SweLL – Progress Report APE - Track A, July-Dec 2000

Carl-Gustav Jansson, Leif Handberg, Ambjörn Naeve

Project Name: Content and Context of Mathematics in Engineering Education
Date: 2001-01-28

Project aim and goals:

Curriculum aims and goals
The goal of track A is to encourage and try out methods for student use of conceptual modeling[1] and e-folios[2] 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.

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(s) 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 conceptual modeling and organized opportunities for reflection compared to traditional studies?

Achieved Results:

a) Implementation:

Study 1 (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 UML[3] 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.

Study 1 (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.

[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. for use in several different contexts during present studies or in the future.

[3] Unified Modeling Language, a modeling language originally developed for software development. UML relates and describes concepts by *objects* and *processes* in diagrams within different views.

- **A comparative study of a course** in wave-physics is planned (which links study 1 and 2). Three groups of students, from different engineering programs, with different experience in the use of organizational opportunities for reflection regarding the use of mathematics and conceptual modeling, will be tested after each version of this course. The task will be to select concepts from a mathematics concept map and judge the use in a wave physics context. Strategies have been developed for data-collection and analysis, where the focus will be to discern: What do the students reflect on during their studies and mathematical conceptual development?
- **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.

Study 2 (spring 2000):

- **Evaluation of individual e folios.** At the end of the spring term the media, student's individual e-folios were presented and discussed with the responsible of the program, and experts from the dept. of Didactics. The purpose was to acquire in depth knowledge of the students' progress and development of personal digital portfolios and their conceptions of learning the environment.
- A **Program Summary course** in the form of a seminar series has been started with the aim to emphasize reflection of the learning process and a long-term (the program) perspective in higher education. The seminars will be open for students, teachers and members of the Swe-LL and other LL teams. The following matters have been, and will be, discussed: tools and methods for e-folio work, description and presentation of course content and reflection of the learning situation and the learning environment by using e-folios.
- **A lecture on the history of ideas and concept formation in mathematics** has been given. The purpose is to stimulate the students' reflection on their own learning and the importance of understanding mathematics for other courses.

Study 2 (fall 2000):

- **Evaluation of individual e folios.** At the end of the fall term the media, student's individual e-folios were presented and discussed with the responsible of the program, and experts from the dept. of Didactics.
- The **Program Summary course** was continued from the spring.
- **A second lecture on the history of ideas and concept formation in mathematics** was given.

b) Educational evaluation/assessment results:

Study 1:

During the fall of 2000 the 150 students of the IT program have been carrying out a conceptual modeling exercise 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 are to be constructed: The first one should describe 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 should focus on the function concept and describe the relations between the different types of functions that the students encounter in the mathematics courses, and the third concept map should describe the logical relationships between the different theorems that are presented in these courses.

The modeling activity was initiated by a lecture on conceptual modeling in UML given by Ambjörn Naeve on September 4. As a support structure for the modeling exercise, the students have had continous access to the modeling web site and the interactive UML course described above.
The exercise stretches over the entire first year, and involves 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.

At the moment the first set of concept maps have just been handed in. We are presently working out a way to present the results in a form which is as comprehensible as possible.

Study 2:
During the fall of 2000 the new students at the media technology program have been introduced to the e-folio concept. There has also been seminars in the program summary course with tests and discussions about learning styles.

At the end of the semester the students were given soome texts about e-folios and they were asked to reflect and comment on them.

Their answers have been received and read and here are some results and comments:

• The specifications for the task was sent by mail and posted on a web site. About 50% of the students answered by mail, 30% sent a Word document and 20% gave a link to a web page - their e-folio.

• About 90% of the students are positive or very positive. 10% are neutral and 0% are negative. Two students say that they do not understand the concept.

• Many of the students say they miss:
- Time.
- Tools
- Templates
- Motivation

• Here are some additional comments (translation from Swedish) in random order:
"The e-folio concept seems to me like an ordinary web page".
"… good to catch passing processes."
"… worried about a too fixed shape."
"… good with reflection, if possible on scheduled time for it."
"The layout is important if others are to look at it."
"It would be good to have some parts in common with the whole group."
"I am worried about the extra time it will take."
"You have to be active all the time."
"I was skeptical at the beginning but now it is obvious that this is a good idea."
"It is good but it ought not to be compulsory."
"If I use links to external sites I am afraid that they will be lost in the future."
"I look upon my e-folio as a file system."
"The structure problems are individual"
"It is important with a comprehensive view in ones studies."

• Conclusions so far:
- The most important thing is to encourage the students to reflect.
- When they are used to reflecting there will be a need for tools and structure.

c) International Presentations and Publications:

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).

d) Goal accomplishment:

As for the first year of the project, we consider our goals as reached. In fact, due to the tools development (Conzilla) and archiving efforts that we have begun, 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.

Current state of the project compared to the action plan

Study 1:
In general, the action plan from February 2000 has been followed.
Below we present (in gray) the items from the action plan where minor devivations have occurred.

5. All mathematics courses and applied courses during the first year will have lectures or exercises related to this task. All responsible teachers will be thoroughly familiar with the study. It will be discussed this spring during two planning workshops for the program.

Comment: The planned activities have been carried out. However, they have been "added on" rather than intergrated with the mathematics courses.

7. The data collected during the year will consist of 4 times 150 conceptual maps. We will also make complementary observations during the whole first year.

Comment: The initial plan was to collect four different versions of the concept maps. However, because of the work load involved (and the credits given) we have reduced the number of versions to two.
Moreover, during the modeling process, the students requested to be allowed to work in groups of up to 4 persons. We considered this to be reasonable, especially since conceptual modeling benefits strongly from communication with others.

Study 2:
The action plan from February 2000 has been followed.

Principal investigators:

Leif Handberg, Calle Jansson, Ambjörn Naeve

Collaboration partners:

DSV/KTH:	Calle Jansson, PI Klas Karlgren
CID/NADA/KTH:	Ambjörn Naeve, PI Matthias Palmér Olle Sundblad
Media Technology/NADA/KTH:	Leif Handberg, PI