Curriculum Issues, Competence Models and Informatics Education in Austrian Secondary Schools: Challenges Now and Ahead

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Abstract. At the core of this paper lies an overview of recent developments of Austrian curricula issues in the field of digital education. It puts this important part of educational governance into a broader perspective, comprising considerations about the nature of curricula. The coexistence and interdependency between competence models, national curricula and educational standards are elaborated, together with exemplary in-depth aspects of secondary digital education. After critical reflections about the continuing lack of a coherent and compulsory digital education at lower secondary level, recent amendments of Austrian informatics curricula for upper secondary level are presented and reviewed.

Keywords. Informatics · curriculum · digital · competence · educational standards

1 Introduction

The Austrian school system encompasses elementary level (grades 1 to 4 from the age of 6 years on), lower secondary level (grades 5 to 8), and upper secondary level (grades 9-12/13). Lower secondary level is divided into two types of obligatory schools, namely New Middle School (NMS) and academic secondary schools (AHS), upper secondary level is divided into AHS (grades 9-12) and vocational schools (BHS, grades 9-13).

Since the late 1980s, informatics education in Austrian schools has shown an inconsistent picture especially at lower secondary level. Despite ambitious local, regional and national interventions and initiatives, it lacks still cohesion, consistency and a sequenced structure. Recently, the situation has changed insofar as a framework for digital competences and informatics education has been developed. It should serve as a quasi-educational standard. Schools and teachers are expected to achieve these standards of ICT related knowledge and skills in a cross curricular way.

Upper secondary level provides all students from grade 9 on with obligatory and elective formal IT/informatics lessons which depends on the particular type of school (AHS or BHS). Since more than 30 years nationwide IT/informatics curricula defined a defacto standard for the respective disciplines with different denotations and among other subjects. Since the last decade, a general shift to competence and outcome orientation also affected IT/informatics curricula. Based on educational standards and competence models curricula have been renewed and revised.

This paper can be seen as a mixture of a current country report underpinned with some reflections on putting curricula issues into a wider context. Obviously (real) informatics education for all starts with grade 9, resulting from a poor curricular support at lower secondary level. There are efforts to provide digital competences for all students at lower secondary, but the competence model still lacks accountability and necessary curricula for the particular grades and age-groups.

In contrast to vocational schools at upper secondary level where IT-related education is obligatory, informatics at the AHS is, from grade 10 on, an elective subject with assumed but not yet validated decreasing enrollments.

After looking at curricula in a general context, this paper outlines the current situation in Austria about ongoing curricula issues within existing frameworks and competence models in the age group 10 to 18/19 years.

2 Curriculum Issues in a Broader Context

A curriculum can be seen as a contract between society, politics and schools/teachers about the way of organizing and providing sequences of learning experiences aimed at producing desired learning outcomes. The curriculum reflects the kind of society to which we aspire [1]. Another definition describes the curriculum as all planned learnings for which the school is responsible and all the experiences learners have under the guidance of the school. Curriculum is the totality of learning experiences provided to students so that they can attain general skills and knowledge at a variety of learning sites [2]. Put in the simplest way, a curriculum is a course or plan for learning [3].

Fig. 1. Poster at Aga Khan Academy Mombasa, Kenya, 2011.

A poster of Kenya's Institute of Education, which I photographed in front of the Aga Khan Academy in Mombasa during the IFIP conference "ICT and Informatics in a Globalized World of Education" in August 2011, demonstrates the importance of curricula issues especially in Kenya at that time. Moreover, it indicates that a curriculum is more than just written paper. As shown in the poster, a curriculum implies other educational areas, including the "core functions" as carrying out orientation for stakeholders, providing curriculum materials, teachers' training, media programmes and evaluation issues.

Curriculum issues and curriculum reforms cannot be judged without looking at the educational system, educational governance and the socio-cultural background, and as mirrored in the model, its range of influence.

For some years, in many countries curricula are interwoven with competence models and educational standards. Not least due to the disappointing results of international comparative studies such as TIMMS and PISA about 15 years ago, educational experts in many countries brought up the idea and concept of outcome orientation and educational standards.

