Implementing the Challenge Based Learning in Classroom Scenarios

Nelson Baloian*, Henning Breuer, Kay Hoeksema*, Ulrich Hoppe, Marcelo Milrad

Depto. de Ciencias de la Computación Universidad de Chile, Santiago
nbaloian@dcc.uchile.cl

University of Applied Sciences Potsdam, Germany
breuer@fh-potsdam.de

Institute for Computer Science and Interactive Systems,
University of Duisburg-Essen, Germany
{hoeksema, hoppe}@collide.info

Center for Learning and Knowledge Technologies (CeLeKT),
Växjö University, Sweden
marcelo.milrad@msi.vxu.se

Abstract
Our Challenge Based Learning (CBL) method can be described as a special form of problem-based learning, in which the problems are of realistic, open-ended nature. Additionally, CBL contains features of experiential and project-based learning approaches.
CBL is supported by the provision of Digital Experimentation Toolkits (DExTs) which comprise materials, initial instructions, references to web resources and specific software tools. Within the COLDEX project, a number of remote sites which generate data for analysis in such a DExT scenario is established. Among these is an observatory with a semi-professional telescope and a network of seismic measurement stations in Chile. Technological challenges lie in the ease of use in accessing these data and in communicating the learners' requests and specifications to the remote sites. Within this article we describe several classroom scenarios for the usage of DexTs in schools. Examples are the calculation of the epicentre of an earthquake, the calculation of lunar heights and the definition of strategies for navigation in a maze.

A Introduction
The COLDEX project (www.coldex.info) is about developing scenarios for distributed collaborative learning in an intercultural setting. To develop our scenarios, we adopted a different approach than traditional Problem-based Learning or Discovery learning by providing tools, which teachers and students can use for carrying on the experiments and analyse and process their results not as freely and undefined as in discovery learning but giving more possibilities for the learning group to define themselves new challenges. This approach is similar to provide a LEGO construction kit with a booklet about which constructions are possible to achieve. In this paper we present this approach which we called “challenge-based learning” and three scenarios implementing it.

B Challenge Based Learning
Vygotsky’s sociocultural theory [1] promotes the importance of social interaction and the use of artefacts for knowledge acquisition. Three principles have been proposed for the design of educational environments derived from Vygotsky’s works [2]: First, the notion of authentic activities proposes the modelling of activities and tools derived from professional practices. Second, “construction” refers to learners creating and sharing artefacts within their community. Third, educational environments should be designed to involve a close

collaboration between learners and their peers as well as between students and experts. Regarding these principles several educational scenarios have been developed within the COLDEX project. The underlying pedagogical approach is the Challenge Based Learning method (CBL). It can be described as extended problem-based learning, but it contains also some components from the experiential, project-based and decision-based learning perspectives. Project-based and problem-based activities are usually focused on a driving question or problem [3]. In CBL the question or the problem is replaced by a challenge. This challenge is initiated either by the COLDEX project, a teacher or a student group. The assignments or "challenges" to be solved might include ways to develop, design and implement solutions for problems related to scientific phenomena. A meaningful learning activity consistent with CBL is to present learners with a challenge scenario and to ask them to think about a number of possible solutions using a variety of interactive tools. Such an activity serves to centre thinking around meaningful problems and is typically effective in facilitating small group collaboration. Regarding collaboration it is important that the need for it is not artificially imposed on the community of learners by the system but grounded in the nature of the task. Only if collaboration is needed to accomplish the task learners will appreciate the value of and seriously engage in collaborative activities such as sharing information, discussing partial research results and come with shared decisions and synthetic solutions.

C Classroom Scenarios in the COLDEX project

To support educational classroom scenarios according to the Challenge Based Learning approach several so-called “Digital Experimentation Toolkits” (DExTs) have been developed within the COLDEX project. A DExT includes experimental instructions, scientific background information, modelling and simulation tools, access to real scientific data, and the formulation of initial challenges. What we want to provide is an open-ended learning environment that stimulates learners to identify and solve a challenge according to the educational premises of CBL. Interactive tools for modelling and simulation enable learners to generate and try out hypothesises, and show the experimentation results.

These DExTs are intended to be handed out to schools to be used in but not only in normal school lessons. They provide innovative use of interactive media to enrich the curricula. Teachers should be enabled to integrate these new resources easily in their lessons. As only a few teachers have time to spend on courses or time-consuming studies for “learning” to use these toolkits they are mostly self-describing and trouble-free. DExT´s are not to be seen as expert systems which present themselves as authoritative and definitive. Our toolkits adopt a more post modern position on the problems of practice, celebrating difference, contextually and a democratic form of interaction that allows the user to create and direct instead of being directed. In this sense, they are perhaps best located as a means of representing and sharing practice, rather than a way of privately receiving advice on one's own practice [4].” DExT’s count in tools for modelling or simulation and experimentation. The modelling tool is used when the students make a view about their thoughts early in a project, some kind of previous knowledge statement, or when the students are going to design something later on. Different simulation tools are used for testing estimated values and outcomes concerning different influences of events.

