SweLL – Scientific Project Report APE - Track C, July - Dec 2001

Project Name: CVEL experiments (3D communication and visualization environments for learning)
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Project aim and goals:

Curriculum aims and goals
The main goal of the project is to:
- increase students' ability to understand complex spatial and dynamic relationships in a variety of disciplines;
- increase possibilities of collaborative interaction between students and shared; exploration of course contents from remote teaching settings;
- improve the ability to access and retrieve course material by visually exploring digital content archives.

Educational evaluation aims and goals
Proposed guiding questions at this stage focus on what a 3D experience can bring to the learning process in terms of:
- What impact on learning has instructional support such as a shared experience and/or mentoring by peers and teachers in a 3D environment?
- What impact on learning does the pedagogical support built into tools such as interactive 3D objects and shared 3D environments have?

The focus of the evaluation studies will be to explore whether the use of 3D tools enhance students ability to understand complex spatial and dynamic relationships in the chosen subjects. Another important aspect is to explore whether a shared 3D experience (sharing and interacting with the same 3D object) enhance students' ability to develop intuitive understanding of the "spatial anatomy" of a mathematical transformation.

Presentational structure
The project consists of 2 parts, one carried out at DIS/UU (**Part I**) and one at CID/KTH (**Part II**). The progress of the two parts is reported separately.

PART I - Achieved Results (DIS)

a) Implementation

From the results of a previous pilot study with 8 users in the virtual teaching environment (see also 3rt half year report) we concluded that mouse based interaction for drawing or even writing posed significant problems to the students. Hence, new input modalities had to be found that could improve human interaction when editing the virtual whiteboard or content on the slide projection boards. After surveying suitable input device techniques we ended up with developing an interface module that connects digitizer tablets to the whiteboards of the virtual learning environment.
Another step in this software extension was the definition of an alternative protocol for representing and propagating digital content of the whiteboard. Digital content of the whiteboard in the current version of the virtual learning environment is stored in form of discrete pictures (bitmaps), which causes visual artifacts when observed from a very close viewing position. Also, memory and bandwidth requirements are relatively high. To overcome this problem, annotations on the whiteboard are alternatively represented as vector-based strokes that require only little geometric data. In order to make these strokes visible on the whiteboards, the visualization process for the whiteboard module was modified such as to transform the stroke-based input into a visual picture on the whiteboard.

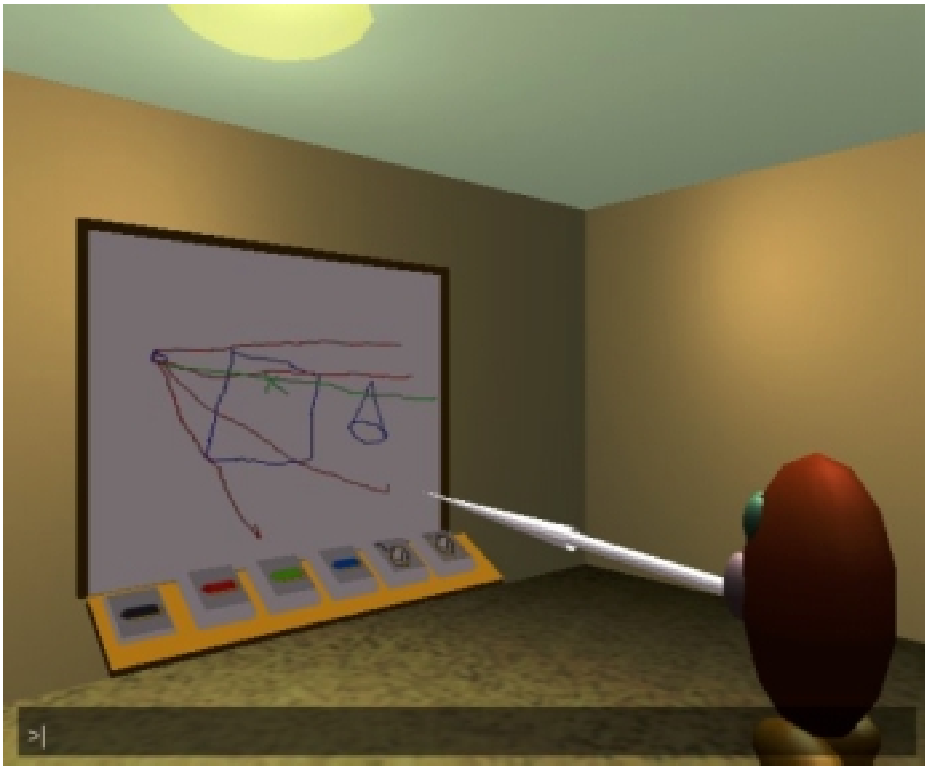

Fig. 1: Drawing on the whiteboard using old-style bitmapped graphics for drawing.

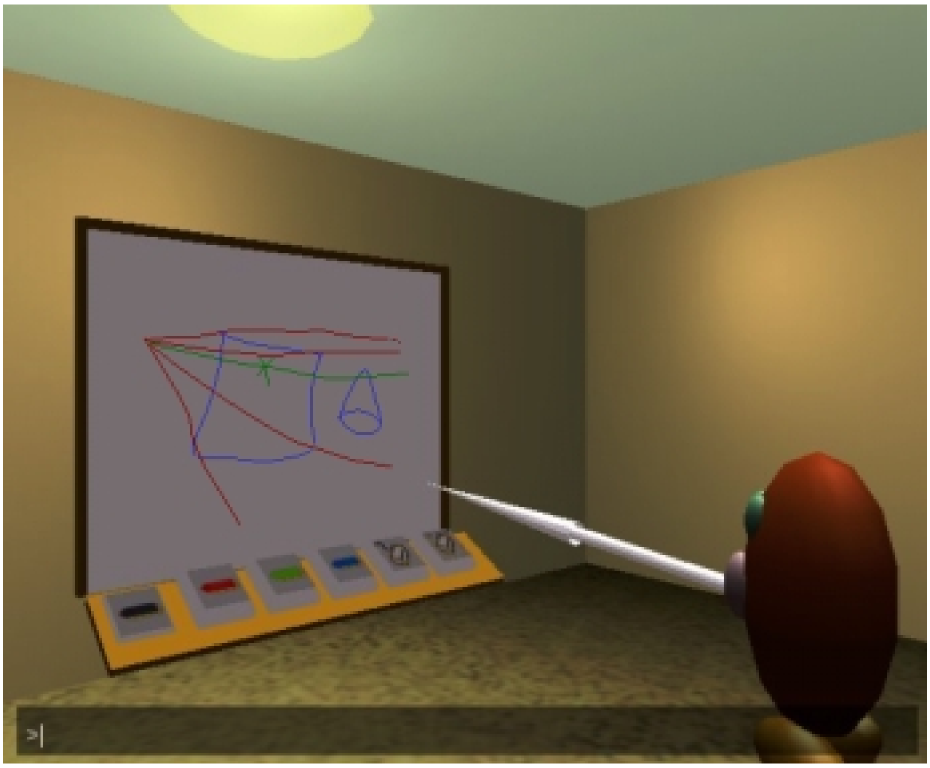

Fig. 2: Drawing on the whiteboard using new-style vector based graphics for drawing.