3 Competence Models and Educational Standards

Educational standards can be regarded as precise and binding expectations in terms of competence attainment of the learners. The trigger and rationale for competence orientation not only in Austria, but in other European countries as well, was the need for comparing education systems. The EQF (European Qualification Framework [4]), published in 2008, put this idea into a relevant and influential document. Acting as a translation device to make national qualifications more readable across Europe, it has the potential to relate different countries' national qualifications systems. Although the EQF is voluntary and the member countries are not obliged to cross reference their frameworks, Austria's vocational school system has been strongly influenced by it and adopted its ideas from its release in 2008 on.

In 2011 the Federal Ministry of Education, Arts and Culture released competence models and defined educational standards for all subjects. Exemplarily, the competence model for Applied Informatics in the BHS is shown in Table 2.

Table 1. Competence model for Applied Informatics for vocational schools

		Action Dimension			
		Understanding	Applying	Analyzing	Developing
Content Dimension	Informatics Systems				
	Publication and Communication				
	Spreeadsheets				
	Databases				
	Informationtechnologie, Human and Society				
	Algorithms and Datastructures				

Based on this competence model, new curricula have been developed. They represent more or less educational standards which consist of detailed descriptors as chunks of learning objectives. Each of these descriptors is assigned to one blank cell in Table 1. These new curricula are formulated with strict competence orientation [5]. Additionally, the syllabi (list of descriptors) from grade 10 onwards are split into modules for every semester. Accordingly, assessment takes place on a semester basis. Students get semester reports with qualifications and rights which were previously reserved to year-end reports [6].

Due to an Austrian common agreement on competence orientation among education experts, not only vocational schools had to switch from input-oriented educational plans to an outcome-oriented approach, but also lower secondary and upper non-vocational education as provided by NMS and AHS. As a consequence, two competence models have been developed.

Table 2. Competence Models for General Secondary Education (grades 5-12)

	Content	Levels of Competences		
		Knowing Understanding	Applying Designing	Reflecting Evaluating
Media Reflexion Related Topics	**Information Technology, Human and Society**			
	Impact of IT in Society			
	Responsibility in Using IT			
	Privacy and Data Security			
	Developments and Vocational Perspectives			
Digital Media Knowledge	**Informatics Systems**			
	Technical Components and their Use			
	Design and Use of Personal Information Systems			
	Data Exchange in Networks			
	Human-Machine Interface			
Use and Production of Digital Media	**Software Applications**			
	Documentation, Publication und Presentation			
	Calculation and Visualization			
	Search, Selection and Organisation of Information			
	Communication and Cooperation			
Principles and Computational Thinking	**Informatics Concepts**			
	Representation of Information			
	Structuring of Data			
	Automatization of Instructions			
	Coordination and Controlling of Processes			

	Content	Levels of Competences		
		Knowing Understanding	Applying Designing	Reflecting Evaluating
Media Reflexion Related Topics	**Information Technology, Human and Society**			
	Impact of IT in Society			
	Responsibility in Using IT Privacy and Data Security			
	History of Computing			
	Vocational Perspectives			
Digital Media Knowledge	**Informatics Systems**			
	Technical Basics and Functionalities			
	Operating Systems and Software			
	Networks			
	Human Computer Interaction			
Use and Creation of Digital Products	**Applied Informatics**			
	Production of Digital Artefacts			
	Calculation Models and Visualization			
	Search, Selection and Organisation of Information			
	Communication and Cooperation			
Principles and Software Developement	**Practical Informatics**			
	Concepts of Information Processing			
	Algorithms, Data Structures and Programming			
	Data Models and Databases			
	Intelligent Systems			

I can reflect my responsibility when using IT systems in terms of quality and quantity.
I can evaluate and recommend various measures to protect data and IT systems.

I can design calculation models for solving problems.
I can analyse data with specific software.
I can visualize data appropriatly.

I can explain important technical terms and concepts in the context of tables.
I can describe, explain and sketch database models and relations between tables.

Finally, the framework for Digital Competence and Basic Informatics Education (left table in Table 2) for lower secondary level has been published in 2011 [7]. It consists of four main categories and four content areas and 70 "I can …" descriptors. Many sample tasks have been developed to illustrate and concretize the expected objectives and competencies within the Austrian project "DIGIKOMP" and the campaign "No child without digital competence" [8, 9]. It is worth mentioning that this competence model for lower secondary education, in contrast to other traditional subjects, has been developed without referring to an existing respective national core curriculum.

