Let's teach informatics - empowering pupils, students and teachers

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Abstract: Our goal is to develop a didactical structure for a compulsory informatics course. This structure depends on certain fundamental elements, and these will remain in the long run. Results from curriculum research on informatics in secondary education are used to decide which aspects must be included in the subject teaching of informatics. After describing the didactical structure the paper focuses on how successful teaching and learning processes should be organised to enable students to take an active role in long-term learning, express their requirements as users of modern technology; and learn skills and acquire competences in using informatics systems. We propose a modular course to fulfil these requirements. This has been set up to enable some modules to be taught at the secondary I-level (K5-10) and others at secondary II-level (K11-13). These modules enable schools to determine the manner in which informatics will be taught. Our research findings are based on evaluation of informatics as a compulsory course for 6th graders at a German Gymnasium, evaluation of a curriculum for 11th graders at a comprehensive school, and a survey of teachers' opinions on teaching informatics. The paper concludes by stating how the project will move forward and identifies the key questions that will be addressed.

The original version of this chapter was revised: The copyright line was incorrect. This has been corrected. The Erratum to this chapter is available at DOI: 10.1007/978-0-387-35663-1_34

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1. WHAT TO TEACH IN INFORMATICS

Only a few schools in Germany have included informatics as a compulsory course for all pupils. However, in the next few years, more schools will establish a compulsory course as all pupils need certain basic knowledge. It is too time consuming to prepare pupils to use specialist applications without giving them a basic knowledge of informatics on which to build in other subjects.

From the point of view of competences and skills the basics are twofold:

- Pupils have to be educated in the principles which enable the process of extracting information from data and those which allow the formulation of information so that it can be represented in data in order that informatics systems can process, transfer and convert it.
- In addition to knowing how the processes are carried out theoretically in an informatics system pupils should receive practical experience in acting with systems so they use theoretical elements in a practically oriented way.

Both approaches to the subject are interwoven and all pupils should acquire basic elements in informatics to support practical experiences in the field of handling information systems. If pupils are educated in informatics they will be able to transfer their knowledge from one application field to another with the help of cognitive models.

The outcome for students in Germany has been described thus:

"... most German students' information literacy is insufficient. German students consider the supply of digital information to be confusing. They feel unable to evaluate the results of their search for information. However, the Internet is the most frequently used medium in searching for scientific information although the use of this medium rarely follows systematic rules. Many German students confine themselves to simply 'browsing the net'. German universities have not taught them how to use the new media systematically. That is why students had to acquire this knowledge as autodidacts." (Klatt et al 2001)

It is important that informatics systems are used (not only at the school level) in conjunction with a field of application. If we examine concrete curricular elements it is apparent that they are currently restricted to some major applications such as word processing, calculation programs, database programs and presentation software. In most cases students only learn how to handle concrete applications. This is not educational informatics - it is a surrogate for handling situations and can, in no way, replace the teaching of informatics. It's comparable to other subjects taught at school: "schools don't teach boiler design - they teach thermodynamics." (Shaw 1992)

We carried out research to describe and to prove various elements of teaching informatics as a subject at school and we wrote proposals to:

- establish a connection between the various elements in teaching informatics as a subject at school (Hubwieser et al 1997);
- prove the hypothesis that it is possible to decide which elements of teaching informatics are fundamental (Schwill 1994).

Informatics should be taught as a subject, developing and integrating correct models of informatics systems in teaching processes. Pupils and students learn best with concrete examples. However, these applications are based on informatics models and, to understand how these products work, knowledge of informatics is imperative.

Over time it has become clear that the object-oriented model is capable of supporting the process of setting up an informatics system as it uses one language throughout. This process works the other way round as well. One is able to "re-engineer" the process for educational purposes. In analysing, deconstructing or describing the functionality of some well known applications in this way pupils are able to build up their own mental model. This enables pupils to criticise the concrete realisation - a first and mandatory step in developing the ability to look at applications with a background in informatics.

1.1 Conceptual elements

We must remember that working on informatics systems is now no longer associated with isolated "personal computing systems" but rather takes place in networked environments. Every introduction must take into account the fact that pupils/students should know the basic elements "behind the scenes" before they go to work in such a complex environment. This is necessary to protect their personality, which should not be damaged by the learning processes. Basic knowledge regarding Netiquette, based on network protocol structures, must be understood.

Another element concerns the basis for constructing and analysing (deconstructing) solutions for problem areas in an object-oriented manner. Setting up a model normally works in a constructive manner, but some research has been done to find ways of decomposing object-oriented software systems (Schulte 2001).

We should not rely on one paradigm - students should be aware that it is possible to work with several paradigms to solve problems. One of the major decisions in the problem solving process is how to find the appropriate paradigm for modelling special elements in the specific problem field.