Fig. 3: Natural writing on digitizer tablet in order to control virtual drawing pointer.

According to the activity plan for the fourth semester of the project we integrated live voice communication into the application program of the virtual learning environment.

Therefore it is easier now to start up the system, since the user does not need to know about the technical details required for starting up a separate voice-communication client. Under the fourth semester, during development and technical assessment, it showed that the publicly available software library (OpenH323) we used did not fully live up to our expectations we had with regard to runtime stability and reliability. For the continued developments and experiments in the continuation project VASE, we are therefore going to adopt a commercial solution, which has been proposed and been tested successfully by our L3S partner in Hanover.
According to our qualitative observations of users of the virtual teaching environment we found that the means of navigation through the 3D classroom environment (based on keyboard and mouse control) are absolutely efficient to participate in virtually replicated lectures.
What poses bigger problems is the controlled manipulation of freely maneuverable objects that are part of interactive 3D classroom experiments. We tried to solve this problem by introducing constraint based modeling of the behavior of interactive experiments and visualizations. This has been combined with an abstraction and classification of generic input classes for spatial interaction. The result of this is that spatial interaction with complex simulations is broken down to sequences of different 3D manipulation modes. Modes of interaction are e.g.:

- Free or bound translation along arbitrary line in space
- Free or bound rotation about arbitrary axis in space
- Free spatial motion between two parallel planes in space
- Free motion along predefined 3D spline-curves
- Free positional motion on spherical orbit
- Many others…

The objective of these spatially constrained interaction metaphors is to increase the learning curve in the user of interactive 3D experiments. Since 3D manipulation of objects is in certain intervals bound to predefined spatial paths and/or sub-regions, it requires less perfection in the users navigation behavior to successfully control interactive scenarios and thus to accomplish the manipulations actually intended.
Finally, all development efforts in the 4th semester of the projects have been carried out with an object oriented design approach in mind. This is in order to enable the transfer of the developed systems to the recently started VASE project that aims towards investigating the design and usage of virtual learning platforms on a higher user level.

b) Validation, educational evaluation and assessment results:

Informal assessment studies have been carried out with small groups of students within the scope of the course “Interactive Graphical Systems” in the IT engineering program at Uppsala University, in fall 2001. The objective of these assessment studies or experiments was to further verify general usability aspects of the adopted technology and to integrate the users into the development process for new interaction modalities for the virtual classroom environments.

One group of students focused on the assessment of white-board interaction and submitted a proposal for redesigning the whiteboard interaction based as described earlier. The result of the improved whiteboard interaction is a clearly enhanced writing experience, which is close to natural handwriting. Delineation of subtle details and structures could be performed much more intuitively and with improved accuracy, as subjectively experienced and reported by the students.
Other advantages of the proposed vector based input on the whiteboard where:

a) Faster propagation of manipulations on the whiteboard, which increases the subjective feeling of interactivity.
b) Vector based representation of whiteboard strokes allows for selectively erasing or undoing strokes performed by the user. Also, in regard to archiving of the whiteboard contents, the vector-based whiteboard provides better opportunities for storage of complex teaching sessions.

The use of a digitizer tablet for interaction with the virtual classroom environment creates for the first time an additional specific hardware investment to run the system efficiently. However, we consider that additional costs, which are approximately 100US$ are well motivated and should not really imply an obstacle for the use of the virtual teaching environment. In fact, from our observations of students in the abovementioned course we learned, that many students on their own acquire this type of digitizer tablets and appreciate them in the context of daily document writing and editing.

Being a virtually zero-cost, purely software based solution the OpenH323 software library appeared to be appealing for the prototype development under the project. Since no extra hardware is required to accomplish the audio communication, this software-integrated approach provides a good basis for widely spread use of our virtual classroom environment and thus gives good opportunities to assess the technology in bigger scope. Before a real commitment to this OpenH323 software could be made, we performed in our local development team further usability tests and benchmarks of the audio-communication infrastructure adopted under the project. In contrast to our observations from the previous user study (see 3rt half-year report), we noticed several technical shortcomings, which suggest replacing OpenH323 on a longer term. One critical aspect is that simultaneous verbal communication between many users causes a strange mix of sampled audio-fragments. Obviously this is due to the incapability of the voice communication server of OpenH323 to resample and mix the audio-signals received by several clients. This problem we never encountered that clearly in the previous virtual classroom session, where 8 students and one teacher where communicating. We suppose that this was due to the fact that the virtual lecture represented a quite formal communication protocol, where usually only few people talk at a time as it works in the real world.

c) Presentations and Publications:
Several efforts in the 4th semester of the project were concerned with the dissemination of our results. Most of the activities where carried out in form of seminar presentations held

in the premises of the Uppala Learning Lab. The focus group were decision makers in the public education system and representatives from established companies in e-Learning. Also in the scientific community on conference presentation was given at the 2nd WBLE Conference in Lund. Our paper that presented the results of our assessment study was among seven contributions accepted for the Workshop on "Evaluation and Assessment". Several participants in the audience expressed their appreciation of our very concrete assessment approach. Our achievements in the project have also been published in form of a research report.

1. Conference talk and presentation of 2ReeL at the European conference on e-learning WBLE 2001 in Lund 24th-26th of October 2001.

2. Presentation of CVEL project for Alumniförening at Uppsala Learning Lab, 5th of September 2001.

3. Presentation of CVEL/2ReeL for the Minister of Education of Lower Saxony, Mr. Oppermann, at Uppsala Learning Lab seminar, 10th of October 2001.

