat. No.</th>
<th>Field descriptor</th>
<th>Subcategories</th>
</tr>
</thead>
</table>
| FPO 1    | Planning and design of learning situations | - Time planning (Time allocation),
                - Explanation of the planning: subject specific consistency, psychological argumentation
                - Granularity: long term lesson planning, planning the entire curriculum, planning a lesson |
| FPO 2    | Reacting on student’s demands during teaching processes | - Reacting based on understanding: flexible use of connected knowledge in critical situations, responding to students appropriately, responding flexibly
                - Mastering complexity
                - Keeping compliant with planning |
| FPO 3    | Evaluation of teaching processes | - Techniques,
                - Criteria
                - Derive consequences |

Regarding our second research question (see section 2), those phases comprise specific critical incidents that will be presented to the teachers during the upcoming interviews according to the CIT (see step 2 in section 1), e.g. reacting on the situation that several students have problems in understanding.

### 4.2 Aspects of Teaching and Learning

The second dimension *Aspects of Teaching and Learning* (ATL) encompasses the remaining pedagogically relevant categories. According to our opinion, those aspects are more or less relevant for all fields of operation that are aligned on the first dimension FPO. This second dimension contains 15 categories on level 1.

**Table 3. Aspects of Teaching and Learning (ATL)**

<table>
<thead>
<tr>
<th>Cat. No.</th>
<th>Category</th>
<th>Subcategories</th>
</tr>
</thead>
</table>
| ATL 1    | Learning content | - Multiple representations
                - Category systems for learning content
                - Specific school-related content
                - Selection and justification of learning content
                - Didactical (re-) construction of subject-matter knowledge |
| ATL 2    | Subject | - Relations to other subjects
                - Definition of computer science education
                - History of computer science education
                - Relationship of the subject to the scientific discipline
                - Objectives of the subject
                - Legitimacy and relevance of the subject |
| ATL 3    | Curricula and standards | - Curriculum development
                - Relation to other subjects
                - Approach and structure of the curriculum
                - Selection and commitment
                - Actual examples of curricula |
| ATL 4    | Objectives of lessons | - Focus on education standards
                - Competencies
                - Learning objectives |
| ATL 5    | Extracurricular activities | - External collaboration
                - Contests |
| ATL 6    | Science | - Subject discipline
                - Computer science education as a scientific discipline
                - Relationship between teaching of the subject and the scientific discipline |
| ATL 7    | Teaching Methods | - Organizational arrangements
                - Methodological principles
                - Subject-specific teaching methods |
| ATL 8    | Subject-specific teaching concepts | - Introductory lessons
                - Programming classes
                - Historical approach |
| ATL 9    | Specific teaching elements | - Lab-based teaching
                - Experiments
                - Tasks and assignments |
| ATL 10   | Media and educational material | - Application of hardware and software
                - Textbooks
                - Unplugged media |
| ATL 11   | Heterogeneity in the context of subject-specific learning | - Age
                - Gender
                - Ethnical background
                - Family socialization
                - Disabilities |
| ATL 12   | Student cognition | - General subject-related cognitive aspects
                - Individual learning
                - Diagnostics, performance evaluation and assessment
                - Cognitive activation |
| ATL 13   | Teachers’ perspective | - Collaboration
                - Core tasks
                - Qualification
                - Motivation
                - In-service training
                - Teaching experience |
| ATL 14   | School development | - Policies
                - Quality management
                - School profile |
5. THE EMPIRICAL RESULTS

In this section we will present the outcomes of the teacher interviews from 2010. The comparison with our literature-based PCK model (see section 4) will follow in section 6.

The interviews were coded by two of the authors who compared, discussed and matched their codings and categories straight after the interviews. This way, we developed the following category system that was based on 598 codings:

1) Conditions: preconditions, frame conditions
2) Goals
3) Approach: example driven, time planning, programming, writing outline, writing script, planning homework, identifying difficulties, by own mistakes
4) Sources: textbook, curriculum, additional material, internet, teacher training, books/journals from subject-matter, colleagues, existing knowledge, material from own studies, pre-planned lessons
5) Collaboration: in school, with other departments, between schools
6) Time planning
7) Methods and organizational arrangements: individual learning, student activity, presentation, classroom teaching, teacher-class dialog, worksheet, entry in exercise book, project work, file, repetition, group work, differentiation, talk by students
8) Media: beamer, blackboard, moodle, computer, software, overhead projection, textbook, whiteboard, illustrations
9) Problems: technical difficulties, too much content, room, ensuring learning, standards, pre-requisite knowledge, official support, class size
10) Assessment: written, oral, project, not graded

6. COMPARISON

Looking closely at the coded text passages of the categories, two persons tried to incorporate the original category system (see section 5) of 2010 into the literature-based PCK model (see section 4). Astonishingly, all categories of the interview system could be included. This means that all issues that had been addressed by the teachers were already covered by our original, literature-based PCK model.