1.2 Structuring - modularising

To structure teaching processes it is essential to look at cognitive adoption. The process of building up knowledge and competence in informatics must be designed to enable pupils not only to develop skills in handling informatics systems. They must also be able to discern structures and develop mental models of informatics systems with which they can work successfully:

"Because the details of the technology change from day to day, keeping up with those details is difficult and often unproductive. Therefore the study of the subject must concentrate on the fundamental scientific principles and concepts of the field." (ACM 1997)

Modern curricula are structured in a spiral and a project-oriented manner. This segmentation leads to entities which are taught at several cognitive levels - at first pupils learn more elements associated with concrete applications and later on the scope of the first model is restructured on higher cognitive levels. Curricular elements in informatics should structure the field of informatics to create a subject-oriented terminology.

This would help when:

- working on concrete applications;
- discussing the use of terms in informatics;
- it is used in all the courses in informatics;
- working on informatics in other subject fields.

It is also essential that theoretical elements of informatics should be taught at every cognitive level. These elements cannot be ignored due to the lack of time. The following modules have been identified - network and distributed processes; modelling informatics systems; elements of the theory of informatics; applications in specific fields (linguistics, mathematics) and their background based on informatics. Because of the central role of the first element, network and distributed processes must underpin the curriculum. The other elements should be mixed and no one theme should span more than a quarter of the school year.

2. HOW TO TEACH INFORMATICS

2.1 Using models

Nearly all types of models that have ever been developed are used in informatics (Thomas 2001) so the models which have to be taught must be carefully selected. Building upon an abstract layer of structures to implement actions on data is not easy but there is evidence for finding problem fields where students can find ideas for formulating problems and getting ideas for solutions. This serves as a starting point in arriving at successful abstraction and then putting it into practice.

It is important to determine which elements must be taught to all pupils to enable them to integrate these elements in their own subjects and establish a basic knowledge for their future. In addition it is necessary to integrate an historical perspective as well as social elements in teaching informatics. In this way students learn how and why certain rules have been introduced. For example "to log in" should imply that a student not only can log-in but also knows what takes place behind the scenes. Talking about Netiquette offers a way into discussion on how connectionless network protocols provide the opportunity for forging the sender's e-mail address.

On the other hand it is imperative that students have a deeper insight of the process of setting up the deconstruction of a real application so they can see how informatics systems are structured and what the commonalities between the different versions are.

It is essential that every learning process should incorporate historical elements. This allows the developing process to be studied from different points of time or view, enabling the students to identify where critical decisions took place and how the future might be affected. Tom van Weert (2001) has pointed out that:

> "Co-operative ICT-supported learning is possible at a higher level"

but we think that it is worth thinking of problem-oriented teaching of informatics at all levels - not only at secondary school or university levels.

Finding a way to structure the complex problem-solving process enables students not only to work on informatics problems successfully, but also to structure the problem fields as well. Students pointed this out when asked what was the effect of being taught informatics for about half a year. A year later even more students felt that they found their knowledge in informatics had been a strategic element in managing problems in other subject areas.

In February 2001, the author conducted research in some Bavarian schools. The aim was to introduce informatics as a subject at the secondary I level at the Gymnasium for 6^{th} grade. It was found that these pupils were capable of learning and using the abstract terms associated with the informatics systems they were using. This was observed in situations where the pupils had to transfer elements from one application context to another. They were capable of doing so because the model they had to describe the application with was a sophisticated one. The description had to be done in an object-oriented manner (Frey et al 2001). This was because they were able to use common terms for different applications and application levels. It is important to realise that such elements are not widely taught!

2.2 Teachers think about teaching informatics

Following a review of the teaching process and the structures associated with teaching informatics the next research element was to interview informatics teachers on the teaching of their subject. We carried out narrative interviews with 16 teachers of informatics. We have transcribed these to find out if there are common elements and where the main differences in vision and practice of teaching informatics exist.

Our first analysis indicates there are some key issues all teachers agree on. They want to use sophisticated teaching software in the classroom. They want such software to be available under a free licence (like GPL) so they are able to adapt it for their learning groups. They are looking for educational software they can not only use but also can modify for specific needs in the adapted teaching and learning environment they want to prepare for their students. Such software gives control back to teachers, so they can decide what concrete elements are visible, what patterns are used in a special user interface and so on.

Nearly all of the teachers who were interviewed told us they are unhappy to leave out the more hardware oriented elements from the teaching and learning process. They told us that the role of informatics in school has changed over the years. It will change even faster in future years because more and more parents want the school to teach children about informatics so they might have the opportunity to play an active role in the future.

3. CONCLUSION - REMAINING QUESTIONS

The results of our research clearly indicate the necessity of finding ways to incorporate informatics as a compulsory course for all pupils at secondary I level.

We must stress that the teaching of informatics must not simply cover the use of application no more than the teaching of physics enables pupils to cable houses or set up power stations. It should provide practical experiences in order that concrete elements, which pupils understand at a theoretical level, are put into practice.

We should not forget the gender breakdown in secondary II courses. Given the choice students who choose informatics as a course at the secondary II level at German gymnasiums in North Rhine Westfalia were male. We have to construct the compulsory course so that, in the future, girls become more involved in informatics.

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