4. Presentation of CVEL/2ReeL for representatives from the Department of Education at Uppsala Learning Lab seminar, 13th of November 2001.

5. Presentation of CVEL/2ReeL conceptual framework for industrial representatives from NIIT Nordiska AB, Uppsala Learning Lab, 13th of December 2001

6. Seipel S, Lindkvist M.: "Interactive Graphical Environments for Collaborative Learning and Teaching", Research Report 2001:9, Department of Information Science, Uppsala University; ISSN 1403-7572.
   (See appendix)

d) Goal accomplishment:

For the 4th period of the project as well as for the entire project, we consider our goals as reached. In light of the substantial accomplishments in regard to the 2ReeL and the valuable experiences gathered for the continuation project within VASE, we even consider to have reached beyond our initially expected goals.

e) Current state of the project compared to the action plan

Detailed review of action plan activities for 4th semester 2001 (original text grayed):

Planned project activities (DIS):

6. Continued development and adaptation of the 2ReeL platform in response to user feedback. Integration of open source libraries into 2ReeL platform environment.

Adaptations to the input modalities in have been made according to the response we received from small-scale studies with selected students. The result of which has been described in detail above. Audio communication in the virtual learning environment based on the Open H323 system has been integrated into our software, which eases startup of the client application by untrained users.

7. Modularization of 2ReeL environment components. Initial migration of 2ReeL towards an easy to use high level authorware system for building of interactive networked learning environments.

Throughout the developments under the 4th semester of the project, all new components have been conceptually designed in a modular fashion. This provides the basis for reuse of the accomplished system components in the continuation project VASE. Thus providing a initial step towards a flexible authoring system for building individual virtual classroom environments. Though, it is far beyond the scope of this and also the VASE project to deliver a full featured graphical development system for end users.

8. Assessment study: Another user study is envisaged with regard to usability of multi-point audio conferencing and concurrent verbal interaction from remote sites. A group of students from the engineering program in information technology at Uppsala University will be the test population.

The assessment study with regard to usability of multi-point audio conferencing and concurrent verbal interaction from remote sites has initially been performed by our technical development team. The results of the tests and benchmarking procedures indicated clearly that further tests with the students were obsolete (due to the shortcomings identified in the communication library, see above). Therefore, we performed some informal studies with selected students in regard to usability of the interaction modalities in the virtual classroom environment. The results from these informal studies triggered the design and implementation of an alternative method for whiteboard manipulation.

9. Conference talk and presentation of 2ReeL at the European conference on e-learning WBLE 2001 in Lund 24th-26th of October 2001.

The dissemination activities were performed according to our plans. The response from international exerts in the field at the conference WBLE was very affirmative.

PART II - Achieved Results (CID/KTH/NADA)

Background and summary of earlier results

Virtual Reality and Mixed Reality systems have the potential to allow students to discover and experience objects and phenomena in ways that they cannot do in real life. Since the early 90s, a large number of educational virtual reality applications have been developed. These include tools for teaching students about physics [Dede et al., 1996], algebra [Bricken, 1992], color science [Stone et al., 2000], cultural heritage objects [Terashima, 1999] and the greenhouse effect [Jackson, 1999].
There is convincing evidence that students can learn from educational VR systems [Winn, 1997]. However, issues relating to collaboration and learner motivation have largely been overlooked. Also, few authors have focused on the mathematics of geometry as content, even though geometry is particularly suited for graphical visualisation. KTH has built the Cybermath system to allow further studies of these issues [Taxén & Naeve, 2001a,b].

The main effort of CID in the CVEL project has been concerned with developing the CyberMath system, which is a shared, avatar-based virtual environment for the interactive exploration of mathematics. As described in earlier progress reports, the first CyberMath prototype was built on top of DIVE (Distributed Interactive Virtual Environment), [Carlsson & Hagsand, 1993], which is a Virtual Reality system developed by SICS (Swedish Institute for Computer Science). DIVE has the ability to display shared interactive 3D graphics as well as distribute live audio. It is possible to allow different users to access the same virtual environment from workstations with different hardware configurations. CyberMath is built as an exploratorium that contains a number of exhibition areas. This allows teachers to guide learners through the exhibitions but learners can also visit CyberMath at their leisure, alone or together with others.

At the time of writing, three example exhibition areas in the mathematics exploratorium have been completed. Their respective content is:

- **Interactive transformations**. An $\mathbf{R}^3 \rightarrow \mathbf{R}^3$ transformation maps a three-dimensional point to another three-dimensional point. In this exhibit, users can investigate the effects of any such transformation on different mathematical entities, including points, lines, planes, boxes and spheres. The user can manipulate the entities and immediately see the results of the transformation, either in a separate coordinate frame or in the same coordinate frame as the untransformed surface.
- **Differential geometry**. In this area, users can learn how to construct advanced three-dimensional surfaces using methods from differential geometry. The exhibition includes a number of three-dimensional animations and wall posters that illustrates these methods.
- **Focal surfaces**. In this exhibit, we illustrate how two cylindrical mirror surfaces can, when used together, focus sunlight at a point in space in the same way as a paraboloid mirror can.

As described in earlier reports, our aim is to enable the CyberMath system to function efficiently in many forms of interactive learning environments, including public environments such as museums etc. However, bringing virtual environments into such environments places heavy requirements on the supporting technical platforms with respect to stability, efficiency and visual quality. Such requirements include the following:

- *The software platform has to be extremely robust.* This is especially true for situations where young children are allowed to interact with it. In schools and museums, it is not uncommon that visitors go through huge efforts to break or vandalize the exhibits: computer hard drives are re-formatted, running software is broken into and hardware peripherals are broken or even stolen.
- *The software platform has to be secure and easy to manage and restore*. If our system is to be maintained by teachers or museum staff, it must be easy to reset the application to its default configuration and to move it from one computer to another.
- *The interaction with the software has to be smooth and efficient.*

- *The software platform must be capable of producing visuals of high quality*. This is important for attracting the attention of visitors and keeping their interest in the exhibits.
- *The software platform must be flexible* in the sense that it can be used for mixed reality applications and not only standard avatar-based virtual environment applications.

From the experimental testing and lecturing activities that we have carried out with the CyberMath prototype (reported earlier), it became obvious that the DIVE platform, does not meet these requirements. Our main concerns lie with its limited visual quality, fixed feature set, low execution speed and lack of security features. Also, DIVE is somewhat crash prone and hard to configure and set up. Thus, a search for a more suitable platform was initiated.

