WebLabs: Virtual collaborative learning experience for researchers, teachers and students

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Abstract: *The paper presents experiences from a 3 year international project,* WebLabs: New representational infrastructure for e-learning, *in which researchers, teachers and young students from UK, Bulgaria, Cyprus, Sweden, Portugal and Italy participated. The project explored innovative pedagogy based on the integration of constructionist learning approach and virtual co-learning. For the purposes of the project a visual programming environment,* Toon Talk, *and a virtual collaborative system,* Wplone, *were adopted, and special instruments* - webreports - *were designed and developed. The experience proved that mathematical and science concepts, usually considered as difficult and unattainable for young children, can be made accessible and meaningful to them, by using different representations as well as group co-learning and reflection.*

> *The use of information technology in learning is gaining irreversible momentum as it cuts across disciplines and enhances learning opportunities for all ages...*
>
> Sylvia Charp

1. Introduction

The vision of the technology enhanced learning expressed 18 years ago in the *Technological Horizons in Learning* by its editor-in-chief Sylvia Charp [1], has been accomplished in many educational projects during the last two decades. *Students* have gained *access to information resources, faculty, lectures, demonstrations, conferences, outside activities, etc., that were previously not attainable.* Of course, just extending the access to the information resources wouldn't guarantee an enhanced learning. Providing an infrastructure in which learners could collaborate with their peers, teachers and researchers in exploratory style is crucial for *enhancing the scientist in the learner* [2]. The learning effects could be enhanced further if the collaboration crosses the borders of one's school, town and country. Such a virtual collaborative learning experience in mathematics and science was the focus of *WebLabs*, an international project with Bulgarian participation, some aspects of which we will discuss in this paper.

1.1 About *WebLabs*

WebLabs was a 3-year EU-funded educational research project carried out by scientific and educational institutions from Bulgaria, Cyprus, Italy, Portugal, Sweden and UK [3]. A new representational infrastructure for e-learning has been created by the participants. The aim of WebLabs was to build new ways for young learners (10-12-year old) to think and talk about mathematical and scientific ideas such as *infinity*, *convergence and divergence*, *cardinality*, *dynamics and complex systems*. The theoretical framework upon which *WebLabs* was conceived, was based on the idea of *constructionism* (an approach suggested by Papert in the early nineteen-nineties) that students learn by building with appropriate tools, virtual 'external' realities that mirror their developing mathematical or scientific meanings, and by sharing this public or semi-public entity within a community. In addition, *WebLabs aimed to ensure that collaboration was exploited for learning, by including asynchronous discussion and evaluation at a distance as part of the programme of activities, as well as synchronous face-to-face interchange* [4]. A web-based environment, *Wplone*, has been used to mediate collaboration so that the participants could share ideas and constructively criticize each other’s working models [5]. The project embraced exploratory activities in the following domains: *mathematics, kinematics and dynamics, complex biological and ecological systems, robotics*. The main objective of WebLabs was therefore that children design, share and comment on each others' evolving knowledge.

1.2 The project’s educational aims

The educational philosophy of WebLabs has been encapsulated in the project aims [4]:

- To build web-based transparent modules (TMs) in ways that make their workings visible, manipulable and accessible at one level or another to all students.
- To enable students to share and collaborate through dynamic web reports.
- To evaluate learning in a context where the community’s ideas are being expressed through web reports.

Thus, the Weblabs’ pedagogic approach comprised a careful design and operation of educationally powerful activities that:

- support learning in ways that are made explicit, and
- engage learners in meaningful and worthwhile thinking, explanation and discussion.

1.3 Elements of e-learning

In order to fulfill its aims of promoting learning through the processes of modelling and sharing, Weblabs research was based on two technical systems: *ToonTalk*, an animated programming language, and *webreports*, a web-based collaboration system. The specific means through which various elements of e-learning were implemented include [6]:

- *long distance birds:* a *ToonTalk* concept for information exchange among different computers;
- *Webreports*: a mechanism for the participants to describe and share their ideas and programming constructs;
- *Wplone*: a web-based environment used to mediate the collaborative learning activities over distance.

