Selected Spotlights on Informatics Education in Austrian Schools

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Abstract. In this paper we take a look on Informatics education in Austrian primary and secondary schools. The development of two reference models for digital competence and Informatics education should be seen as a big conceptual step forward, but regarding its nationwide implementation there is still a long way to go. Further, we report on a promising local initiative in Informatics for primary education as an outreach program. Then the current status of the development of a "curriculum reform light" for the obligatory subject Informatics in the 9th grade is pointed out. And finally, a major reform of the school leaving exam (Matura) at academic secondary schools including Informatics has been implemented in 2015 for the first time. In the last chapter we reflect on its general conditions, first experiences and results.

Keywords: School education, Informatics, Competence Orientation, Reference Models, Digital Competence, Curriculum, Final Exam, Matura

1 Introduction

Since the late 1980s, Informatics, ICT and Digital Media education at all levels of Austrian schools for general education have shown an inconsistent picture. Although there are many ambitious local and regional initiatives, Informatics education is not adequately represented in school, given the digital nature of our era. There is still a long way to go in Austria, especially in primary and lower secondary education.

This paper outlines the big picture of two comprehensive, coherent and comparable frameworks, including Informatics, ICT and digital literacy for all Austrian pupils and students in general education. It does not go into detail regarding vocational education at upper secondary level where the situation is much clearer, better structured and more binding.

The Austrian school system encompasses elementary (grades 1 to 4, from the age of 6-7 years on), lower secondary (grades 5 to 8), and upper secondary level (grades 9 to 12) [1]. The secondary level is divided into two types of obligatory schools, namely

New Middle School (NMS), and academic secondary schools (AHS). This type of school comprises a four year lower level and a four year upper level, and concludes with the upper secondary diploma or school leaving exam (Matura) which entitles to study at universities. Currently about two thirds of the pupils attend the NMS and about one third the lower level of the AHS for four years.

Due to the lack of binding national IT-frameworks and central Informatics curricula at primary and lower secondary level so far, schools and teachers act independently, teaching, if at all, Informatics and ICT according to school specific curricula. As an undesired consequence, schools and students proceed and perform at extremely different paces.

2 Two Similar Frameworks for Digital Competence and Informatics Education for all Levels

The two competence models presented here refer to all pupils and students, from primary education on to the upper secondary level and Informatics Matura [2].

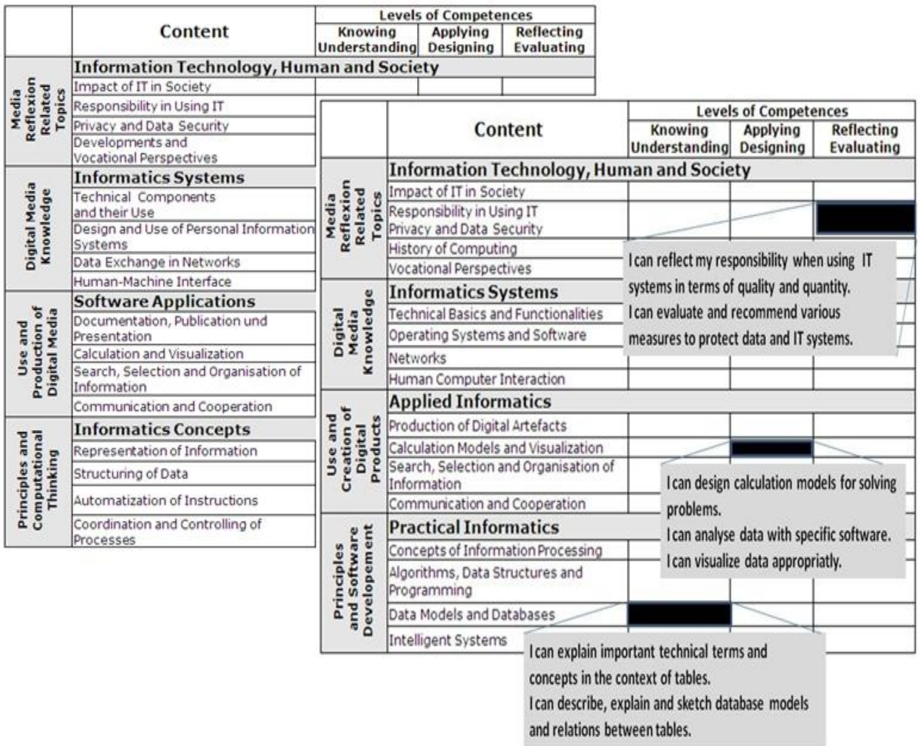

Fig. 1. Models for Digital Competence (primary and lower secondary level, to the left) and Informatics Education (upper secondary level, to the right)

Lower secondary level (10-14 year olds) should be regarded as both a window of opportunity for and important phase of basic Informatics education. Standard learning objectives with clear expectations for teachers and students, based on a consistent, coherent and outcome-oriented reference framework, were overdue, and their development has been least triggered by the Digital Agenda [3], a framework for digital competence (left table in Fig. 1.) developed.

