Embedding, reorganization and construction of mathematical and didactical contents as an objective in teachers education

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Abstract: MaDiN - (Ma)thematics and (Di)dactics (N)etwork is a fast growing knowledge base containing material about teaching mathematics (URL: http://visum2.uni-muenster.de). Four universities in Germany participate in this project developing contents in different branches of primary, lower and upper secondary student teachers education in mathematics. The project is funded by the German ministry of science and education with 1.6 Million Euro and will cover mathematical as well as didactical contents for the education of student teachers from primary to higher secondary level. Knowledge organization in mathematical and didactical contents focuses on two aspects.

- Embedding and reorganization of existing mathematical and didactical contents and
- authoring of documents and multimedia material in a web based workspace

The lecture will present this method of contents organization for student teachers, give a survey of the constructivist background of the system and the role of media (video, audio, ...) in the system. Embedding web based contents and the authoring of individual teaching experiences is one of the objectives in teaching student teachers. An authoring tool provides the facilities for the individualization, reorganization and construction of contents. The lecture will show, how internet based learning is embedded in the process of teaching student teachers.

1 Introduction

Embedding and reorganization of knowledge requires a knowledge base in which teachers can organize contents according to their learning process. The MaDiN-Project (Mathematics Didactics Network) provides student teachers, teachers and teacher educators with a fast growing knowledge base containing material about teaching mathematics. The objective of online knowledge management in teacher education is to combine authoring activities with the embedding of existing contents. Student teachers have different experiences and focus on different contents of mathematics education. This is the starting point for individualized knowledge management. The experiences of student teachers in school determine their focus of interest and their authoring activities in the knowledge management system. They develop for example. lesson plans in geometry and combine this with didactical contents from the knowledge base. The knowledge of student teachers is organized in a private profile which provides an individualized knowledge representation of each student teacher. The article will present this method of knowledge representation in the field of mathematics education. At the end of 1998 M. Stein took the situated learning approach (Mousley & Sullivan 1996) as a starting point for the MaDiN-Project to use the multimedia facilities for teacher education in mathematics in Germany. The production of didactical and mathematical contents, which is accessible on the web, is the basic objective of MaDiN to enable knowledge management in teachers education. The cooperation with the MEOW-Project began in 1999 (Edit Cowan University – Perth, Jan and Tony Herrington, http://www.scam.ecu.edu.au/meow/). Since 1.1.2001 four working groups (Th. Weth, Erlangen, H.-G.Weigand Würzburg, U. Tietze, Braunschweig, and M. Stein Münster) are joining the MaDiN project focussing on different mathematical and didactical aspects in primary, lower and upper secondary teachers education. This project is funded by the German ministry of science with 1.6 Million Euro.

2 Knowledge Representation

In the general case learning processes include organization and reorganization of knowledge. To support this type of knowledge management in teachers education knowledge representation as an objective of MaDiN is discussed first. The following section describes the structure of the knowledge base, in which the mathematical and didactical contents in MaDiN is organized.

The knowledge base in organized in a tree shape with a collection of multimedia information at each tree node. This *collection* of different types *of information* (HTML-pages,

video, audio, animations, ...) belongs to the subject of the node. If we take as subject *"Problem Solving in Geometry"* this collection contains for example

- a *video* of a geometric problem solving activity with a *Problem Solving* (recorded in a classroom),
- a collection of tasks for children in primary schools using a *Problem Solving* as a tool,
- *activities* for student teachers to analyze the geometric problem solving activity of children with a *Problem Solving*,
- *Internet links* to the subject *"Problem Solving in Geometry"*, e.g. to geometric problem solving activities with a *Problem Solving* in lower secondary schools.
- *Theoretical* background information to the applications of the *Problem Solving* in primary schools.
- additional *literature* references to the subject *"Problem Solving in Geometry"*,
- *news*, e.g. "conference July, 25., 2002 in XY -Title: Geometry in Primary Schools"