In addition, being a traditional avatar-based virtual reality system, it is unclear whether DIVE is suitable for the special rendering requirements of mixed reality applications. Therefore, an effort was made to find an alternative application framework. Systems that were examined and rejected include ActiveWorlds [http://www.activeworlds.com], ALICE [Conway, 1997], MASSIVE [Benford et.al., 1999, Shaw et.al., 2000], Open Inventor [Wernecke, 1994], OpenGL Performer [http://www.sgi.com/software/performer], Java3D [http://java.sun.com/products/java-media/3D], and OpenSG [http://www.opensg.org]. Instead, we have chosen to develop our own platform - called Wasa [Taxén et.al., forthcoming].

Wasa is a collection of utilities and components rather than a complete, monolithic system, which makes it flexible and extendable. It is also highly portable, efficient, and produces very high-quality visuals. Since Wasa currently lacks a stable network distribution model, KTH has begun the integration of Wasa with the EQUIP platform of the University of Nottingham [Greenhalgh & Izadi & Rodden & Benford, forthcoming].

Work performed during July-Dec 2001

During the fall of 2001 the CVEL work at CID has focused on extending and the Wasa platform in order to support the requirements described above. We have also created a set of course-related mathematical content and integrated the CyberMath system with our concept browser Conzilla. These efforts form the starting point for module 5.3 of the PADLR-project: Personalized Mathematical Courselets.

Extensions of the Wasa platform

In order to allow more realistic physics simulations, we have extended Wasa with a generic particle animation component, a collision detection component and a new shading component. We are also developing components for projection onto non-linear surfaces and for fluid dynamics.

Particle systems can be used to visualise a wide range of phenomena [Reeves, 1983]. In particular, they are suited for renderings of dynamic flows of matter or interacting discrete entities, both of which we anticipate will make the system more useful for learning about physical penomena. Our collision detection component, based on [Melax, 2000], allows particles to interact with a virtual environment.

Our new shading component allows virtual objects to be lit by captured real light. Recent work by Debevec has produced algorithms where a so-called light probe is used to represent all light that arrives at a point [Debevec, 1998]. Light probes are typically obtained through photographs of real environments, although our shading component includes the capability of constructing light probes from environments that have been lit by the Wasa lighting utilities. When a light probe has been obtained, it can be used to illuminate virtual objects in real-time, as illustrated in figure 6. Our shading component implements a recent algorithm described by [Ramamoorthi & Hanrahan, 2001] that allows the irradiance reflected by Lambertian surface properties to be approximated by just nine values. An advantage of this algorithm is that these nine values are easy enough to compute to be useful in real-time applications. By generating light probes from a set of connected web-cams, we intend to light virtual objects with real, dynamic light. We believe that this is a new and unique approach for mixed reality applications.

We would like to be able to project images onto surfaces with unusual curvatures, or even onto surfaces that change dynamically. Such projection surfaces will distort the output from a traditional renderer, which may be an intentional effect. However, curved projection surfaces can be used to give the viewer an increased sense of depth in an image without the need for stereo viewing. Unfortunately, such a projection requires the geometry to be pre-distorted before it is sent to the rendering component. We are currently developing a utility for defining and executing such distortions.

At this time, the Wasa includes a simple network distribution library that can be used for small-scale applications. However, in order to build more advanced networked application, a more sophisticated distribution system, such as EQUIP, is needed. EQUIP also allows user interface components and peripherals to be dynamically added to and removed from applications in a controlled manner at run-time. This feature has the potential to greatly simplify user interface management. Therefore, we are adding the capability of distributing Wasa entities with EQUIP. Thus far, we have built a proof-of-concept prototype that allows mouse interaction events to be distributed across a network by EQUIP to a Wasa application, where they modify a virtual object. We are currently investigating different approaches for extending this work.

Creation of mathematical content

A large number of mathematical structures have been visualized using special tools such as Mathematica and the Graphing Calulator. These components include material from the basic courses in Linear Algebra, Differential and Integral Calculus of one and several variables, Differential equations, Fourier Analysis and Differential Geometry.

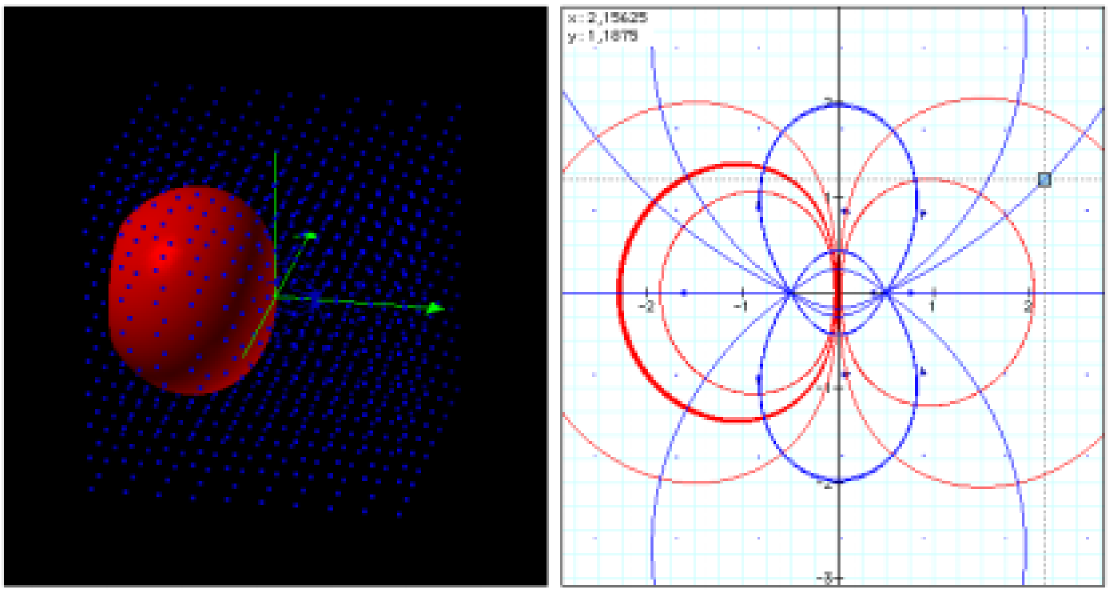

Figure 1. The electrical force field of a dipole and an equi-potential surface in 3D (left).
An intersection of the 3D image with the horizontal symmetry plane (right) showing the equi-potential field (in red) and the force-field (in blue). The thick red curve is the intersection of the red equi-potential surface with the horizontal plane.