One function of this model is to provide schools with guidance for implementing educational objectives. These can serve as a road map for policy makers, teachers, pupils and parents as well. A second is to form a basis for assessing educational outcomes in terms of widely accepted objectives [9], [13]. The competence model and its objectives can also provide an orientation for individual diagnosis and supplementary support measures.

Although there has been a broad agreement and commitment for "No child without digital competences" among many stakeholders, the challenge still remains to turn these designed ideas in the form of a competence model into a set of teaching practices. This will require much effort in terms of pre- and in-service training and the readiness of schools and teachers to achieve this goal.

One current approach, especially in the NMS, is a planning grid where teachers in all disciplines are invited to carry out selected and prepared tasks. By now, more than 200 sample tasks and assignments have been developed by teachers. They are published under a CC license on an official website [9]. Each task provides a range of variable learning objectives of the competence model. It is up to the teachers to find good progression pathways to cover as many learning objectives as possible.

Among many experts in Austria there is a concern that this cross curricular approach without a sequenced curriculum for the grades 5-8 and without a respective subject in its own right cannot be successful. A commissioned evaluation conducted by the Austrian educational institute BIFIE [10] could give an answer.

In the past and currently, still many schools in Austria offer formal IT and informatics lessons on an elective level and based on autonomous curricula. Together with a half-hearted implementation of DIGIKOMP (for lower secondary education) this leads necessarily to an undesirable patchwork and thus to an institutionalized digital gap between schools and pupils at an age of 14 years.

One key challenge in Austria's educational system is definitely to be clear about the necessity of a systematic and curricular-based implementation of digital competence for all pupils at lower secondary level.

4 Curricula for Upper (General) Secondary Education

4.1 Curriculum for the Obligatory Subject Informatics in the 9th Grade

Secondary academic schools (AHS, Gymnasium) provide a broad general secondary education at pre-university level for grades 5-12. Since the late 1980s, informatics has been compulsory in grade 9 and elective in the grades 10-12. Due to a major reform of the school leaving certification process (Matura) in 2015, there is a need for new competence oriented curricula, based on the existing competence model for upper secondary level (right grid in Table 1). Its similarity with the competence model for lower secondary level is obvious and intended. There are only a few changes in denotations which indicate the shift from digital competence (IT literacy) and ICT at lower secondary level to informatics at secondary level. This model consists of four categories, each further divided into four independent areas. Eighty descriptors in the form of “I can …” statements describe the competences, providing more detailed information about the objectives and the corresponding topics and serving as the basis for the new competence oriented informatics curriculum in the 9th grade. This should provide teachers and students with a comprehensive and clear picture of informatics.

Table 3. Contents of the curriculum in grade 9

Informatics, Human and Society
- Students describe the importance of computer science in society, evaluate its impact on individuals and society and examine exemplarily the advantages and disadvantages of digitalization.
- They take measures and apply legal principles related to data security, privacy and copyright issues.
- They describe and evaluate the development of computer science.
- They know professions related to Informatics and applications of Informatics in various occupational areas.

Informatics Systems
- Students describe and explain the structure of digital devices.
- They explain the functionality of informatics systems.
- They explain the basics of operating systems and handle graphical user interface and utilities.
- They describe the basics of networked computers.

Applied Informatics
- Students use standard software for communication and documentation as well as for the creation, publication and multimedia presentations of their own works.
- They apply standard software for calculating and visualizing.
- They know the basics of information management and use suitable software for the organization of their learning.
- They can explore sources of information, systemize, structure, evaluate, process digital content and apply different representations of information.

Practical Informatics
- Students explain terms and basic concepts of Informatics and put them into context.
- They understand, design and represent algorithms and implement them in a programming language.
- They explain basic principles of automata, data structures and programs.
- They use data bases and design simple data models.

The competence oriented curriculum for grade 9 which is an amalgam of the old curriculum of 2003 [11] and the competence model in Fig. 1, is in review for approval and will be enacted from the school year 2016/2017 on. Its subject matters and competencies (Table 3.) mirror the competence model in Table 2. Considering the fact that there are only two hours of lessons per week, it covers a very wide range of contents. For many pupils aged 15 years this is the first contact with formal informatics lessons. Therefore, it may be questioned if the broad content including many objectives of this curriculum is overloaded.

