New Standards for Lower Secondary Education in Informatics in Germany

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Abstract. Over the last years, the situation of informatics in schools was significantly strengthened in Germany. Furthermore, the scientific discipline of informatics and its influence on our daily lives are constantly evolving. In light of this, in 2025 the German Informatics Society published new standards for lower secondary education in informatics in Germany, replacing the first version published in 2008. In this country report, we describe the development process and the resulting revision of the standards. In particular, we present overarching themes and illustrate changes to the preceding document. This way, we demonstrate how the developments and trends in informatics (education) were addressed within the German context, contributing to the international discourse on the curricular evolution of informatics in schools.

Keywords: National Standards · Lower Secondary Education · Computer Science · K-12

1 Introduction

In 2008, the German Informatics Society (GI) published a first version of national standards for lower secondary education in informatics [1]. These had a recognizable influence on implementing the subject *informatics* in lower secondary schools and the development of curricula in the German federal states. Furthermore, standards for higher secondary education (2016) [2, 3], and recommended competences for primary schools (2019) [4] were developed by the German Informatics Society as well.

Over the years, the need for a revision of the 2008-standards had grown. Informatics as a scientific discipline has evolved and is shaping our world more and more noticeably. This has had an impact on teaching informatics in order to meet the needs of general education for young people, inevitably necessitating curricular changes and adjustments – similar to other countries and standards [5]. Moreover, 12 out of 16 federal states have introduced or announced the introduction of a compulsory subject informatics in lower secondary schools over the last years [6]. Extensive experience in teaching informatics in schools led to an adjustment of expectations. Against this background, in 2021, the GI set up a working group to revise the standards.

In this country report, we provide an overview of the new revised version, published in 2025 [7]. To this end, we first describe our national background by explaining the German educational system and the initial version of the standards from 2008. We then describe the development process for the revision. Building upon that, we outline the revisions made to the standards with a focus on overarching themes, taking into account the national and international discourse on curricular developments concerning informatics in schools.

2 Background

2.1 Educational Standards

Educational standards define competences that students should achieve in a subject at a certain grade level. In contrast to the focus on content and methods in previously common curricula, educational standards are competence-oriented as a consequence of the PISA studies [8]. They are based on scientific findings and pedagogical objectives and describe competences that students should develop in relation to content and subject-specific methods. It is not about what and how students should learn, but rather what students should be able to do [9].

2.2 The German Education System

The German education system is federal in its nature. Each of the 16 federal states has its own education system with different types of schools. As a common feature, from the age of six, school attendance is compulsory for a period of nine or ten years in all of Germany. In most federal states, this period begins with four years of elementary school. The lower secondary level typically spans from grade five to ten. The upper secondary level is voluntary. Students at this level attend school two or three years more, for a total of 12 or 13 years. A comprehensive description of the German education system can be found in [10].

In Germany, educational standards are an instrument for educational monitoring and quality assurance. They also ensure the comparability of educational outcomes across the different federal states, thus enabling students' mobility between the different federal educational systems. For major subjects, legally binding standards are created on behalf of the Standing Conference of the Ministers of Education and Cultural Affairs. Within a federal state, a new curriculum is then expected to requirements of these standards. The educational standards for upper secondary education also form the basis for the final examination, serving as general qualification for university entrance.

2.3 The First Version of the Standards for Lower Secondary Education in Informatics (2008)

Over the last decades, various countries developed standards, curricula or alike for informatics in schools [11].

However, since now (2025) there are no official national standards for informatics in Germany, as it is not yet a compulsory subject in all federal states. Therefore, in 2008, after a four-year development process, the GI published recommendations for educational standards for lower secondary education in informatics [1]. The aim of these standards was to demonstrate the general educational nature of informatics and thus successfully promote the introduction of a compulsory subject in the federal states. In this sense, the standards have the goal to empower students to understand and be involved in shaping the digital world we are living in.

These first standards are based on the competence model used in the NCTM-standards for mathematics education [12]. Accordingly, competences are divided into process areas and content areas (see figure 1). Process areas are summarised into five categories and are focused on activities, which are not necessarily exclusive to informatics. One example from the category *reason and evaluate* is: *"The students evaluate the usefulness of a given representation of information for a specific situation"*. Content Areas are summarised into five categories as well and more focused on activities directly related to the content of informatics. One example from the category *algorithms* is: *"The students realise formal representations of algorithms and implement them into a programme"*. A competence in the field of informatics consists of both a process component and a content component.

3 Development Process

Similar to the process for the first version in 2008, the working group for the revision of the standards consisted of both practitioners and researchers in the field of computing education. In total, about 15 people from all over Germany met regularly between March 2021 and the end of 2024 in a mix of multi-day face-to-face meetings (especially at the beginning, allowing for intensive discussion) and online sessions (more towards the end, finalising the standards). During the meetings, subgroups were often formed to focus on specific aspects, such as individual content or process areas, based on individual expertise and interest. The results and intermediate states of the discussions were frequently fed back to the whole group, related to each other, and discussed intensively—also taking into account the academic discourse in the field.