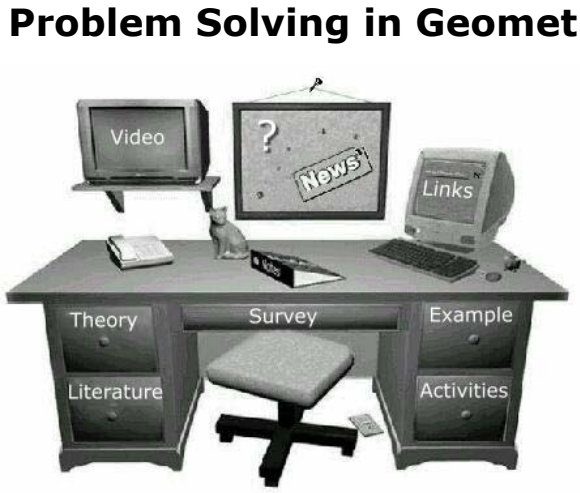

Figure 1: *Desktop for "Problem Solving in Geometry"*

So a link between tree nodes in MaDiN is a link from one collection of information to another collection. Now we need an interface for this collection of different types of information. In MaDiN we chose a Desktop as metaphor, which was originally created by the MEOW-Project (Jan and Tony Herrington, http://www.scam.ecu.edu.au/meow) and adapted to an interface for a collection of information.

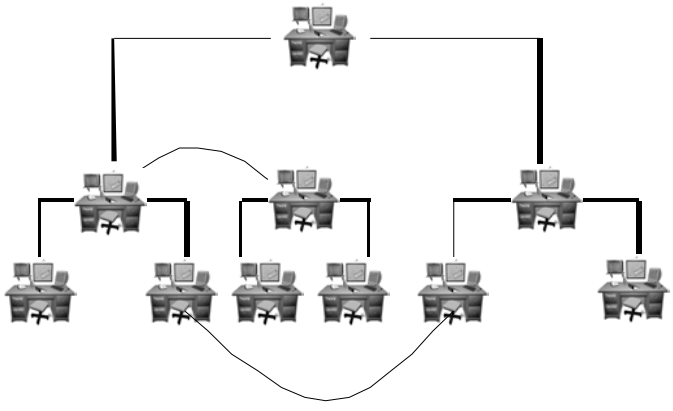

Figure 2: *Information in the desktop depends on the tree node*

So when a user is navigating from one collection of information to another collection the desktop with the drawers is filled with *hypertext, videos, links* and *references* according to the subject the user is looking at. This *context dependency* of the desktop has the objective that the user only gets the information of a chosen subject (e.g. only literature references and videos to subject *Problem Solving in Geometry*). This means that the user can access the video screen only, when there is a problem solving video to the subject *Problem Solving* offered from the author.

The basic idea of the *MaDiN context dependent knowledge representation* is that the desktop *classifies the information*. The following attributes show the chosen types of information in the MaDiN system:

- ***Survey:*** presents a short description about the respective subject, which could be used as introduction containing hints for the user to start with -- drawer in the middle,
- ***Theory:*** the didactical or mathematical theory about the respective subject of the desktop -- drawer on the top left,
- ***Examples:*** the examples are used as an illustration for the theory -- drawer on the top right,
- ***Literature:*** References -- drawer on the bottom left,
- ***Activities:*** Exercises for the student teacher according to the subject of the desktop -- Drawer on the bottom right
- ***Video:*** Videos and animations -- monitor on the left
- ***News:*** scheduled events according to the subject of the desktop -- News sign at the board in the middle,
- ***Links:*** Internet links -- monitor on the right,
- ***Help:*** gives advice for solving problems in the *Activities* drawer -- Help sign at the board in the middle.
- ***Contact:*** presents the e-mail address of the author or the tutors of the lecture/seminar -- telephone on the desktop.

3 Teaching Experiences and Reorganization of Didactical Knowledge

When student teachers have their first teaching experiences they have only a limited knowledge about organizing and initiating learning processes for the children. So learning about teaching has to start with these limited prerequisites. These teaching experiences determine the knowledge representation of student teachers, because they teach different lessons, in different classes and have different favorite methods of teaching. Therefore it is a necessary to organize knowledge in a personalized way. This individual knowledge representation is extended according to the experiences the student teachers have. Student teachers are encouraged to do online authoring in order to document their teaching experiences. This includes the lesson plans and the reflections after the lesson. Sharing ideas, lesson plans and material for the children on the web can help other students in developing their lesson plans. The individualization of the knowledge representation and cooperative development of ideas makes it necessary to have the contents accessible on the web. This means that student teaches produce web pages and multimedia material for an information system, which serves e.g. as a basis of discussion in seminars.