Each intended curriculum is at first sight a theoretical plan which has to be implemented and achieved in practice. A pilot study about the contents taught in four elected schools has been conducted in the school year 2013/2014 and yielded interesting insights. The data were collected after an informed consent of the schools from the central database of an Austrian wide digital class register. Most academic secondary schools have outsourced the documentation of taught contents. Teachers have to record the subject matter they teach each week. Therefore, this central database provides a rich source of data which can be compared to the specification of content in the respective curriculum.

The word cloud (Fig. 2.) gives an impression of the subject matter covered (or at least recorded as covered) by informatics teachers. It is striking that there is very little programming or databases. Standard software widely dominates the content. Although the sample of data is very small and needs to be extended to yield valid results, the assumption that informatics in grade 9 is mainly application driven has been confirmed.

Fig. 2. Contents taught in informatics lessons in grade 9 of four Austrian schools.

At this point it is opportune to point at different views on curriculum levels. The intended curriculum is content specific by the state, district or school to be addressed in a particular course or at a particular grade level. The implemented curriculum is content actually delivered by the teacher, and the attained curriculum is actually learned by the students [12].

Table 4. Typology of curriculum representations [17]

INTENDED	Ideal	Vision (rationale or basic philosophy underlying a curriculum)
	Formal/Written	Intentions as specified in curriculum documents/materials
IMPLEMENTED	Perceived	Curriculum as interpreted by its users (especially teachers)
	Operational	Actual process of teaching and learning (curriculum-in-action)
ATTAINED	Experiential	Learning experiences as perceived by learners
	Learned	Resulting learning outcomes of learners

Table 4 illustrates the long way from the intended curriculum to its way into the brains of the learners where effective curricula with the status “attained” leave something magic called “competence”.

The analyzed empirical data in the word cloud in Fig. 2. can be unambiguously assigned to the implemented and perceived curriculum. It shows how the teacher in grade 9 interprets the curriculum, but it does not tell us anything about the attained curriculum and the learning outcomes of the students.

These measurable learning outcomes are at the core of the idea of competence orientation. This is represented by the top dimension “consequences” of the Darmstadt Model, whereas the operational and experimental stage can be subsumed under the “decision area”, the “battle zone” in the class where the curriculum meets the students in concrete lessons.

4.2 Informatics from Grade 10 to 12 as an Elective Subject

Influenced by the Austrian vocational education system, all curricula including the elective subject informatics for grades 10-12 in the AHS (Gymnasium) have undergone revisions. After an evaluation process the revised informatics curriculum will be implemented from the school year 2017/2018 on in grade 10, affecting the teaching and learning plans for all students who will choose this subject then.

A newly designed competence oriented oral final examination (so-called Matura) has been implemented and were conducted for the first time at the end of 2014/15[13]. Oddly, these competence oriented exams took place before the new competence based curricula had been enacted. Despite these obvious formal deficiencies ("old curriculum and new Matura"), a nationwide cursory evaluation of the oral Informatics Matura yielded no obvious problems. Apparently, the competence model [11] sufficed as a reasonable basis and the old curriculum which has been implemented in 2003 is without constraints. It comprises eleven different topics, without any further specifications when and to what depth to teach the following broad topics:

> *Basic principles of information processing, concepts of operating systems, construction and operation of networks, databases, learning and work organization, concepts of programming, artificial intelligence, expansion of theoretical and technical foundations of computer science, basic algorithms and data structures, computer science, society and the world of work and legal issues.*

Teachers are currently responsible for the selection and sequencing of these topics in combination with appropriate software tools. Together with the competence model, these topics serve as the basis for the oral Matura.

Readjusting curricula for the sake of alignment with the new Matura is just one reason for the recently revised informatics curriculum. The other one is a further reform ahead, namely "Modularization" in analogy to the reform in the BHS. This means also for the AHS that all syllabi including informatics from grade 10 onwards have to be split into modules for every semester, and assessment will take place on a semester basis similar to the practice at university level.

Table 5. Distribution of content areas on a semester basis.