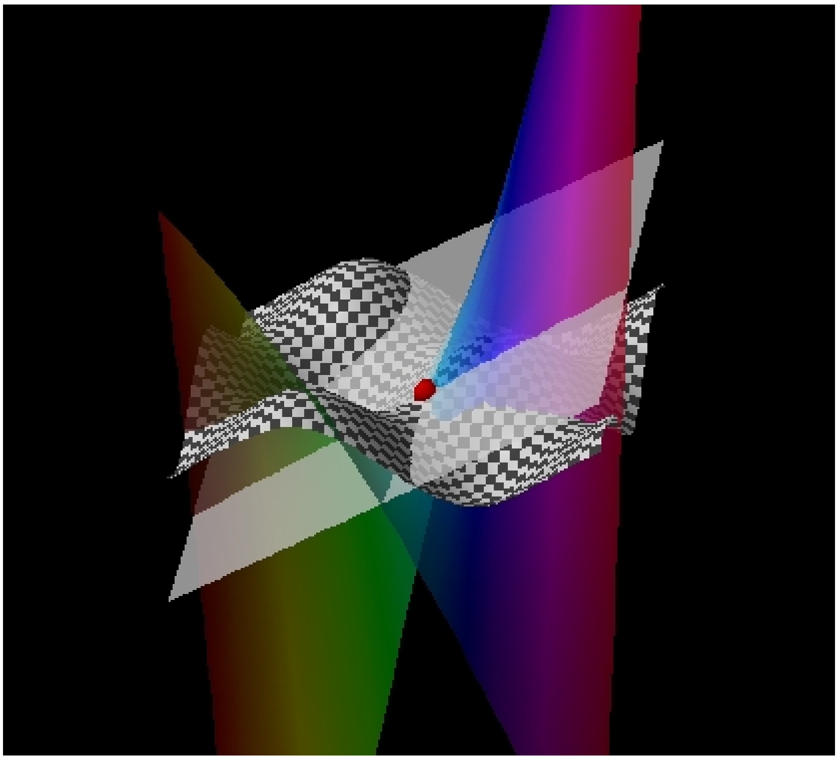

Figure 2. The first- and second-order Taylor expansion of the checker-boarded surface around the red point. The surface is negatively curve at this point, since the tangent-plane in the neighborhood of the red point is located on both sides of the surface.

This material will work as a starting point for creating ways of easy transfer into the CyberMath system. Such transfer will be crucial in order to ensure its efficient use in realistic educational settings

Transfering mathematical content from other systems into CyberMath

During the fall of 2001 we have created a special Mathematica-to-Wasa conversion utility that can be used to convert standard three-dimensional Mathematica objects and animations to the Wasa file format. It is now straightforward to turn the converted Mathematica objects into interactive CyberMath exhibitions. This makes it possible to support rapid-turnaround teacher-driven development of new CyberMath exhibitions in the same fashion as in the QuickWorlds project (Johnson et al., 2000).

Remote recording of a lecture involving a power-point presentation, a live lecturer and the CyberMath system

In collaboration with Claus Knudsen at AMT (Advanced Media Technology laboratory) and Hilding Sponberg at Gjövik College in Norway, we have remotely recorded a test lecture as a streaming video. The recorded material was located at KTH in Stockholm, but the recording itself was remotely controlled from Gjövik. Some snapshots from this recording is shown in the pictures below.

Integration of Cybermath with the Conzilla concept browser

During the fall we have integrated the Cybermath system as a learning object (knowledge component) within the Conzilla concept browser [Naeve, 1999, Nilsson & Palmér, 1999, Naeve, 2001b], which has been developed with partial support from WGLN within the APE-track A project (see separate progress report).

What follows below is a number of pictures showing a walk-through of a session in Conzilla involving shared interactive learning environments for mathematics. The scenario is the following: A visitor is navigating in the mathematical knowledge manifold of Conzilla and enters the context-map called Conzilla

- Mathematics environments. The visitor then views the content of the concept Shared Interactive Mathematics Learning Environments - first under the aspect **Intro**, (Figure 3, 4, 5) then under the aspect **Tools** (Figure 6, 7, 8) and finally under the aspect **Contacts** (Figure 9, 10). The pedagogical rationale for this scenario is that viewing the intro-material on CyberMath (which is a canned video lecture) makes the visitor interested enough to check out the CyberMath tool itself. This in turn raises questions that can only be answered by a human knowledge source, which the visitor contacts through the Videocafé application shown in Figures 9 and 10.