Community involvement played an important role. At an annual computing education workshop for researchers and school teachers, a group of critical friends provided feedback to the respective status in the years 2022, 2023 and 2024. Furthermore, before the largest (biennial) German-speaking conference on informatics in schools (INFOS) in 2023, more than 150 participants were provided with an interim version and asked for written feedback as well as their

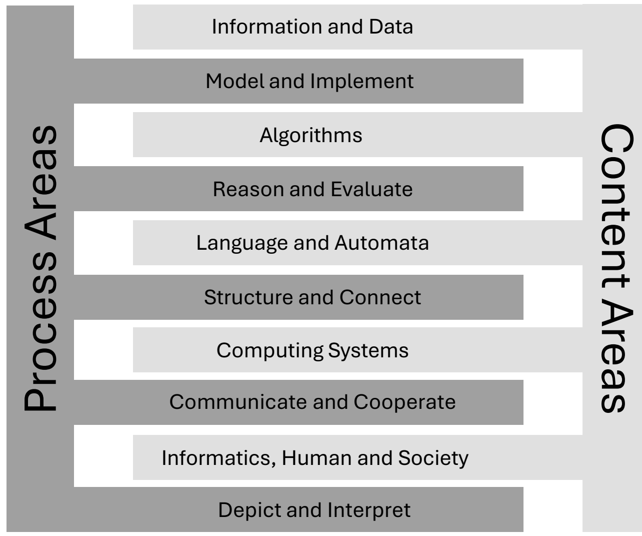

Fig. 1. Competence Structure of the 2008 Standards

participation in a workshop as part of the conference programme. After incorporating the feedback, an online survey was conducted in the fall of 2023, inviting the entire informatics in schools community. As a final step of community involvement, four established experts in computing education and educational research were asked for their assessment.

After incorporating community feedback through these formats and reaching a final consensus in the working group, the standards passed various committees in the GI and were finally published in January 2025.

4 The 2025 Standards for Lower Secondary Education in Informatics

In the following, we describe the revisions made to the standards. First, in section 4.1 we present overarching themes. Subsequently, in sections 4.2 and 4.3, we provide a more detailed comparison of the process- and content areas, respectively, illustrating the changes made with specific examples.

4.1 Overarching Themes of the Revision

For the revised version of the standards, extensive changes were made. However, the new version is more of an update in the sense of a natural evolution rather than a disruptive paradigm shift. In the following, we present overarching themes that emerged during the development process.

Changing the Target Group Back in 2008, the actual curricular integration of informatics as a subject was scarce and primarily implemented in elective formats. Therefore, the previous standards aimed at teachers and educational decision-makers, both groups with—at that time—often a rather limited background in teaching informatics. They also provided more explicit orientation on content as well as pedagogical recommendations on how to teach it. Given the ongoing nationwide introduction of informatics as a mandatory subject and the far larger percentage of well-educated teachers, the working group decided to change the primary target group and now clearly address curriculum designers in the different federal states. To this end, the standards were realigned to serve as an orientation and recommendation for curriculum development, not as a direct basis for teaching.

Alignment with Policy Recommendations In line with this, the new standards are aligned with the latest national educational recommendations, particularly the number of lessons that ought be allotted for informatics. In 2022, the Scientific Commission of the Standing Conference of Ministers of Education published a comprehensive report recommending at least six lessons per week, distributed over the course of lower secondary education (e. g. one lesson a week from year 5 to 10) [13]. In clear support of this demand, the new standards are designed under this assumption and adapted to fit within this scope.

Addressing Every Student Furthermore, the revision paid particular attention to the aims of general education in the context of informatics for all. In 2008 and the following years informatics reached only a comparatively small group of students, mostly at grammar schools and in elective courses. As a compulsory subject, however, informatics has to be approachable and relevant for everyone, regardless of school type or career plan. Combined with the increased experience gained in the last 20 years in teaching and learning informatics in lower secondary levels, competences were critically reevaluated with respect to whether they are indeed suitable and relevant for everyone, not just for certain rather motivated students.

Cutting Ties Back in 2008, the German political discourse on informatics in schools was still heavily influenced by digital or media literacy and ICT-related skills. Hence, the 2008 standards included an extensive justification for why informatics should be an essential part of a contemporary general education. Furthermore, quite a few competences were, in fact, related to digital literacy. For instance, there was a strong focus on object orientation to model computing systems (i. e. text processing or spreadsheet software), injecting computing concepts into ICT education, which was in line with the information-oriented approach to informatics in schools popular at the time [14]. While still emphasizing the importance of modelling, such injections were significantly reduced. Instead, the new standards take a more self-confident approach by focusing more on informatics-specific content and removing corresponding justifications.