This model for "Digital Competence and Basic Informatics Education" incorporates many aspects. It is integrative, consistent, interdisciplinary and multidisciplinary.

A detailed discussion of the structure and example descriptors can be found in [4]. In general, curricula can be regarded as results of cultural traditions and findings from science and empirical research, including framework conditions given by educational policy. The competence framework for lower secondary education has been developed without referring to a national (core) curriculum because currently there is none.

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 accepted objectives. The competence matrix can also provide an orientation for individual diagnosis and supplementary support measures.

The framework and classification scheme (Fig. 1.) with four main categories and four content areas for each, together with about 70 "I can …" descriptors, has been disseminated among Austrian teachers. Many prototype subject 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." [5],[6].

Fig. 2. Planning grid for digital literacy and competence in lower secondary education

Subject to there being broad agreement on this project in all NMS and AHS, the acceptance of the standardized learning objectives and the development of tasks under a CC-license, schools should then be able to transfer theory into practice through effective implementation processes.

One current approach, especially in the NMS, is a planning grid (Fig. 2.) where teachers in many disciplines are invited to carry out selected tasks and to cover, if possible, all learning objectives of the competence model. This project, currently in progress, will be evaluated by the Austrian educational institute BIFIE.

Integrating these tasks in other subjects and/or implementing a new (interdisciplinary) subject are key issues for the future. Ongoing challenges include the supply of competent teachers, the development of competence-oriented curricula and corresponding teaching and learning material for the grades 5 to 8.

Currently, it does not seem to be realistic to implement compulsory Informatics lessons for all pupils at lower secondary level in a short time. However, there is hope that within a future major curricular reform, a new integrative and innovative subject covering all aspects of digital education including Informatics could be established.

3 Interventions and Initiatives at Primary Level

It speaks for the robustness of this model that there is an Austrian initiative to harness it as a framework for primary level within the project DIGIKOMP4 [7]. This model has the same main and subcategories as the framework for lower secondary level. The objectives are tailored appropriately to the particular age-group, but are still seen as very demanding. More than 50 tasks have been developed and published online. This can be seen as an ambitious endeavor to build IT-competency from a very early stage on. However, the general conditions in Austrian primary schools for a large-scale promotion and implementation of IT and Informatics are not beneficial. The reasons for this situation are manifold and need further investigation.

Whilst the situation in Austria is rather different from the top down / bottom up overhaul of computing education experienced by teachers in England, there are some interesting Austrian interventions and initiatives, typically focusing on outreach or of an informal, regional and project-driven character:

- Informatik erleben [9]
- Technik basteln [10]
- Wiener Zauberschule der Informatik [11]

Currently the funded project “Informatics – A child’s play” and the idea of an “Informatics-Lab” [12] try to attract primary school pupils to Informatics. Many pupils in Austria associate the term informatics with the mere use of computers, tablets or smartphones. The main goal of the concept Informatics-Lab is to provide them with a better understanding of what Informatics really is. Other goals are to attract more pupils for the Informatics at an early age; the provision of co-operative learning environments where students teach one another through peer tutoring; development and use of neurodidactical lesson concepts; and the teaching of basic principles of computer science in a playful way [13].

Sample Workshops **[**http://informatikwerkstatt.aau.at]

- **All is logic** (Boolean Algebra)
- **1 + 1 = 10** (Binary Numbers)
- **Top secret!** (Codes and Encryption)
- **Fully networked** (The Internet and Networks)
- **Touchable computer** (Computer Systems, Hardware)
- **The data bus is on its way!** (Information Processing)
- **Well planned is half done** (Modeling and Diagrams)

The pilot project took place in July 2014 and recently 2015 at Klagenfurt University. Three research questions were the basis of an ongoing study:

- Is the concept Informatics-Lab able to increase the interest in Informatics?
- How are the individual learning workshops rated?
- Which learning methods helped the most in understanding the topics?

Feedback and replies of about 90 participants have been evaluated. The results were very promising and mainly positive. The answers about the learning methods are remarkable: The visitors rated the tutors most effective in explaining the topics. 75% said that individualized learning was very or rather helpful. More than 60% rated cooperative learning with peers and the booklet as very or rather helpful.

This regional project and initiative already seems to be having an impact on the positive perception of Informatics from an early age.

4 Special Case 9th Grade – A Compulsory Curriculum for All

Secondary academic schools (AHS, Gymnasium) provide a broad general secondary education at pre-university level for grades 9-12. Since the late 80s, 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 has been a need for an educational guide providing recommendations for the structure and implementation of competence oriented curricula, tasks and final exams.

