

Learning Media Competences in Informatics

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Abstract. At the University of Siegen we design within the research project “Informatics in secondary schools and e-learning to master the digital media upheaval” a contribution of informatics to foster media competences in the context of the Internet. Existing international curricula for informatics as well as information and communication technology (ICT) are analysed confining to the aspect of providing media competences. Finally, an example is given of how learner’s knowledge about informatics concepts leads to media competences.

1 The Internet as Subject Matter in Informatics to Support Media Competences

At the University of Siegen the Human Collaborative Research Centre “Media Upheavals” examines the prerequisites and structures of the analogue media upheaval at the beginning of the 20th century and of the digital media upheaval in the crossover to the 21st century. The project is promoted by the German Research Foundation (DFG). Within the subproject “Informatics in secondary schools and e-learning to master the digital media upheaval” the demands for secondary education are examined [4, 6].

The research project aims to answer the following questions: How far should secondary education in informatics contribute to development of media competences? How could learners acquire and develop necessary knowledge and abilities? There are international and national approaches for curricula, e.g. the UNESCO ICT curriculum designed by IFIP researchers [7] and the Association for Computing Machinery (ACM) curriculum for computer science [1], which contain different aspects of media education. But we are missing a proved approach to specify the basic competences necessary for a mature citizen for dealing with digital media infrastructure. Therefore, further questions are: which competences should be educational standards and how learners develop these competences.

An approach to identify subject matters supporting media competences in the area of informatics is to analyse curricula and educational concepts. It is possible to identify learning objectives, contents and applications. The author does not want to develop another curriculum but the Didactic System “Internetworking” to structure learning objectives, subject matters and the cognitive approach. The strategy of a

Didactic System as a framework concept was already used in the context of object oriented modeling [2]. It enables the author to design a cognitive approach towards needed competences. Besides, the didactic concept will be evaluated in secondary education.

Within the research project subject matters will be assigned to three items

- A. Internet structures,
- B. Communication in the Internet,
- C. Information security in the Internet.

While item A focuses on basic concepts of informatics and computer networks, item B addresses communication and network-based applications and item C comprises issues which are related to the six security services identification and authentication, authorisation (logical access control), confidentiality, integrity, non-repudiation/non-denial and availability. The items A-C include aspects of their impact on information society.

Informatics system is a central term in the discussion about subject matters of informatics. "An informatics system is the specific combination of hardware, software and networking facilities needed to solve some application problem. The term includes those non-technical issues and their solutions that arise from embedding the system into the application area, in particular questions of system design, user training, security issues and consequences of using the system" [3, p. 301]. Informatics systems referring to the Internet will be examined in the analysis of curricula in the following sections.

There are two cognitive approaches considering subject matters for supporting media competences in informatics – the potential of informatics and the perspective of media education. They focus different learning objectives while looking at the same subject matter. These two viewpoints are mutually dependent: informatics aspects are motivated by real-life occurrences being related to media whereas media educational aspects are adequately discussed knowing and understanding informatics concepts [6]. This relation allows two strategies to identify informatics concepts:

1. Which concepts can be motivated by real-life occurrences being related to media and media upheavals?
2. Which concepts are necessary for adequately dealing with media?

A new quality of requirements inheres in new digital media based on the Internet (see Table 1). There are particularly three characteristics compared to traditional media. They support automated data processing, interaction and networking. These characteristics result in requirements for competences: Automated data processing facilitates new applications like home banking. An understanding of human machine communication becomes more important, i.e. a learner must have competences for understanding informatics systems behaviour. Interaction means the learner is recipient and active participant at the same time and there are new possibilities for the design of media. Therefore, a learner is in need of knowledge about legal framework in data privacy and copyright and abilities in design. The last aspect, networking, involves the necessity to consider weaknesses of the infrastructure and the responsibility of a learner to ensure secure communication. Hence, a learner needs awareness of security requirements. It will be investigated within the research project how far these and derived competences a learner could develop in education confined to the subject matter Internet.

Table 1. Requirements of informatics systems as digital media

characteristics	consequences for educational concepts	resultant competences
automated data processing	– new applications → human-machine communication becomes more important	– fundamental understanding of informatics systems
interactivity	– learner as recipient and active participant – new possibilities for design of media	– knowledge about legal framework – abilities to design
networking	– security risks of the infrastructure – responsibility of the learner for correct configuration	– awareness of security requirements

Within the research project “Informatics in secondary schools and e-learning to master the digital media upheaval” the author will design informatics lessons to support media competences. Media competences comprise design abilities, social competences and user abilities.