Beside the contents generated by student teachers also didactical and mathematical experts offer contents in the knowledge base. These contents can be embedded in the personalized knowledge representation of the student teachers. In order to personalize knowledge representation *authoring* and *embedding* of contents is taught to student teachers.

In *seminars* student teachers can analyze authentic material of classroom situations (Mousley & Sullivan, 1996). Their analysis is documented in the individualized knowledge representation. This is the first contact with the contents generation in MaDiN. The MaDiN system is designed in a way which demands (nearly) no technical knowledge for the generation of web based information, so that the didactical concept can focus on the *organization* of web based contents and the *structuring of mathematical and didactical knowledge*. Beside the fact that the work of the students is presented in a closed area of MaDiN the student teachers have to *integrate their contents* into the existing information system of MaDiN. The individualized information system of the student teacher combines personal material with material of the official MaDiN information system. For this combination of personal area and the official expert contents the student teacher has to explore the MaDiN information system for helpful connections (links) to the subject of the seminar. This includes major *receptive work* with MaDiN.

4 Knowledge Analysis

Cooperative work in a fast growing knowledge base requires capabilities of knowledge analysis and representation (e.g. concept mapping, see M cAleese, R. 1998). *Object Oriented Analysis* is a problem solving strategy developed in Computer Science. Despite of the fact that this strategy has its

origin in Computer Science, it is a modelling concept *strictly independent* of a programming language. The main difference between concept mapping and OOA is, that the OOA distinguishes between

- Procedural Knowledge (Processes and Methods) and
- Knowledge of Facts

The *MaDiN method of structuring knowledge* applies basic ideas of OOA to *structure knowledge* (for instance, about didactical subjects like *Problem Solving in geometry*).

- **Decomposition into Objects:** The OOA method analyses a system and decomposes it into objects that are found in the system. *Decomposition* is one principle of the OOA, so that all objects can be decomposed in subobjects again. The process of decomposition provides the tree structure.
- **Relationships between Objects:** Between Objects can exist two types of relationships: The parent-child-relationship *(Aggregation)* and a basic *Association.* For example, the OOA model could contain an *association* between the *problem solving strategies in geometry* and *psychological aspects of problem solving*.
- **Classification of Objects:** The objects are classified by properties they have in common The relationship between Theory, Example, and activities (see section 2) is one derivation of the classification principle within the MaDiN system. The theory classifies the examples (e.g. classification of errors problem solving in geometry).
- **Processes in Objects and methods :** The OOA distinguishes between objects the methods to handle the object. The methods describe processes.
  - *Mathematical Object:* a sequence of numbers
    Mathematical Process: convergence of this sequence
  - *Didactical Object:* a task in geometry
    Didactical Process: problem solving process of child for this task

  If something is described as method or as a process, this result of the OOA has consequence on the presentation. For example is a *process* visualized by an *animation* to show convergence of a sequence or a *video* to show the steps of a problem solving process in geometry.

Thus the arising structure is a web of objects organized in a tree with characterized processes and methods.

It is important to mention that a model, generated with the OOA, is dependent on the person, who did the modelling. Different views on a system generate different object oriented models.

In the process of using MaDiN in lectures and seminars to developing material for MaDiN as part of the final examination ("states exam") the *constructive aspects* of the student work increases, so more detailed knowledge for contents generation is necessary. Students who wish to present their knowledge in the MaDiN system as part of their final examination, have to visit special seminars in which they are trained to apply OOA to their special theme, and how to use the possibilities of *multimedia* for presentation in a web based system. The full method used in MaDiN is the called *OOTA* (*object oriented theme analysis*) and described in Niehaus 2002 and Ernst, Stein 2002.

Of course not all students write their homework in mathematics and didactics or get in contact with authoring activities in seminars. The main focus in developing a didactical concept is the consistent embedding of MaDiN in the education of student teachers at the university. This leads to a *constructive competence of structuring didactical knowledge and didactical problems*. On the highest level the issues of the student work could be presented within the official MaDiN information system or it could be used as a basis of discussion in seminars for further development.

5 Individualization of Knowledge Representation

Individualization of web based knowledge representation means:

- The student teacher (teacher) has a private web based workspace.
- The workspace contains only the chosen parts of the tree shaped knowledge base, so that important for their work.
- In the web based workspace the student teachers (teachers) can embed new contents according to their personal needs.
- Student teachers (teachers) can add their own material they produce for application in schools.
- Student teachers (teachers) can grant access rights to documents in the private workspace. This facilitates cooperative work in groups of student teachers and teachers.