The similarity with the competence model for lower secondary level is obvious and deliberate. There are only a few changes in denotations which indicate the shift from digital competence (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. 80 descriptors in 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. Taken as a whole, this provides teachers and students with a clear picture of Informatics.

The competence oriented curriculum, which is an amalgam of the old curriculum of 2003 [14] and the competence model in Fig. 1, is currently in review for approval.

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.

Each curriculum is primarily only a (theoretical) paper. However, the implementation of these requirements and the consequent impact on students' competences is the other (practical) side of the coin. The issue of the intended, implemented and achieved curriculum is an interesting field of research. There are already some empirical results regarding the implementation of students achievement under the old curriculum [15]. Recent pilot research yielded insights into the actual contents which have been taught in some schools in the school year 2013/2014. The data were collected after informed consent of the schools from the central database of an Austrian wide digital class register. Most academic secondary schools have outsourced the lesson planning process where teachers have to record the subject matter they teach each week, providing a rich source of data on the planned, if not always enacted, curriculum.

The word cloud (Fig. 3.) 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 the 9th grade is very application driven is justified.

Fig. 3. Word cloud of Informatics lessons in the 9th grade of four Austrian schools.

5 Competence Oriented Informatics Matura – First Impressions and Results

A major reform of the final exam (Matura) at academic secondary schools has recently been implemented, with effect from the 2014-15 school year. All subjects, Informatics included, have been affected. A strong competence orientation, especially in the task construction provided the underlying philosophy for the reform. Whereas in languages and mathematics central regulations provided all students with the same tasks at the same time, in other disciplines, including Informatics, it has been left to the schools to select topics and develop individual tasks, based on particular curricula and competence models.

Oddly, the first exams under the new system (the Matura of summer 2015) took place before the new competency based curricula were in place, which will be adapted in the subsequent school year! Despite this flaw and criticism regarding the rather short preparation time for this major Matura reform, a nationwide evaluation actually yielded rather positive feedback, including for the oral Informatics Matura.

The new Matura includes the elective subject Informatics in grades 10-12, based on an open curriculum since 2003. Currently it is not competence oriented and consists merely of 11 different topics, without any indication of the level of knowledge expected in these. These broad topics are:

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, legal issues.

Unlike the main subjects (German, foreign languages and mathematics), there are no central regulations and centrally developed tasks for Informatics. Insted the teachers are 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.

Since 2012, a competence model for Informatics in upper secondary level (Fig 2.) now extends the curriculum with a better structure and orientation. It is not yet known to what extent this competence model is used by the teachers in their Informatics lessons. However, this model is one building block of official ministerial recommendations outlining some sample tasks [16].

The particular innovation of the Matura reform and the oral Matura is the mandatory competence oriented alignment of the tasks and the assigned number of topics. In the case of the elective Informatics, teachers at any particular schools have to agree on 12 topics which have to be publicly announced about six months before the exam.

School A	School B
- 01 History of Computer Science	- 01 Data Structuring and Modeling
- 02 Spreadsheet	- 02 Algorithms
- 03 Databases	- 03 Programming
- 04 Internet and Web 2.0	- 04 Office Programs
- 05 Operating Systems	- 05 Mathematics in Informatics
- 06 Data security and privacy	- 06 Computer Architecture
- 07 Software development and binary system	- 07 Fractals in Computer Science
- 08 Web Publishing/Markup Languages	- 08 Networks
- 09 Programming Languages and Concepts	- 09 Operating Systems
- 10 Digital Imaging	- 10 Web design
- 11 Hardware Basics	- 11 Artificial Intelligence
- 12 Network Technology	- 12 Data security and privacy

This table illustrates two examples with different approaches to Informatics content. There are about 340 secondary academic schools in Austria, although not all schools offer elective Informatics courses. That does not necessarily mean that there in all courses there are candidates who chose Informatics as an oral Matura subject.

As it is rather difficult to collect data from Austrian schools we only can estimate the figures. We estimate that in two thirds of the schools there are currently elective Informatics courses, suggesting that nationwide between 500 and 1000 students out of approximately 17000 chose the oral Informatics Matura.

If a school has candidates for the oral exam, the teacher has to prepare two "competence oriented" tasks for each topic. A competence oriented task has, by law, to cover three aspects of proficiency and requirements areas: reproduction, transfer and problem solving and reflection.

With these regulations, the legislator intended to transform the Matura from a knowledge-based to a competence-based assessment. Until these reforms, the tasks and questions were heavily content-based, asking for knowledge rather than the application of higher-level thinking through problem-solving or critical thinking. As long as it was only facts that assessments required, these will be what teachers teach and students learn, regardless of any efforts in curriculum renewal: 'that which we measure becomes that which we value'. Educators at all levels need expertise in the evaluation of competence and skills, building on a solid basis of content knowledge.