2 UNESCO Curriculum

In the UNESCO curriculum informatics technology (IT) is defined as “The technological applications (artefacts) of informatics in society” [7, p. 9]. ICT is IT combined with other technologies, specifically communication technology. Therefore, ICT primarily regards informatics systems from an application oriented, i.e. user-oriented, point of view.

Within the UNESCO ICT Curriculum there are four stages of teaching and learning. The first stage is called “ICT Literacy”. The primary objective is to discover ICT tools. The second stage is called “Application of ICT in subject areas”, i.e. learning how to use ICT tools. The third stage is called “Infusing ICT across the curriculum” and addresses the understanding how and when to use ICT tools. And the last stage is “ICT specialization” in which specialization refers to the use of ICT tools. Within stage one there is a module called information and communication (A7) and a module called social and ethical issues (A8) which refer directly to the objectives and subject matters as mentioned above. Within stage two and three the informatics system is not centric but subject matters of mathematics etc. or a project topic. There are informatics concepts within stage four but without direct references to the informatics system Internet.

The two modules of stage one referring to the subject matter Internet are analysed in more detail: Module A7 aims to an understanding and the ability to communicate with networked computers with sources of information as well as with other people. This contains the following sub-objectives.

“Students should be able to:

1. *show understanding for the way you can communicate, exchange and collaborate within an ICT network;*
2. *identify the various methods and types of activities of communicating via a network;*
3. *send and receive messages and documents by using email facilities;*
4. *retrieve information by navigating, searching and selecting information from the Internet and the World Wide Web;*
5. *be critical about the quality of all information, and acknowledge the ownership and privacy aspects of information;*
6. *subscribe to mailing lists and newsgroups, and participate in video-conferencing;*
7. *send, receive, read and print faxes using a fax-modem and an appropriate software tool.” [7, p. 69]*

The learning objectives of this module are assigned to all of the three parts A-C. The first two objectives phrase the requirement of a basic understanding of Internet structures (A). The third, fourth, sixth, and seventh objectives are concerned with possibilities of communication and application of distributed systems (B). The fifth objective is assigned to part C as far as it refers to an informatics system.

The second module referring to the Internet is A8. It is about social, economic and ethical issues associated with the use of computers. Students should be able to explain the current situation and trends in computing. The sub-objectives are listed as follows.

“Students should be able to demonstrate an understanding of:

1. *the benefits and drawbacks of computer use to society in general;*
2. *the economic advantages and disadvantages of the use of computers;*
3. *the ethical questions that have arisen as a result of computer use with respect to privacy aspects, copyright issues and computer viruses;*
4. *the current situation and trends in computing against the background of past developments in a) hardware, b) software, and c) ways of operating.” [7, p. 71]*

The third objective in module A8 is assigned to part C. The informatics system is not a central item in the first and second objective. The fourth objective does not reflect the approach to the informatics system Internet.

Hence, module A7 and module A8 comprise aspects of all parts concerning the informatics system Internet. The main focus is part B which is about applications in the Internet. The curriculum partially meets the requirements that are caused by interactivity in module A8. The third objective contains privacy aspects and copyright issues. Design abilities are not listed as an objective. Besides, requirements of automated data processing are not adequately considered. The curriculum does not aim to a fundamental understanding of informatics systems, but applications are examined. Those security services which are of essential meaning in the context of automated data processing are not considered, e.g. confidentiality. An understanding of security requirements of networked systems is involved in the context of privacy aspects, copyright issues and computer viruses.

3 Media Competences in Informatics Education

In [1, p. 6] computer science is defined: “Computer Science (CS) is the study of computers and algorithmic processes, including their principles, their hardware and software designs, their applications, and their impact on society.”

The ACM curriculum proposes a dissection of computer science education into four Levels. Level I must provide learners with basics of computer science. It is recommended to integrate this part into other subjects. It ends at grade 8. Level II should be integrated into grade 9 or 10. It is called "computer science in the modern world". The overarching goal is to prepare students to master computer science from the user's point of view rather than from the designer's. It is considered as the last mandatory course and, therefore, the last chance for a majority of students to attain necessary knowledge and abilities. The objective of Level II is to provide all students with an introduction to the principles of computer science. Furthermore, it should provide learners with the ability to apply a computer in their life. The course must provide learners with minimum standards of competences. ACM proposes to implement Level III "computer science as analysis and design" as an elective course. The studies of Level II will be continued. “It places particular emphasis on the scientific and engineering aspects of computer science” [1, p. 11]. Level IV provides depth of study in one particular area of computer science.