This option of individualization in the MaDiN system takes two constructivistic aspects into account.

- The ***receptive aspect*** offers the user a knowledge base, in which the user can navigate to MaDiN contents she/he is interested in. This knowledge should be embedded in the individual structure of the user's knowledge.
- The ***constructive aspect*** offers the user the option to modify the knowledge base according to the individual structure of the user's knowledge without modifying the original contents (Simons, 1993).

6 Conclusions

The diversity of teachers and children in teaching and learning mathematics implies an permanent adaption to changing preconditions. Individualized knowledge representation focuses on the personal needs of teachers for the organization of learning processes in schools. Building up this private workspace is an objective in teachers education so that teachers were able to organize knowledge, share ideas and develop and modify material for mathematics education *collaboratively*. In addition to the developed contents of the student teachers, the workspaces can also contain embedded contents from lectures and seminars. The preceding sections show that knowledge organization in MaDiN is a didactical concept which supports the teachers education from university to in service training. Individualized knowledge representation follows a constructivistic approach to construct and organizes multimedia contents according to personal needs. The MaDiN project started with Mind Mapping and applied the Object Oriented Analysis (OOA) for contents. This method was developed further to the Object Oriented Text Analysis (OOTA-Research Project: A. Ernst, M. Stein, 2002), so that student teachers can apply this method for structuring knowledge. The underlying idea of Constructivism together with the object oriented concept presents a didactical approach which mixes the *role of the author* with the *role of the reader.* In the MaDiN system, *expert user, author* and a *didactical novice* share and embed contents in a knowledge base. Granting rights to the private workspace facilitates *collaborative work* and joint development of mathematical material in schools. When teachers education at university includes collaborative work in a web based knowledge base student teachers are prepared for web based in service training

So embedding and reorganization of existing contents in a private workspace is only the first step towards a contribution of ideas and contents to a community of teachers. This skill is necessary for the cooperative development of personalized internet based contents.

References

Bishop, A., FitzSimons, G., & Seah, G. W. T. (1999). Values in mathematics education: Making values teaching explicit in the mathematics classroom. *Proceedings of the 1999 annual conference of the Australian Association for Research in Education, Melbourne.* Retrieved 28 November 2000 from the World Wide Web: http://www.aare.edu.au/99pap/bis99188.htm

Buzan Centres homepage: http://www.mind-map.com

Ph.D., Leslie A. Ditson, Lynne Anderson-inman, ,Ph.D., Mary T. Ditson, M.C.A.T., Computer-based concept mapping: promoting meaningful learning in science for students with disabilities, *Information Technology and Disability V 5 N1-2 Article 2, online* http://www.isc.rit.edu/~easi/itd

Ernst, A, Stein, M, (2002); Didaktische Aspekte der Aufbereitung von Lerninhalten für eine konstruktivistische Lehr-Lernumgebung im Internet, *Mathematica Didactica (in print)*

Honebein, P. C., Duffy, T.M., Fishman. B. J. (1993), Constructivism and the design of learning environments: context and authentic activities for learning, in: T. M. Duffy, J. Lowyck, et al (Eds), Designing Environments for constructive learning, *Springer-Verlag Berlin Heidelberg, p. 87 - 108*

Jacobson, M.J., Spiro, R. J. (1995), Hypertext learning environments, cognitive flexibility and the transfer of complex knowledge: An empirical investigation, *Journal of Educational Computing Research, 12 (4), 301-333*

McAleese, R. (1998), Coming to know: The Role of the Concept Map -- Mirror, Assistant, Master?, *General Reports, 1998*

Mousley, J.; Sullivan, P. (1996), Learning about Teaching. Australian Ass. of Teachers, Adelaide

Niehaus, E. (2002) Objektorientierte Analyse für die webbasierte Aufbereitung mathematikdidaktischer Inhalte: *Mathematica Didatica (in print)*

Simons, P. R.-J, (1993), Constructive learning: The role of the learner, in: T. M. Duffy, J. Lowyck, et al (Eds), Designing Environments for constructive learning, *Springer-Verlag Berlin Heidelberg, p. 291- 314*