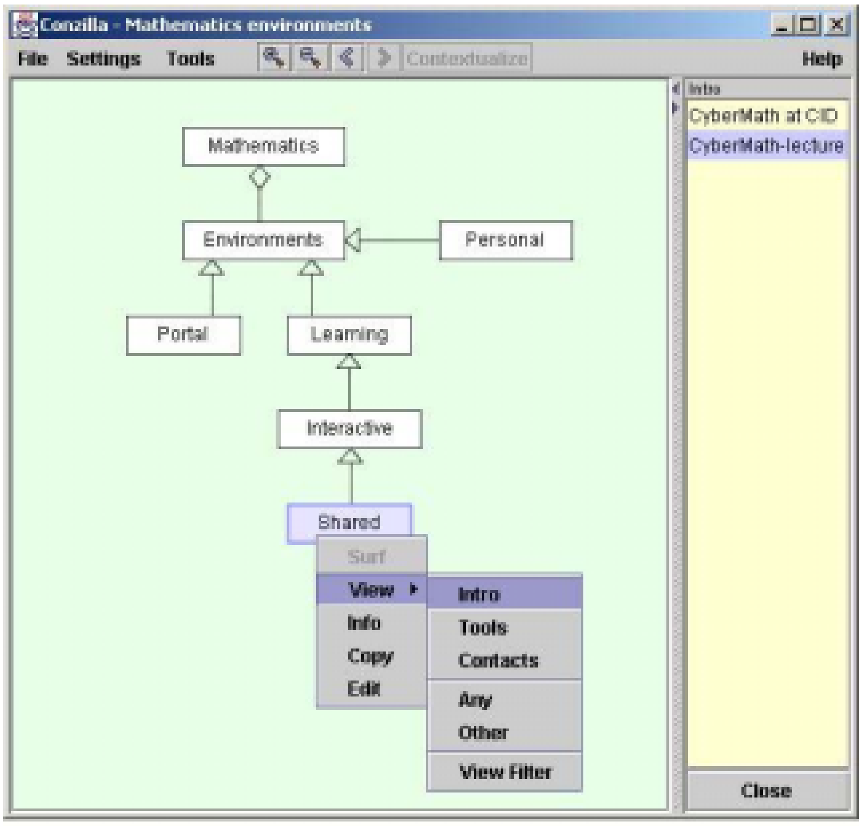

Figure 3. Right-clicking the concept Shared-Interactive-Mathematics-Learning-Environments and choosing **View -> Intro** brings up the yellow content window on the right, which shows the content of this concept (Shared …) under the chosen aspect (= **Intro**). Double-clicking CyberMath-lecture brings up the remotely recorded streaming video lecture mentioned above.

Figure 4. The canned lecture involving a power-point presentation (left) and a talking teacher (right). (The power-point presentation shows the solar energy exhibit in the DIVE version of CyberMath.)

Figure 5. Continuing the canned lecture, the producer (in Gjövik) switches from the talking teacher to the CyberMath system (shown in the monitor to the right).

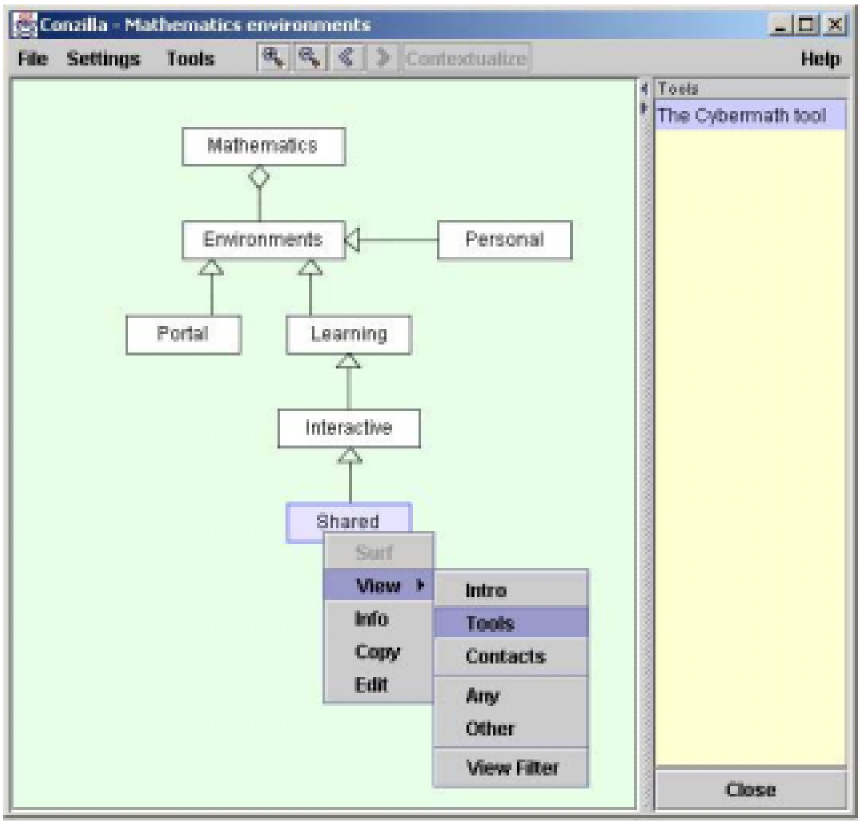

Figure 6. Closing the streaming video lecture, returning to Conzilla, right-clicking Shared and choosing **View -> Tools** brings up the content window on the right. Double-clicking The CyberMath tool starts up the CyberMath system.

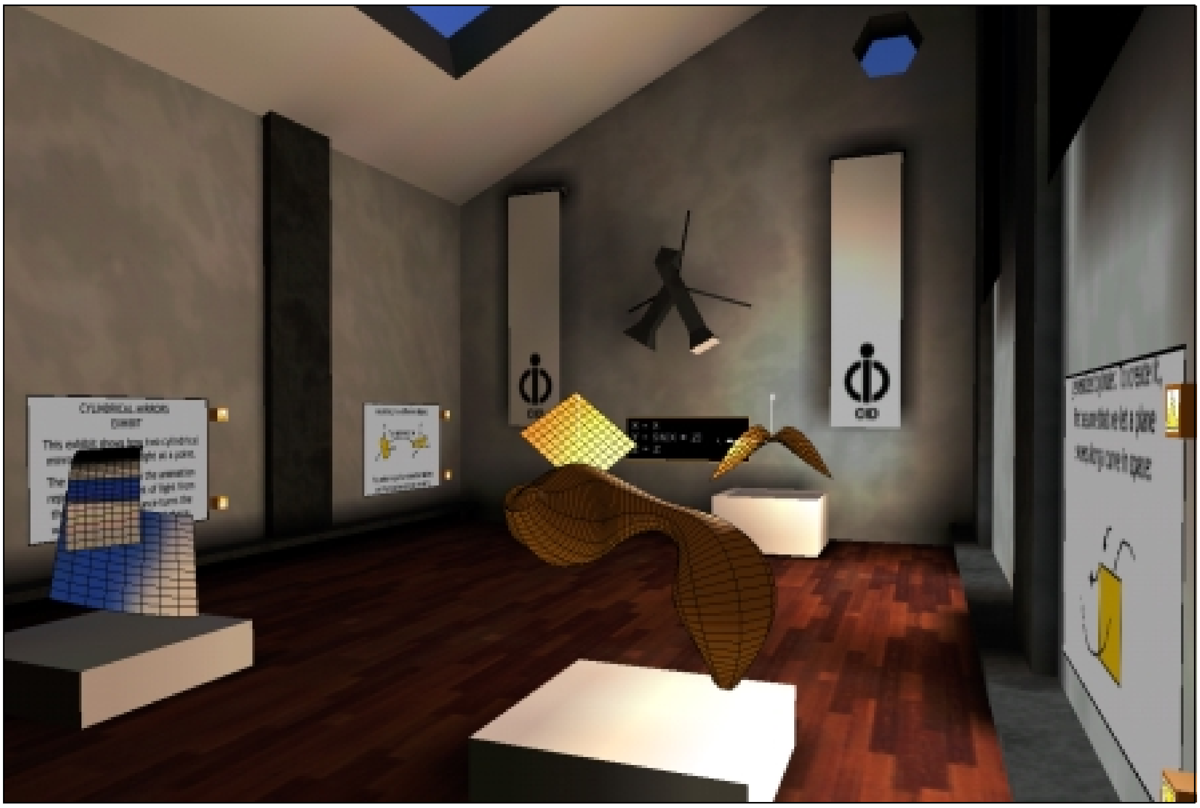

Figure 7. Entering the Wasa version of CyberMath. To the right is the solar energy exhibit (shown in the monitor to the right in Figure 5). In the background is the transformation exhibit.