Integrating Innovations in Informatics As a young and dynamic scientific discipline, informatics is characterised by ongoing changes and innovations, which frequently influence the world we live in. With respect to general education, such innovations need to be analysed concerning relevant competences to prepare students for their future lives, without falling for short-lived technological developments or *hypes*. The most prominent example is the recent advancements in artificial intelligence (AI), resulting in an ever-growing importance of AI systems in our society and daily lives. To educate responsible citizens, everyone ought to learn about the core ideas and principles of AI, which are also discussed as a new perspective on computational thinking [15]. Against this background, respective competences based on the discourse in computing education [16–18] were included across existing content areas. This underscores an integrative approach to AI education in schools [19]: AI is considered as a different perspective on existing content and therefore the existing content areas were thus extended correspondingly. It did not turn the whole curriculum upside down. Similarly, competences concerning education for sustainable development [20] were added throughout the content and process areas.

Updating Traditional Content Besides new competences, existing content was re-evaluated and revised. A central example of this is the perspective on data. While being an important part of the 2008 version, it was mostly focused on representations and operations. In line with the discourse in computing education, this was developed further, shifting the focus towards a more holistic perspective in the sense of data literacy and the data life cycle [21]. Similarly, other competences were revised to reflect developments in the field, e. g. concerning the internet, cryptography, or the impact of computing on our society [22].

Abstracting Further Moreover, to achieve the goal of preparing students for their future, so that even in 20, 30, or 40 years they are able to understand situations and phenomena surrounding them to a certain level, we have to provide them with transferable fundamental ideas and principles of informatics [23, 24]. While in general the 2008 standards met those goals, in some cases, competences rather closely referenced specific technologies. Such cases were revised to use more general terms to further reduce dependence on technological developments. For example, references to email and chat were replaced by "the use of computing systems for synchronous and asynchronous communication, cooperation and collaboration".

Strengthening the Design-Perspective Lastly, the 2008 standards put a strong focus on the understanding of certain computing concepts, but sometimes did not explicitly require their application in relevant contexts. In line with constructionism [25], the new standards more clearly highlight the design of personally meaningful artifacts, which certainly requires but goes beyond a mere understanding of concepts.

4.2 Process Areas

The new standards adopt the competence model of the previous version (see figure 1), including its five process areas: *model and implement*, *reason and evaluate*, *structure and connect*, *communicate and cooperate*, *depict and interpret*. In order to increase alignment with the 2016 standards for upper secondary education, each process area was differentiated into three requirement levels: (I) *reproduction*, (II) *reorganisation and transfer*, and (III) *reflection and problem solving*. Those correspond to the Uniform Requirements for the Abitur Examination [26]. Due to their general and grade-independent formulation, they were deemed to also be applicable to lower secondary education. The resulting competence model, supplemented by the requirements levels, is illustrated in figure 2.

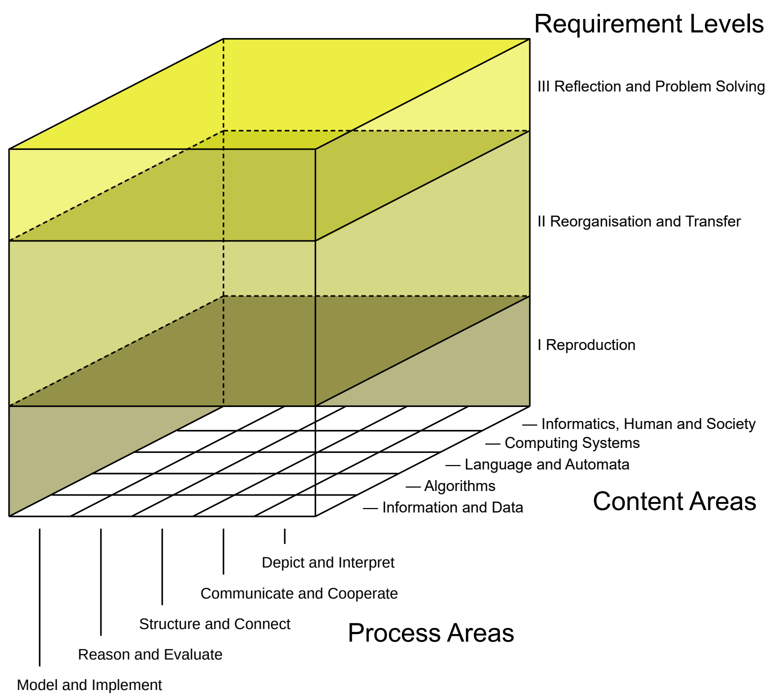

Fig. 2. Competence Structure of the 2025 Standards

In general, there were no paradigmatic shifts in the orientation of individual process areas. All areas were revised to use more abstract wording. For instance, phrases such as "diagrams, graphics and illustrative models" were frequently used in the old version. The new standards summarise these as "representations". Moreover, many previous process competences included references to content. For instance, the 2008 version required students to "identify objects in computing systems and recognise attributes and their values", which references object-oriented programming. One update addressed the process area *communicate and cooperate*, as collaboration and cooperation were clearly distinguished and collaboration considerably strengthened. Overall, the new version aimed to better separate processes from content.