Level I is about basic skills for dealing with a personal computer. Level II and Level III are of special interest for the research project, because they comprise Internet-related topics. An important difference of Level II and III is the way of looking at the informatics systems. While in Level II learning objectives from the user's perspective are emphasized in Level III they are referring to the designer's view. The subject matters of Level IV are not specified. One approach for selecting a subject matter is learner's interest.

In Level II basic components of computer networks as servers, file protection, routing protocols for connection/communication, spoolers and queues, shared resources, and fault-tolerance is one topic. Another one is organization of Internet elements, Web page design (forms, text, graphics, and client- and server-side scripts) and hypermedia (links, navigation, search engines and strategies, interpretation, and evaluation). The last of the three internet-related topics (out of ten) is about ethical issues that relate to computers and networks (including security, privacy, intellectual property, the benefits and drawbacks of public domain software, and the reliability of information on the Internet), and the positive and negative impact of technology on human culture. “Students in this course should gain experience designing algorithms and programming solutions to a variety of computation problems” [1, p. 15]. Even though not every school is able to implement every issue of the curriculum it is suggested that all the issues that are part of this course must be mandatory for each graduate student. The first topic listed here is about basic issues. It comprises basic principles of distributed systems. Therefore, this topic is assigned to part A. The second topic refers to the World Wide Web (WWW) as a medium. The emphasis is on designing Web pages. This implies aspects of communication. The unit is assigned to part B. Security and ethical issues within the third topic relate to part C. The matters are directly or indirectly linked to the six security services.

Requirements resulting from interactivity, i.e. knowledge about legal framework and abilities in design, are considered in privacy and intellectual property respectively in Web page design and hypermedia. A fundamental understanding of informatics systems is regarded within the first topic about computer networks and, furthermore, in Web page design with client- and server-side scripts. The topic about ethical issues deals among others with the awareness of security requirements.

The emphasis of Level III is on programming. There are three topics referring to the informatics system Internet. Design for usability considers Web page design. Characteristics of networks are one aspect within levels of language, software and translation. The third topic referring to the Internet is about social issues especially about software as intellectual property. Learning objectives linked to these topics are not specified in more detail. Once more it is possible to assign the topics to parts A-C. The first topic about design for usability is assigned to part B. The second topic about characteristics of networks is assigned to part A. The social issues are related to part C because measurements of software industry to prevent from copying software are based on the security services, in particular authorisation.

In this Level design criteria are made a subject of discussion within the context of design for usability. Legal aspects are considered when it is about software as intellectual property. A fundamental understanding of informatics systems is supported by the topic levels of language, software and translation. The awareness of security requirements of networked infrastructure is not part of Level III.

Informatics supports a fundamental understanding of informatics systems in a more intense manner comparing objectives of ICT and informatics. System understanding is a base for preparation of learners for new demands of a knowledge based society that depends on IT. System understanding contains the aspects user visible behaviour, inner structure and system characteristics. Learning the fundamental principles of informatics systems supports media competences. E.g., understanding of basic concepts of Internet communication like protocols and addressing gives a learner the awareness about problems related to authentication and Simple Mail Transfer Protocol (SMTP) or confidentiality and home banking. A learner will attain those competences during design and implementation of a network application. An important question is how far is the step from understanding informatics concepts to applying this knowledge in real-life situations.

4 Course Concept Based on the Didactic System “Internetworking”

The framework for a course concept will be developed as the Didactic System “Internetworking”. A Didactic System comprises structuring of learning objectives S_i which is called knowledge networks, exercise classes EC_j and learning software E_m supporting learner activity within the learning process [2]. Subject matters in informatics are motivated by real-life processes (called phenomena) of media as described above. An example of a phenomenon is Phishing. It is based on a spoofing email including the request for transmitting personal account data, e.g. for home-

banking. An adequate dealing with suspicious mails prevents learners from serious damage.

An exemplary implementation of the Didactic System “Internetworking” into an element of a course concept will show how informatics concepts contribute to media competences. The lessons will lead to an understanding of Internet communication protocols and their relationships with an Internet application. The involved objectives are to describe basic concepts of informatics (S₁-S₆) [4]. To those concepts there are sub-objectives that are assigned to the concepts as presented in Table 2.