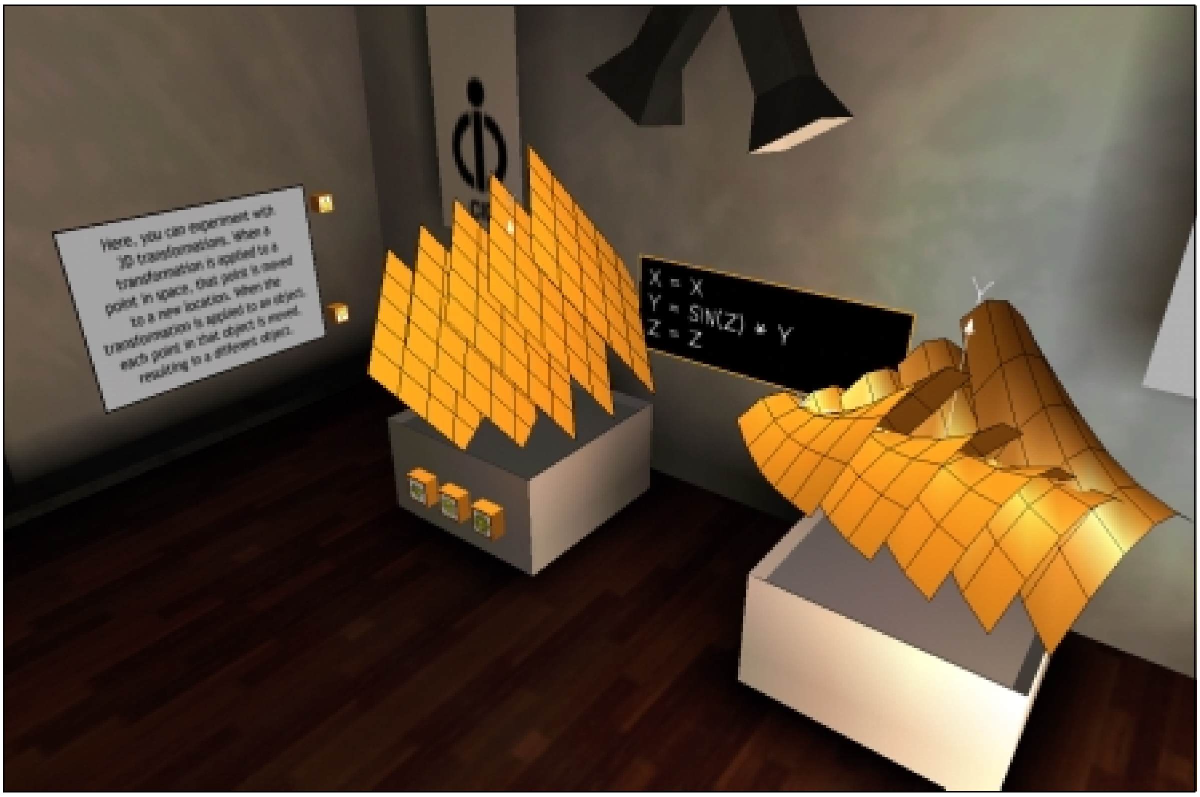

Figure 8. The transformation exhibit in the Wasa version of CyberMath. Clicking one of the three buttons on the side of the left podium inserts a geometric figure in the domain of the transformation whose algebraic expression is shown on the blackboard in the background. The mapping of this figure (a set of parallel planes in the depicted case) is shown over the podium on the right. Rotating and dragging the figure on the left changes its image in real time according to the rules of the transformation. Its algebraic expression can be changed by clicking the blackboard.

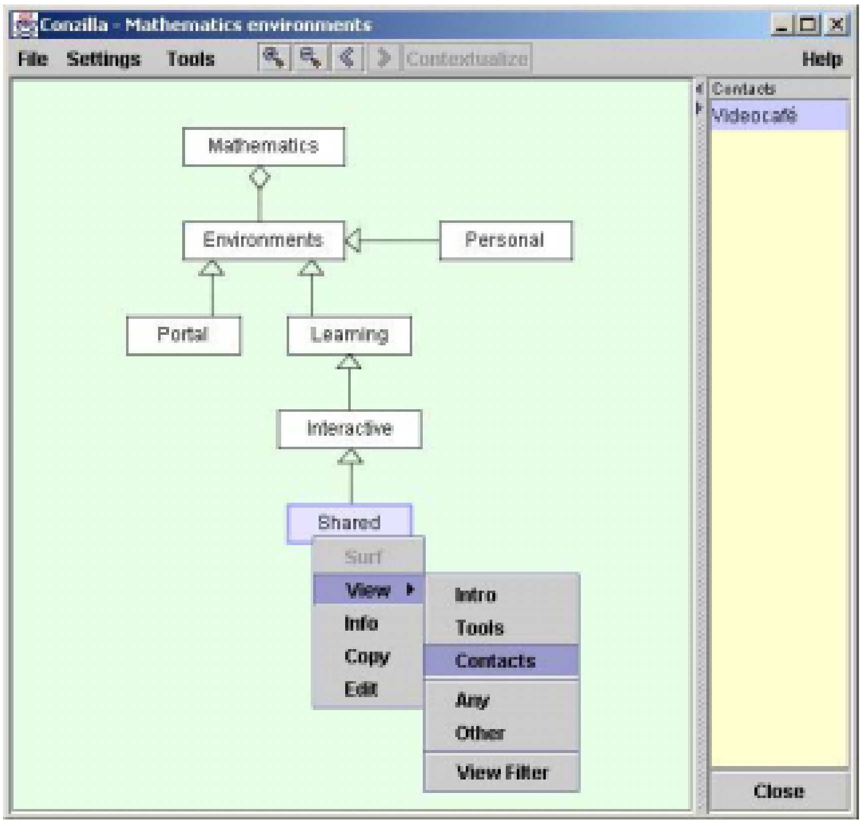

Figure 9. Returning to Conzilla, right-clicking Shared and choosing **View -> Contacts** brings up the content window on the right. Double-clicking Videocafé brings up the CUseeMe application shown in Figure 10.