Our experimentation tools are a prerequisite for the students to construct, visualize and confirm their thoughts in the learning progress. Essential for the toolkits is to get access to modelling and collaboration tools, and to a common repository. This is done through the Internet. A small number of remote sites will be established which generate data.

One conclusion within our classroom scenarios according to the CBL is a change in the teachers and students roles. The students role gets a stronger focus on being a more self- (or group-) regulated ‘researcher’ collaborating by using construction and designing tools. Due to the open ended scientific nature of the examined research question the teachers role focuses more on being a coach or co-experimenter.

D Scenario Examples

The seismo scenario

In this work, students learn how to analyse earthquakes and compute some characteristics of the seismic phenomena. For this, a network of six seismographs were installed in different schools of the Metropolitan Region of Chile. When an earthquake occurs, the computers attached to the seismographs generate a file with the seismographic wave. Since every seismograph is located in a different place, they will register different data.

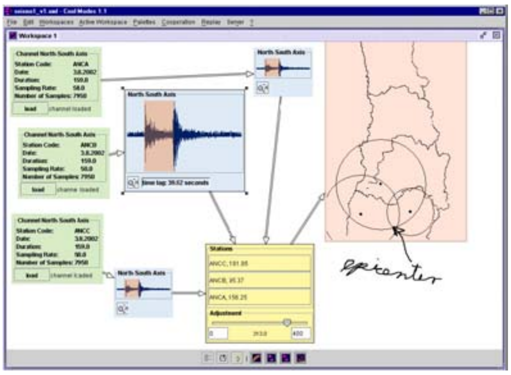

Figure 1 earthquake epicentre calculation

By determining the time difference between the first (horizontal) and the second (vertical) hit of the earthquake's wave registered by a single seismograph the students can determine the distance from the seismograph to the hypocenter, but not the direction. If three or more groups exchange their data and/or results it is possible to define three semi spheres. The point where these semi spheres intersect each other is the point where the epicentre is located. For enabling students to do these calculations easily, we developed a tool (see Fig.1) with which they can download the data from a seismograph (which has been previously uploaded by the group of the school where it is located), draw the wave and calculate the time difference between the two hits of the wave. Then they can draw the circles of the semi spheres on a map of the region and graphically find the intersection, as shown in the picture. An interesting aspect of this approach is that collaboration in this case is naturally required for achieving the goal and not artificially imposed by the system.

The astro scenario

Within our astro scenario the students are enabled to calculate lunar heights by using moon images taken by themselves or retrieved from a repository via the internet. Within the COLDEX project we have access to several different sized telescopes in Europe and America (Chile). All the telescopes are remote controllable and accessed through web services so there is no change needed on the client side software when choosing another telescope. To calculate lunar heights, the students need to be able to model calculation networks. Mathematical background are the sentence of three and the theorems of similar triangles. In a first step they have to discover the needed relationship between several measurements (crater shadow length, distance crater-terminator,..) by using a dynamic 2D-geometry model. After deciding how to proceed they can take measurements out of their moon image using a special measurement tool (e.g. including zooming, ..) storing the measured values automatically into produced input nodes in the same (possibly network shared) workspace. The students then can calculate the lunar heights by using a visual language to define calculation networks. Fig. 2 shows the measurement tool and a calculation network having the taken measurements as inputs.

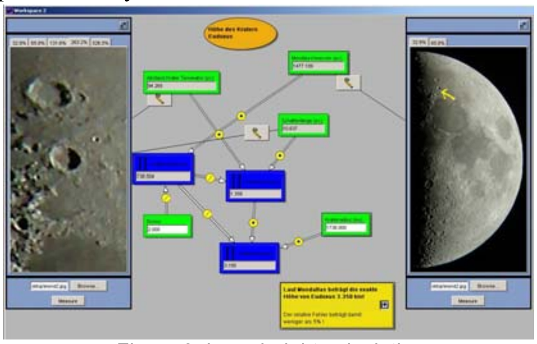

Figure 2 lunar height calculation

Several competitive or cooperative scenarios using the described environment are possible. Within a collaborative school project "building a moon lexicon" one chapter could be about the biggest mares and highest or deepest craters. Therefore tasks could be distributed like:

- developing the needed formula / calculation network
- producing / retrieving moon images (when to take? Which are the best?..)
- working on different areas of the moon

An example of a competitive scenario using the described environment could be a "moon measuring contest": At the begin of the contest the students get access to the dynamic geometry model, to the telescope image repository and the names of the craters which are part of the contest. Within a predefined time limit they have to understand the calculation principle and to measure the heights of the craters as exact as possible to them. Therefore they could e.g. use different images, process their images and build the averages out of their results. The effectiveness of such a group work will be related too how the students distribute the different parts of the work within their groups. This could be a focus on the following discussion. A more detailed scenario description can be found at [5].