The following table 4 presents some exemplary quotations from the interviews to illustrate the top level categories, as far as those were referred at all. Please note that the quotations were translated from German by the authors.

| Table 4. Exemplary codings for the top level categories. |
|---|---|---|
| Cat. No. | Category | Quotes from the interviews |
| ATL 1 | Learning content | I look for an important goal as a headline for the lesson and afterwards for a few keywords that have to be covered, that I |

Yet, in turn, we had to realize that several top-level-cATEGORIES of our theoretical model were not referred by the teachers, as the empirical model did not comprise any corresponding categories. On the FPO dimension, the only missing category was Reacting on student’s demands during teaching processes (FPO 2). As we had asked how the teachers would plan their lessons, it seemed quite reasonable that this issue, which will occur predominantly during the lessons, was not addressed.

On the second dimension, the following three categories were not mentioned at all: Extracurricular activities (ATL 5), Science (ATL 6) and School development (ATL 14). As far as extracurricular activities are concerned, it seems understandable that the teachers were not aware of this issue during the interview, because it might not be in the focus of everyday teaching. Nevertheless, it is desirable that teachers refer to extracurricular activities in certain situations, e.g. preparing large software projects by an excursion to the industry or encouraging gifted students to participate in contests like the International Olympiad in Informatics. Although the importance of scientific results and methods for teaching is undisputed, it seems that the teachers don’t really understand this fact. Consequently, this should be a predominant goal of teacher education, as postulated e.g. by Hazzan et al. [14]. Finally, school development is a task for the more advanced teachers, at least in our country. Therefore not every teacher might have this in mind all the time. Nevertheless, particularly for CS teachers, this is a very crucial factor. In the
end, our subject has to develop and grow in importance, which will afford substantial change in the schools.

Apparently, there were several categories of the PCK model that should have been addressed by all teachers that were interviewed. According to the guideline of the interviews, the interviewer should insist on a statement about those. This was the case for all categories (and subcategories) that were directly related to the Berlin Model and, additionally, for Information sources (media) and Collaboration. Thus we could assume that all those directly or indirectly addressed categories should have been mentioned by all the teachers. Yet, two of those were not found in all interviews, despite the fact that they were explicitly stimulated: Heterogeneity in the context of subject-specific learning (ATL 11, addressed via Student’s preconditions), not appearing in 5 interviews and Objectives of lessons (ATL 4), missed in 1 interview. Presumably, those results were caused by the poor understanding of those categories by the teachers. They were not able to respond on the stimulus in such a way that this resulted in a coding. Again, this might be taken as a suggestion to extend teacher education in regard of those topics. On the other hand, as far as the stimuli are concerned, we don’t have to assume a priori that the other categories would be mentioned by any teacher. The categories that were addressed despite that they were not stimulated are displayed in table 5.

Table 5. Addressed categories that were not stimulated

<table>
<thead>
<tr>
<th>Cat. No.</th>
<th>Category</th>
<th>Coded interviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATL 12</td>
<td>Student cognition</td>
<td>11</td>
</tr>
<tr>
<td>ATL 9</td>
<td>Specific teaching elements</td>
<td>10</td>
</tr>
<tr>
<td>ATL 3</td>
<td>Curricula and standards</td>
<td>9</td>
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<tr>
<td>ATL 8</td>
<td>Subject and standards</td>
<td>5</td>
</tr>
<tr>
<td>ATL 15</td>
<td>Educational-specific teaching concepts</td>
<td>4</td>
</tr>
<tr>
<td>ATL 2</td>
<td>Subject</td>
<td>1</td>
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This shows that the teachers were well aware of the importance of student cognition and specific teaching elements, fortunately.

7. CONCLUSION AND FUTURE WORK

Aiming to find out which competencies might correspond to the identified knowledge elements as well as to extend and further validate our category system, we have coded 43 curricula that are in use for teacher education in CS in the 16 German states. As the first results demonstrate, those don’t address any knowledge elements that could not be integrated in our theoretically-derived model. Currently, we are evaluating the relationships between the elements on the two dimensions of our PCK model, hereby aiming to fill the cells of table 1.

Furthermore, we are preparing a second series of interviews, among experts (teacher educators, teacher trainers and supervisors) in order to expand, explore, consolidate and validate our category system as well as to identify the competencies that correspond to our knowledge elements. We will apply the Critical Incident Technique (CIT) once again [7], [9].

8. REFERENCES