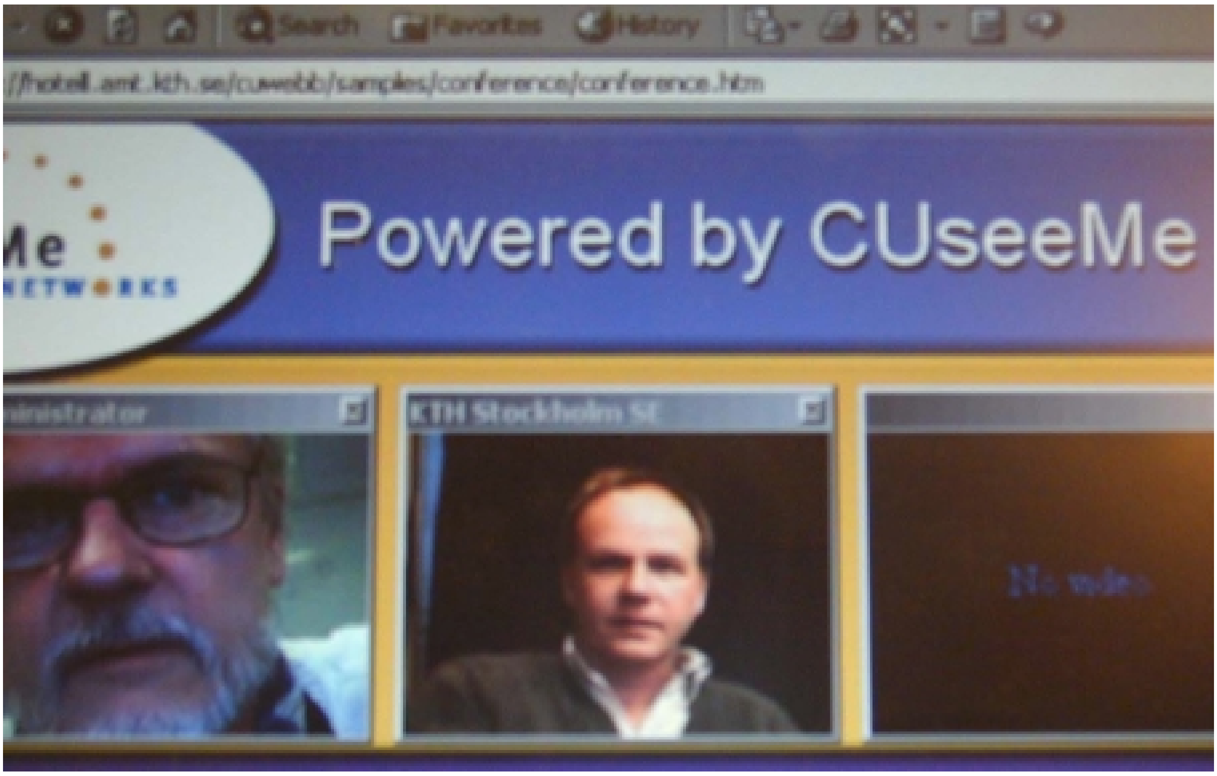

Figure 10. The CUseeMe application establishes a person-to-person contact mediated through Conzilla. It can be any kind of web-based two-way communication system. The basic pedagogical principle underlying this approach is that no "difficult" questions can be answered in an automated way. In fact, it is only when the questions break the pre-programmed structure that the deeper part of the learning process begins.

Publications and presentations during July-Dec 2001

International publications

• Taxén, G., Naeve, A. (2001), CyberMath - Exploring Open Issues in VR-based Learning, SIGGRAPH 2001 Educators Program, In SIGGRAPH 2001 Conference Abstracts and Applications, pp. 49-51. (Paper attached below).
• Knudsen, C., Naeve, A. (2001), Presence Production in a Distributed Shared Virtual Environment for Exploring Mathematics, Proceedings of the 8th International Conference on Advanced Computer Systems (ACS 2001), Szcecin, Poland. (This paper describes an experimental lecture in CyberMath augmented by a presence production system. This lecture was reported in the CVEL-July-Dec 2000 progress report)

These publications are available electronically at http://kmr.nada.kth.se.

Presentations at international conferences

During the fall of 2001, the Cybermath system has been presented at the following international conferences:
• SIGGRAPH 2001, Los Angeles, Augst 13-17, 2001.
• Eighth International Conference on Advanced Computer systems (ACS-2001), Szcecin, Poland, Oct 17-19, 2001.
• Second European Conference on Web-based Learning Environments (WBLE-2001), Lund, Sweden, Oct 24-25, 2001

Invited talks (Ambjörn Naeve)

- Umeå universitet, Sept 21, 2001
- Ingenjörsskolan KTH-Haninge (KTH), Oct 23, 2001
- Högskolan i Kalmar, Oct 30, 2001.
- Riksutställningar, Dec 7, 2001.

Demos in connection with visits to CID

- Swedish Educational Television (UR), Dec 13, 2001
- Swedish National Board of Education (Skolverket), Dec 14, 2001
- National Centre for Flexible Learning (CFL), Dec 14, 2001

Special demos during July-Dec 2001

- The CyberMath system was presented to 200 high school students during the Kowalewski mathematics days held at KTH on Nov, 9-10.
- A special demo involving about 20 students was also carried out in the KTH-Cave environment [Cruz-Neira & Sandin & DeFanti, 1993] on Dec 6, 2001.

Goal accomplishment

For the 4:th period of the project – as well as for the entire CVEL project period - we consider our goals as reached. In fact, in the light of the substantial increase of functionality in the Wasa environment and the integration with Conzilla [Naeve, 2001b] and various forms of presence production systems (such as CuseeMe) into an educational architecture that supports question-based learning [Naeve, 2001a], we consider us to have reached beyond our initial goal expectations.

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