It has been a challenge for teachers to develop the 24 competence-oriented tasks, two for each topic.

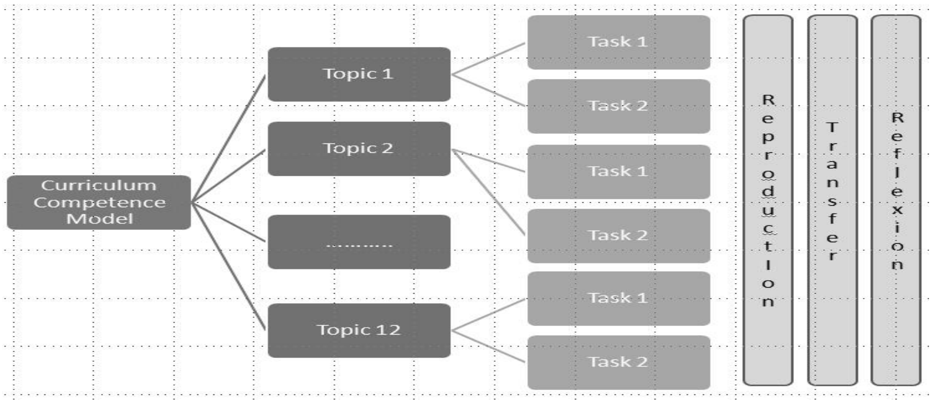

Fig. 4. Topics and tasks

All tasks have to be camera-ready a few weeks before the Matura, when the candidates have to draw two different random topics of which one has to be chosen. After this procedure the teacher chooses one of the two assigned tasks and hands it out to the student.

Part of an exemplary task, the reflective and problem-oriented element, is shown in Fig. 5. The whole task set of this particular school is shared as an open educational resource and can be downloaded from [17].

In Fig. 5. there is a fragment of a task is assigned to the topic "Simulation, Animation and Coincidence".

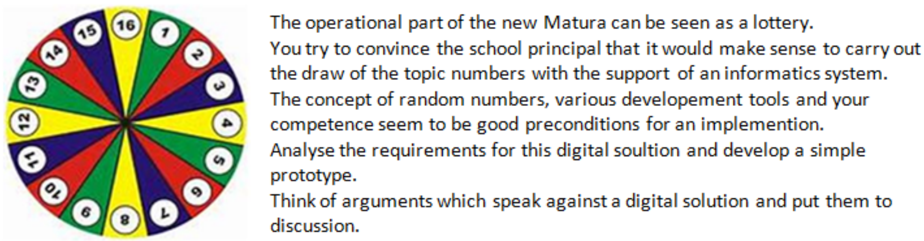

Fig. 5. Example for the reflective and problem-solving part of a given task.

In the run-up to the Matura, a couple of month before the oral exams took place, the author conducted a little qualitative survey among a community of teachers involved about believes of strengths and weaknesses of the new Matura.

Strengths/Advantages	Weaknesses/Risks
All informatics teachers in one school must cooperate, there is no one man show any longer	No depth; interesting topics might be neglected. Tasks cannot be very demanding. For special topics (as robots, …) there will be less time.
Not only factual knowledge is assessed.	Fewer candidates for the Informatics Matura.
Standardization of the number of topics.	The Informatics Matura will be chosen only by very gifted and talented students. It is too difficult for the average.
The new Matura will bring more drive and motivation into the informatics lessons.	Many tasks have to be prepared for few students.
Practical tasks can be well covered through the second requirement area (transfer, application).	The practical part could be neglected.

This selection of 15 teachers' opinions is only a small sample of many interesting comments and insights. Assuming that most of the teachers are cooperative, the evaluation of experiences, the collection and categorization of topics and developed tasks could serve as a valuable resource for the improvement of the Informatics Matura and, moreover, also for the consolidation of the subject Informatics in general.

6 Conclusion

In this paper we have shed light on the current situation of Informatics education in Austria at different school levels in general education. We tried to sketch a picture of the spectrum from bottom up movements and initiatives to top down competence models, campaigns, curricula and central reforms, laying the focus on four active areas. Other projects such as the Beaver Contest and competitions in the field of IT, the influence of the European Computer Driving License on formal IT education, and the situation of teachers' pre- and in-service training have not been mentioned.

There are difficulties in comparing Austria's current status in and progress with Informatics education with that in other countries. However, comparable data from many countries that refer to national frameworks and formal implementation processes in existing school curricula suggest that Austria is trailing behind, in particular there is no coherent and nationwide education policy for IT and Informatics at primary and lower secondary level. By this standard, to start formal Informatics education for all at the 9th grade seems too late.

Nevertheless, as we indicate, there are non-formal activities and autonomous developments in individual schools which add life to the Informatics scene in Austrain education, and thus compensate to a certain extent for political omissions.

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