The maze scenario

The leading challenge within this scenario is to define a maximally general strategy to let a robot escape from a maze. Although this question has its own history [6] the parallelism to the little (at least partial) autonomous acting robots sent to mars over the last years also inspired us within COLDEX to create this scenario. The robot "senses" its direct neighbourhood (free or wall in front, to the right or to the left) and searches for a given rule how to behave in this situation. A very easy to implement strategy is "wall following", which will not assure the escape out of mazes with "islands". These can be solved by more sophisticated algorithms using additional information (absolute heading). A special feature in our scenario is the possibility of "reactive programming-by-example" The robot has to react to the current situation description. It starts with an empty memory. In a situation to which no existing rule applies, the user/learner will be prompted to enter a new action. Each user-defined reaction will be added to the memory as a rule which will be applied under the same circumstances. Rules can be generalised by replacing concrete elements of situation descriptions by jokers which would match any value. The user will only react by defining actions in concrete situations without having to define global control strategies (local reactive programming).

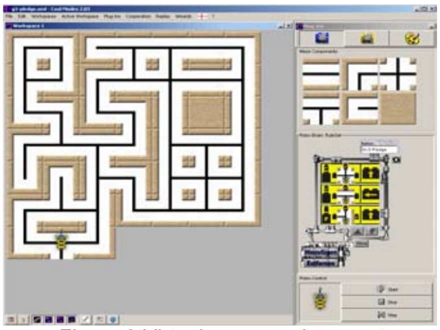

Figure 3 Virtual maze environment

Our maze scenario consists of a physical (wooden maze, RCX-driven Lego Mindstorms robot, communication via PDA or PC, see Fig 4) and virtual environments (Software plug-in for our Cool Modes environment [7] (see Fig. 3) and a tiny PDA environment). Developed rule sets can be stored in and retrieved from a local server within a WLAN. This scenario fits e.g. for competitive group work building a maze the other groups robots cannot deal with / developing rule sets to be able to escape from the other groups mazes.

A more detailed scenario description can be found at [8].

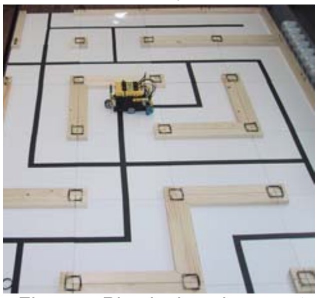

Figure 4 Physical environment

E References

[1] Vygotsky, L. S. (1978). *Mind in society: the development of higher psychological processes*. Cambridge: Harvard University Press.

[2] Bellamy, R.K.E. (1996). Designing Educational Technology: Computer-mediated Change. In B. A. Nardi (Ed.), *Context and Consciousness: Activity Theory and Human-Computer-Interaction* (pp. 123-146). Cambridge, Massachusetts: MIT Press.

[3] D.H. Jonassen (1999). Designing Constructivist Learning Environments, Ch. 10 in *Instructional-Design Theories and Models: A New Paradigm of Instructional Theory, vol. II*. C.M. Reigeluth (ed.) Mahwah, NJ: Lawrence Erlbaum Associates.

[4] Beetham, H (2002). Developing learning technology networks through shared representations of practice. In Rust, C (Ed) (2002) *Improving student learning through learning technologies*. Oxford: Centre for Staff and Learning Development.

[5] K. Hoeksema, M. Jansen, U. Hoppe: Interactive Processing of Astronomical Observations in a Cooperative Modelling Environment. To appear in Proc. of ICALT 2004. Joensuu, Finland.

[6] Abelson, H. and A. diSessa, Turtle Geometry, MIT Press, Cambridge (USA), 1982.

[7] Pinkwart, N. (2003). A Plug-In Architecture for Graph Based Collaborative Modeling Systems. In: Proc. of AIED 2003, pp. 535-536. Amsterdam, IOS Press.

[8] M. Jansen, M. Oelinger, K. Hoeksema, U. Hoppe (2004). An Interactive Maze Scenario with Physical Robots and Other Smart Devices. In: Proc. of WMTE 2004, Los Alamitos, California (USA), pp 83-90

F Acknowledgements

Parts of this work have been supported by the European IST project no. 2001–32327, COLDEX.