2. Developing a collaborative community within *WebLabs*

One of the specifics of the *WebLabs* project was that the young students had the chance of working together not only with their teachers and peers from various countries, but also with distinguished researchers. Rather than being just *reality check for researchers* they were real partners in a research process, in which new learning methods and computer technologies were used and experimented with. When using the computer environment *ToonTalk* as a means for modeling the students learned how to use visual programming in a natural way. In the context of carefully designed educational activities they were able to gain knowledge about important processes and phenomena from mathematics, physics, biology, and to compare their understanding with the rest of the participants. Let us describe briefly why we found the *ToonTalk* environment suitable for the project’s educational goals.

2.1 *Toon Talk* in a nutshell

Toon Talk is a computer environment for visual programming in which the source code is animated thus allowing for abstract computational concepts to be represented by concrete analogues, instantiated in cartoon-like characters [7]. This environment has some unique features suitable for visualizing and exploring mathematics concepts and ideas when working with junior-high school students. The mathematical activities are integrated in a natural way with cultivating some programming skills. The programs in *ToonTalk* take the form of animated robots, which can be named, picked up and trained to perform a certain sequence of elementary steps. A bird is the metaphor for the output of a procedure. After the training, the robots run *forever* if the initial conditions are satisfied. Such type of programming has proved to be especially appealing to young programmers since it is amusing, requires creativity and stimulates the acquiring of new skills for solving problems [5].

For example, in order to generate the sequence of the natural numbers, the students have to train a robot first to add 1 to 1 and then to generalized the process in his thought bubble, and finally – to give the result to the bird. After this when given an input number the robot would generate the consecutive natural number greater than the input number forever (Figure 1).

		
First the robot is trained to add 1 to 1	The concrete first addend in the robot's *thought bubble* is then erased to generalize the process	Now the robot can add 1 to any current number in the box and then pass the result to the bird (*forever*)

Figure 1. Training a robot to count

The Weblabs researchers have put considerable effort into designing a common frame for the activity sequences that have been collaboratively designed by the partners.

2.2 A common frame for activities

The activities designed attempted to integrate collaborative interaction with the transparent modules (TMs) and specific points of co-construction and shared reflection within and across sites. There were two overarching methods of evaluation for the project as a whole:

- to assess the extent to which learners can exploit situations where they can *build models for themselves*.
- to evaluate the project's success in encouraging students to build a *culture of collective discussion and reflection* on their models, both within and between sites.

All the activities were intended to motivate learning, foster informal discussion, stimulate design by building with TMs and allow for collective sharing of models, comparison, argumentation and synthesis in the final web report. The teacher's role throughout the sequence was to monitor, guide and foster constructive interchanges and reflection, as specified in the activities; encouraging collaboration, providing technical support and orchestrating the writing of joint webreports - that summarize a group's activity [5].

The concept of *webreports* was specially designed so as to enable the young learners to share and discuss the problems they had solved, and even more interesting – the problems they had formulated and implemented by means of *ToonTalk* robots.

After been completed at one site, a webreport was usually used as an object of discussion by a group in another site. Students at the second site have been encouraged by their teacher to offer comments on the report, to explore the models in the webreports and possibly to modify them, and incorporate new models and descriptions in a final cross-site web report. This characterized the work across the sites, and provided a point of reference for all the partners' activities.

3. Face-to-face interchange and discussions at a distance

3.1 The Bulgarian team

The main task of the Bulgarian team was to participate in the development of teaching materials and software tools necessary for exploratory activities in mathematics. The mathematical modules included topics that have not been taught in the traditional junior-high school, such as: *coding and numerical systems, number sequences, series (convergence and divergence), cardinality, infinity*.