4.3 Content Areas

As with the process areas, the new standards adopt the five content areas from the previous version (figure 1): *information and data*, *algorithms*, *language and automata*, *computing systems*, and *informatics, human and society*. All content areas underwent significant changes, sometimes altering their overall alignment to educational approaches and theories. In the following we provide a more detailed overview of the changes made to individual content areas.

Information and Data The previous version emphasised abstract data structures, their processing and representation. The new version is instead geared toward the data life cycle and also includes competences regarding data gathering, selection and the evaluation of their suitability for a given problem. It thus highlights a more contextualised view on data as the product of digitising analogue phenomena. For example, a new competence requires students at the end of grade 10 to "interpret data and explain the limits of this interpretation (e. g. with regard to correlation and causality in the context of machine learning)." Overall, this represents a shift from a more structural to a more inquiry-based view on information and data [27].

Algorithms The previous version tended to treat algorithms more as objects of analysis, entities to be defined and whose qualities are to be assessed. The new version instead casts algorithms more as a means for solving problems, entities that are created for a specific purpose. A typical example of this is a new competence, that requires students at the end of grade 10 to "analyse problems, split them into sub-problems and develop algorithms to solve them". References to source code and formal representations were replaced by visual programming languages as the recommended means of implementation. With reference to Lonati et al. [28], the content area thus shifted from treating algorithms and programs primarily as abstract entities and notational artefacts, towards treating them more as human-made tools for problem solving.

Language and Automata This content area was shortened significantly, as the authors agreed that many previously included elements of theoretical computer science are better reserved for upper secondary levels. In fact, several competences were dropped because they had since become part of the upper secondary standards [2]. All references to real-world machines were dropped as well, for instance, those referencing the inputs and outputs of "real automata" like a vending machine. The result is a very lean content area highlighting state-based models and application-based formal languages. For instance, the only remaining grade-6 competency requires students to "identify and describe formal languages from their everyday lives."

Computing Systems The standards define a computing system as a purposeful combination of hardware, software and networking. By interacting with its socio-cultural application context, it forms a sociotechnical system. Such interactions are more strongly highlighted in the new version. For example, a new competence requires students at the end of grade 10 to be able to "describe and realise the interaction of computing systems with their environment through sensors and actuators." Competences relating to networking, security and coping with unexpected system behavior were added as well.

Informatics, Human and Society The previous version focused on specific legal frameworks, such as data privacy or licensing law, and emphasized computing impacts as a central concept. Hence, it cast informatics systems as something students primarily need to evaluate and react to "rather than actively shaping it" [29, p. 122]. In contrast, the new version also highlights social and ethical considerations during system design, such as human values, ambitions and biases that drive and shape development processes [22]. For instance, a grade-10 competence requires students to "reflect on human goals and interests (e. g. accessibility, sustainability, profit, power) while designing informatics systems." Aspects of system security and students' responsibility for it were strengthened as well.

5 Conclusion

While the previous standards from 2008 were crucial for guiding and strengthening the development of informatics in German schools, they were a product of their time and in need for revision to make them suitable for future use. Therefore, a GI working group developed a revised version over the course of four years. In their development process, they repeatedly involved feedback from the German community on informatics in schools, research and practice alike. The key updates reflect the changed state of informatics in schools in Germany, especially the larger amount of mandatory education and the established position as a subject universally considered relevant for general education. Furthermore, the revision addresses developments in the underlying scientific discipline of informatics, that made certain updates necessary. Attention was put on making these standards future-proof by abstracting even further from specific technologies. In doing so, the national and international discourse was taken into account.

However, while we consider the revision of the standards to be an important step in national development, the discourse both about the role and implementations of informatics in schools is far from being settled. As such, certain states or school types still do not include (sufficient) mandatory informatics in schools.

In particular, anchoring informatics in primary and aligning it with secondary education is essential. Furthermore, fostering the teaching quality of informatics in the classroom is an important task. To this end, research in computing education as well as professionalising teacher education and professional development further are central, e. g. addressing issues such as inclusive teaching and learning.

The revised standards for lower secondary education in informatics advance informatics in schools in Germany. The overarching themes and changes of the revision contribute to the ongoing international discourse on curricular development in informatics.

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