

SweLL – Scientific Project Report APE - Track A, Jan-June 2001

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Project Name: Content and Context of Mathematics in Engineering Education

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Curriculum aim and goals:

The goal of track A is to encourage and try out methods for student use of conceptual modeling¹ and e-folios² to document and reflect over their learning process, including courses and the connections between them, which is beneficial for both further university studies and as a basis for life long learning.

The track comprises two studies, which will serve as the objects of research and curriculum development:

Study 1: Modeling of conceptual development in mathematics in the Information Technology Program at KTH.

Study 2: Reflection on the curriculum, by the use of portfolios (e-folios), of the Media Technology Program at KTH with focus on mathematics.

Principal investigators:

Study 1:

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Study 2:

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Collaboration partners:

Study 1:

DSV/KTH: Calle Jansson, PI
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Study 2:

Media Technology/NADA/KTH Leif Handberg, PI

Educational evaluation aims and goals

The main guiding question is if knowledge capture, organization, re-use, self-coaching and collaboration will enhance the learning experience.

Proposed research question for Study 1 posed at this stage are:

- What conceptual structures in first year academic mathematics courses do the students regard as most important, and how do these structures evolve over the first academic year?
- How do these structures correlate with the students' perception of the most important mathematical concepts in high-school mathematics courses?

Proposed research question for Study 2 posed at this stage are:

- How does the teacher's intentions with the course relate the learning outcomes?
- What differences in learning can be observed by the use of organized opportunities for reflection compared to traditional studies?

¹ The concept maps is a way of organizing knowledge and in learning situations they could be used in assessment, reflective exercises, as tools for metacognitive training etc.

² In the portfolio students can organize and store accomplished tasks, assignments, notes, essays, concept maps etc.

Achieved Results – Study 1:

a) Implementation:

Spring 2000:

- **Seminars and conceptual modeling exercises for faculty** involved in IT-program on several occasions. This has formed a good base for the current studies and created interest in widening the range of the conceptual modeling exercises to include all the different subjects on the IT-program.
- **Study-material on modeling** (to be used in mathematic courses) in general and modeling of mathematical concepts presenting conceptual modeling at a suitable level for this experiment, since no previously existing material was found to meet the pedagogical requirements.
- **Interactive study material** and computer-based tools for modeling. This web support includes a UML³ tutorial (Interactive UML), some web-based animations produced within the Conzilla tool and additional interactive exercises. The aim is to facilitate and improve instructional quality and efficiency.
- **Software development** involves improvements and extensions of the Conzilla tool (a conceptual browser and a tool for knowledge management) which separates the organization of knowledge (context) from its presentation (content) and thus enhances the opportunities for students to grasp the relationships between the context and the content.

Fall 2000:

- **Student tasks** split up into two parts (solutions to be submitted at the end of each term). The tasks are of three kinds, i) producing maps of high-level conceptual abstraction, ii) detailed maps on particular concepts and iii) maps on the structure of proofs. The conceptual maps are assumed to reflect students' understanding, perceived difficulty and applicability.
- **A series of lectures** for students of conceptual modeling introducing concept modeling in mathematics.
- **Implementation of interactive content and appropriate tools - Mathematical Resource Components:**
 - 1. Constructing the components:** Using programs like Mathematica, Projective Drawing Board and the Graphing Calculator, we have constructed a number of mathematical resource components that illustrate mathematical concepts and relationships. Some of these components have been transformed into interactive webgraphics and some have also been translated into CyberMath (the shared3D interactive learning environment for mathematics that has been created as a part of the APE-track-C project).
 - 2. Archiving the components:** There are different ways to archive mathematical components of different kinds - including the ones described above. A newly developed test-archive which can be updated dynamically and where the components are viewable under the common browsers is available at <http://www.nada.kth.se/cgi-bin/osu/dirlister2?math>.
 - 3. Interacting with the components:** Exploring how to interact with the components, focusing on the ones constructed by using the Graphing Calculator, a program that is available today for the visual display of mathematical formulas. We have acquired 250 user licenses for the Graphing Calculator at KTH (to cover the teachers and students of the IT- and Media Technology program). The Graphing Calculator offers truly novel ways to interact with the components of a mathematics archive, where frozen animations can be downloaded and easily manipulated by users. This constitutes a very exiting graphical way of conducting mathematical discussions between the teachers and the students as well as between the students themselves. We have started to introduce this technique to some of the mathematics teachers at KTH, and we are planning to introduce it for the students of the IT-program in the spring of this year.

Spring 2001:

- **During the fall of 2000 and the spring of 2001** the 150 students of the IT program have been carrying out the conceptual modeling exercise described above as part of the "Intro to IT" course. The exercise is concerned with creating conceptual models based on the mathematics they have experienced in the IT-program curriculum. More specifically, three different concept maps have been constructed: The first one describes the overall relationships between the most important mathematical concepts that the students encounter in the mathematics courses, as well as the relationships between these concepts and their applications in other courses. The second concept map focuses on the function concept and describes the relations between the different types of functions that the students encounter in the mathematics courses, and the third concept map describes the
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logical relationships between the different theorems that are presented in these courses. As a support structure for the modeling exercise, the students have had continuous access to the modeling web site and the interactive UML course described above. The exercise has stretched over the entire first year, and has involved handing in two sets of these maps - one set by the end of the fall term, and a second set by the end of the spring term. The students have been allowed to work in groups of up to 4 persons.