The project experimental student groups were formed by 10-12-year-old children from Sofia and Plovdiv with special interests in mathematics. During the first year of the project the sessions were lead by two experienced teachers in mathematics and informatics (Nevena Sabeva and Liliana Moneva). Two researchers (the first and the third author) joined the teaching team during the last two years.

To convey the flavor of the atmosphere of the *WebLabs* sessions we present below some examples of web-reports reflecting the activities of 12-13-year-old students from Sofia on number sequences.

3.1. *Weblabetics* – Children's endeavor for a better international communication

The language, in which the students were expected to publish their web-reports was English but the native tongue was also accepted for local communications. The latter sometimes created confusion and frustration. Let us illustrate this phenomenon with a fragment from a group webreport [8]:

When browsing through Plone in search for interesting sequences we had very unexpected experience. We moved step-by-step through the (number) *sequences suggested by Nikmous, Kiriakos, Irakli - all in Greek. The sequences are very clear but when the comments are in a language, which we don't understand, it is very annoying. So our teacher, asked us:* Can you think of a way to express ToonTalk ideas so that anyone could understand them? *Yana suggested to use pictures for representing the ToonTalk characters and drew some on the board* (Figure 2):

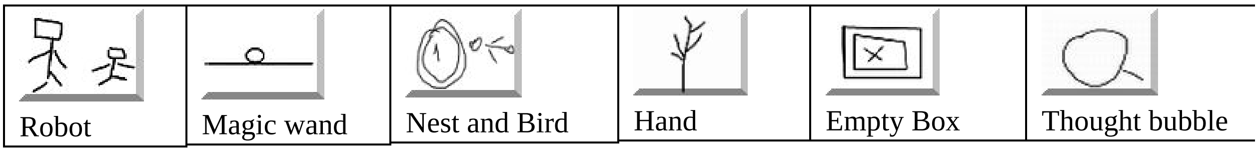


Figure 2. Pictures representing *ToonTalk* tools

The teacher challenged us to translate our Counting robot in the new language. We all thought that this was easy but we soon realized that we didn't have symbols for actions in our alphabet (or rather – Weblabetics*). So we added arrows for "puts" and "takes". Here is the Counting robot in* Weblabetics (Figure 3):

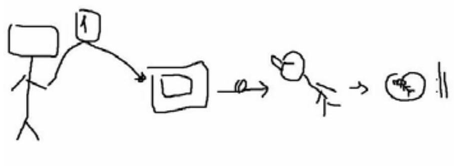


Figure 3. Program code (Counting Robot) in *Weblabetics*

Isn't this clear for everybody? Well, just in case you lack the experience:
*A robot puts 1 in a box, then copies the content, gives it to a bird, which puts it in its nest. Afterwards everything is repeated. Do you see the "**:||**" sign at the end – this is the music symbol for a repetition – Peter thought of it! In short, this is our old friend – the Counting robot (in new clothes)…*

Then Yana suggested to make what she called ToonPaint in which each symbol to be on a button and one would be able to write programs by pressing the corresponding buttons. She really did a good job by drawing an extended and stylized version of the new alphabet. We hope that now it would be easier to talk about ToonTalk and our ideas to everyone in the WebLabs project.

Our teacher told us the story of the Babylonian tower - a common language for everyone is more effective than many languages for a few.

Children were faced with a typical e-learning problem while trying to learn collaboratively over distance – the language problem. In an attempt to overcome it, they reached the idea of designing a graphical scripting language for visual programming. Soon after publishing their report they received the first comments from Ken Kahn, the author of *ToonTalk* (Figure 4):

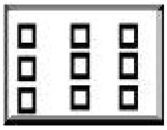
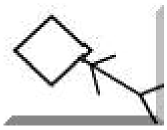
Very interesting...
Posted by: Ken at 13-04-04
This has some very real potential. Though I was uncertain about some of the pictures:
 *is this a text pad? Or a ToonTalk picture?*
I assume that  *is a bird, but what is*  ?