Grade Semester	Social Informatics	Technical Informatics	Applied Informatics	Practical Informatics
Grade 12 Sem 2	Integration of topics and content, repetition			
Grade 12 Sem 1	L1 RIT (2) L2 PDS (2) L2 HIS (1)	L4 SYS (1) L2 OSS (2) L1 HMI (1)	L1 COM (1)	L2 CON (3) L4 ADP (6) L1 INS (3)
Grade 11 Sem 2	L1 PDS (1) L1 HIS (2) L1 VOC (3)	L3 SYS (2) L2 NET (3)		L1 CON (2) L3 ADP (3)
Grade 11 Sem 1		L2 SYS (1)	L1 SSO (3) L2 SPV (2)	L2 ADP (2) L1 DBS (4)
Grade10 Sem 2		L1 NET (3)	L1 SPV (3)	L2 ADP (2)
Grade 10 Sem 1		L1 SYS (2) L1 OSS (3)	L1 PDM (3) L1 COC (2)	L1 ADP (3)

Legend
Social Informatics Relevance of IT (RIT), Privacy/Data security (PDS), History of IT (HIS), Vocational Perspectives (VOC)) **Informatics Systems** Structure and Function of IT-Systems (SYS), Operating Systems and Software (OSS), Networks (NET), Human-Computer-Interface (HMI)) **Applied Informatics** Production of Digital Media (PDM), Spreadsheets and Visualizing (SPV), Search, Selection and Organisation of Information (SSO), Communication and Cooperation (COM)) **Practical Informatics** Concepts of Information Processing (CON), Algorithms, Datastructures and Programming (ADP) , Data models and Database Systems (DBS), Intelligent Systems (INS)

The replacement of the old curriculum with the significantly new one has been accomplished recently and waits for approval. Its implications for teachers and students will be substantial. The freedom of planning lessons for three years with broad topics will be replaced by six semesters with preset learning objectives and self-contained modules. Table 5 shows the proposed distribution of content areas. The numbers in brackets indicate the number of descriptors which put the learning objectives into more concrete terms.

All 16 main content areas from the existing competence model in Table 1 are represented. Algorithms, data structures and programming (ADP) can be found in all semesters with 16 out of 71 descriptors, covering a constitutive part of informatics. The topic databases (DBS) with 4 descriptors is provided to be taught only in the first semester of grade 11.

Actually, this proposed curriculum is essentially a rearrangement of the competence model and its content areas and learning objectives into 5 semesters. The last semester in grade 12 is intended to serve for integrating and repeating the subject areas.

The next years will prove if and how this loss of freedom for teachers in planning informatics lessons throughout three years will be commonly accepted.

5 Discussion

Curriculum issues play a very important role in any educational system, in particular with respect to informatics education. In contrast to other traditional disciplines and due to a comparatively new and still dynamic and fuzzy field, the challenges now and ahead are considerable.

> *"Given the importance of informatics as the scientific and engineering basis for the information society, and the ubiquitous political discourse about the importance of innovation, high technology and IT, one might expect that informatics education would by now have found its natural place in the curriculum of industrialized countries, particularly in Europe. Unfortunately,*

and paradoxically, this is not the case. In fact, informatics education has retreated in most European curricula since pioneering efforts in the 1970 and 1980s".

This citation from Informatics-Europe [15] can be applied in particular to the Austrian situation. From the perspective of experts, it expresses concerns about the insufficient representation of digital education at all levels of school education except for special areas of vocational education. However, the next years with approved new curricula, accompanied by professional teachers training and appropriate teaching material, will be a challenge.

Seen from a more general and abstract point of view, there is evidence that a certain "vocationalization" of general school curricula not only in the field of informatics takes place [16], a phenomenon which is also addressed in this paper. The shift of from education (in German "Bildung") to an unconditioned and maybe exaggerated competence orientation, to a sort of "utilitarism" and a loss of teaching freedom are increasingly discussed by some teachers and education experts.

Finally, some questions are still up to discussion. Who controls and influences the expert groups who develop models and curricula? Who is in charge for the implementation, and above all, how it is ensured that the enacted models, curricula and educational standards correspond with the teachers' expectations and students' attainments? Obviously, these questions also apply to traditional subjects. With respect to informatics and digital education, we should be, in the first place, so modest to agree at least on a widely accepted balanced curricular coverage of secondary education.

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