- **Student tasks from the fall term** have been collected and systematized. A systematic way to encode the structure of the large variety of types of concept maps has been developed, which will be presented in an upcoming report. This encoding will make it possible to investigate a variety of correlations between different types of conceptual representations. The maps from the fall term exercise have all been encoded in this way.
- **Student tasks from the spring term** have recently been collected. The work to encode of these maps in our systematic notation is presently going on.
- **The implementation of interactive content** and appropriate tools has continued along the lines specified above. These archives and tools will be introduced to the students on the IT-program this fall as a part of the continuation of the APE-project within the PADLR-project.

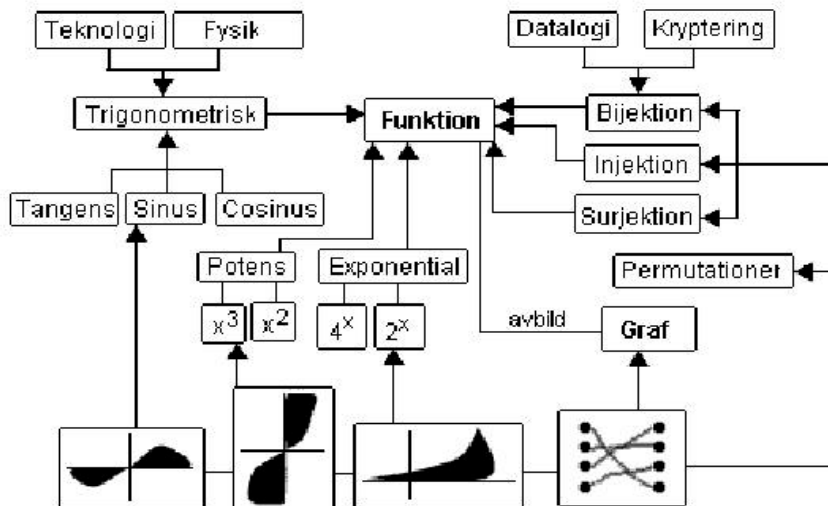


Fig. 1: A UML diagram describing the function concept drawn by a student of the IT-programme (fall 2000).

b) Educational evaluation/assessment results:

A series of meetings with Monica Langerth of the Learning Lab assessment team has been conducted. Through these meetings we have established a strategy of applying the theory anchored evaluation model developed by Monica Langerth and Helge Strömdahl. As input to this model, a series of deep interviews with selected students at the IT-program will be carried out during the fall of 2001. The results will be integrated in the upcoming report.

c) Presentations and Publications:

Fall 2000:

The Conzilla program was presented in Washington DC on October 28 at the CILT-2000 learning conference (www.cilt.org/cilt2000) arranged by the Center for Innovative Learning Technologies. A report from this conference - in powerpoint format - can be found on <http://www.learninglab.kth.se/library/presentations>.

The Conzilla program was also invited for a special presentation at a workshop on modeling and visualization in Washington DC on October 25 arranged by EdGrid and NCSA (National Center for Super-computing Applications) in connection with the CILT-2000 conference (see www.eot.org/edgrid/mvworkshop.html).

Spring 2001:

During the spring of 2001, the project has been presented at the following national and international conferences, workshops and seminars:

Klas Karlgren:

- K2Lab conference, Åre, 19/2-2001

Ambjörn Naeve

- KTH Learning Lab, seminar 10/1 - 2001
- Uppsala Learning Lab, seminar 21/3 - 2001
- International Conference on open learning and Distance Education (ICDE) Düsseldorf, 3/4 - 2001.
- Högskolan i Gävle, Norway, telepresence mediated presentation, 3/5 - 2001.
- Luleå Technical University, seminar on mathematical didactics, 7/5 - 2001.
- Mitthögskolan Östersund, e-Learning conference, 16/5-2001.
- WGLN workshop on performance learning, KTH, 18/6 - 2001

Upcoming conference presentations

Ambjörn Naeve

- SIGGRAPH-2001, Los Angeles, USA, Aug12-17, 2001.
- 8:th Conference on Advanced Computer Systems (ACS-2001), Mielno, Poland, Oct17-19, 2001.
- 2:nd european web-based e-learning conference (WBLE), Lund, 24-26/10 - 2001.

d) Goal accomplishment:

As for the first 18 months of the project, we consider our goals as reached. In fact, due to the tools' development (Conzilla) and archiving efforts, we even consider us to have reached beyond our initial goal expectations. These results form an important part of the base for the planned continuation of our project. In fact, they have been crucial in creating a formal continuation of the project as the submodule "Personalised Mathematical Courselets" within the PADLR-project (Personalized Access to Distributed Learning Resources).

Current state of the project compared to the action plan – Study 1

The action plan from 2001-01-28 has been followed except on one point. Due to the relatively large curricular differences between the different programs, we have reached the conclusion that the shared comparative study, would have been impossible to carry out in a meaningful way. Therefore this study has been abandoned in favor of a planned seminar day which focuses on giving the students detailed feedback on their modeling efforts. See the accompanying action plan for further details.

Achieved Results – Study 2:

a) Implementation:

Spring 2001:

- Within the **Program Summary course** learning, learning reflection and the use of e-folios have been further discussed.
- **Individual follow-up.** At the end of the term each media technology student had an individual summary with the responsible of the program and experts from the dept. of Didactics.

b) Educational evaluation/assessment results:

Conclusions so far:

- Though the students are interested and understands the concept, few have actually started to work on their e-folios.
- The skills and experience of making html-pages differs a lot and also the attitudes among students on hoe to get these skills. Some students wait till they are taught, some takes the time to learn themselves by doing.
- To get most of the students started there is a need for an introductory course about the use of computers and specially html.
- A valuable outcome of the project is that it forms a basis for the coming “folio thinking” project within WGLN.

Current state of the project compared to the action plan – Study 2

The action plan has been generally followed.

Next semester an introductory computer and html course will be held. There will also be teacher students from Uppsala working as tutors to the media technology students.