Table 2. Learning objectives

objectives	sub-objectives
S ₁ : network services	S ₁₁ : distinguish different network services
S ₂ : network layers	S ₂₁ : describing the concept of models of layers
S ₃ : Internet addressing	S ₃₁ : describe parts of an Internet Protocol address (IP address) S ₃₂ : describe internet structure and address assignment
S ₄ : client-server model	S ₄₁ : describing the principle of transmission by relay servers
S ₅ : protocols	S ₅₁ : constructing system behaviour by state diagram S ₅₂ : listing weaknesses of SMTP S ₅₃ : describing the possibility of spoofing email sender data (e.g. spoofing of a sender address) S ₅₄ : locating the Internet protocol SMTP within application layer
S ₆ : Internet application	S ₆₁ : applying standard email software S ₆₂ : identifying spoofing links within an email based on Hypertext Markup Language (HTML)

S₁ and S₃ describe prerequisites for this exemplary element. The learning process will be based on understanding of the concept of network services (S₁) and of the structure of the Internet (S₃). A learner should be able to discern network services, e.g. packet-oriented data transmission and connection oriented data exchange. Regarding the Internet structure a learner should be able to describe the characteristic design of an internet, i.e. the composition of several networks and the connection by routers. Besides, the learner should know the principles of internet protocol (IP) addresses.

There are two phases of the learning process. In phase one a program for email transmission will be developed. Within the second phase the learners perform some experiments with the application that will illustrate aspects of SMTP and mail format. Learners apply their own program to solve some tasks. The tasks guide the learners to understand the communication sequence between server and client application. Furthermore, the learners explore the possibilities of communication and configuration.

The learners should design and implement communication using SMTP in phase one. They have to model communication by means of a state diagram and implement it using a graphical user interface (GUI). This exercise aims to the learning objectives

S₂, S₄ and S₅. They understand the systems behaviour as a sequence of states during the communication process between two hosts. They get to know SMTP as a protocol which allows access to network services without authentication. Furthermore, the data transmission path over relay stations is explored. They classify application protocols when the transmission services of the transport and internet layer are called.

Within phase two the learners will perform the following exercises:

1. Send an email message with sender address alice@home.de.
2. Send a message in HTML format to your own mailbox. The message must contain a link where the link text is not corresponding to the link address.
3. Send an email message to your own mailbox and find out your host's IP address and which relay servers were used for transmission.

These exercises are necessary to apply the new knowledge within real-life situations to become aware of the consequences. It is possible to send an email with an arbitrary sender address, because authentication is not compulsive. Exercise 2 shows the possibility of hiding deceptive contents in a HTML message in the context of email. In exercise 3 the knowledge about addressing in the Internet is applied to reproduce a transmission path. The assigned competence enables the learner to identify spoofing mails.

A further example of phenomena is Cookies. In this context privacy aspects and possibilities of media design can be discussed. Learners should know properties of the Hypertext Transfer Protocol (HTTP), which is a stateless protocol. Cookies allow to store and retrieve personal data. Therefore, there is the possibility to use this data to analyse learner behaviour. The second aspect is dynamic Web page design. The learner should know how dynamic Web pages can be implemented. For example, with Cookies greeting by name can be implemented. These learning objectives consider the characteristics networking and interactivity of the Internet.

5 Resume and Perspectives

As we have discussed, competences in applying the informatics system Internet are media competences. The understanding of informatics concepts contribute to an understanding of informatics systems. Therefore, informatics is a subject to attain media competences.

The question for media related subject matters from the perspective of informatics was examined by analysing the computer science and the ICT curriculum. Subject matters of the computer science curriculum comply with the criteria listed above. The ICT curriculum focuses on part B, i.e. communication in the Internet, and does not comply with the objectives derived from automated data processing and networking.

The question about subject matters motivated by phenomena should be examined systematically. The example of Phishing has shown how this question leads to concepts of informatics and the relation of concepts of informatics and media competences.

The author has described the basic concept of the Didactic System "Internetworking" composed of the three components knowledge network, exercise classes, and learning software. It is necessary to design learning material in particular

exercise classes and learning software. We will implement the concept for informatics in school within 2006 with student teachers. The empirical study will be evaluated and learning material will be adapted. Test-Items as they were used within the PISA-studies will be designed as a contribution for educational standards in informatics.

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