Figure 4: A comment from a *Weblabs* researcher to a group webreport

So the next version of *Weblabetics* prepared by Yana was with a text explanation (Figure 5):

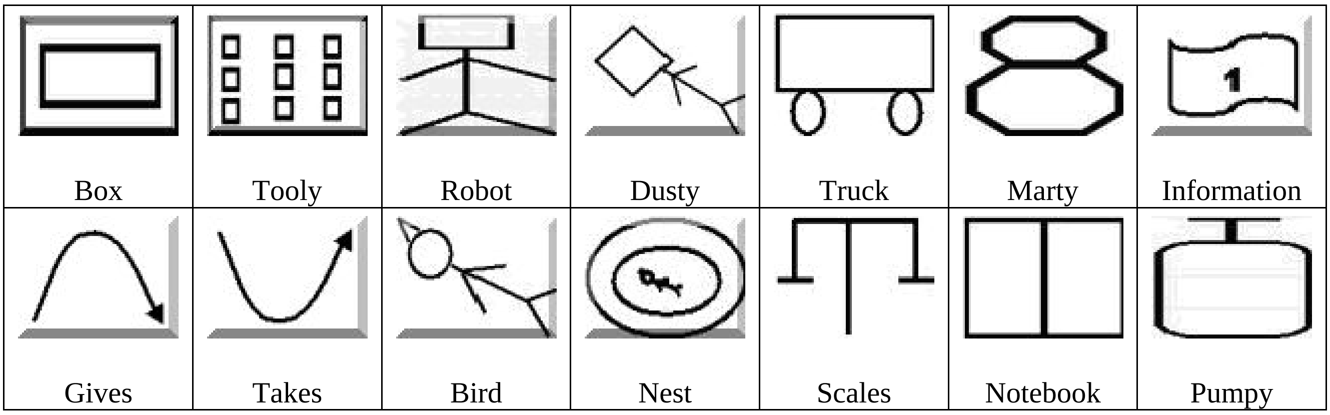


Figure 5: A stylized version of *Alphabetics*

Interestingly, the kids from other sites were less enthusiastic than the researchers. A student from Plovdiv wrote (in Bulgarian): *These pictures are not very clear to me. Besides the things in life are not that simple….*

3.2 Challenges as a catalyst for collaboration

The first activities designed around the topic *number sequences* were based on the well-known "Guess my rule" game. Applied in *Weblabs* as "Guess my robot", this game turned out to be a real catalyst for children motivation and virtual collaboration. The aims of "Guess my robot" were to encourage students to think of a sequence, to build a robot generating it, then to publish the first several terms of the sequence and to challenge others to build a robot generating the same sequence. A further challenge was *to compare the robots used by different players, to discuss the different methods, and to take a robot that "encapsulates the process" and use it to generate new sequences by using new inputs* [10]. This game was an excellent context for students to understand that different articulations of their constructions can yield the same results, to compare and contrast different solutions and to find arguments proving that two (or more) robots are equivalent. As a result of a vivid discussion among students from Portugal, Bulgaria and Cyprus a Portuguese girl (Rita) clamed that thanks to the algebraic representation of robots used by the Sofia group she was able to prove the equivalence of her robot and the robot built by the children in Cyprus (*ibid*).

The next module of activities was designed around the *growth of sequences*. In response to our task to think of some sequences whose growth is different, Ivan and Yana (12-year old students from the Sofia group) came up with the following ideas [11]:

Ivan: *Consider these sequences:*

1001, 2001, 3001, ...

1, 2, 4, 8, 16, ...

1, 1024, 59049,...

Is it possible for the terms of the second sequence to surpass the corresponding terms of the first one? What about the corresponding terms of the second and the third?

Yana: *I have two sequences for you*:

1, 16, 81, 256, 625,...
1, 8, 27, 64, 125,...

If you start with the second one it will be easier for you to solve the first one, I think.

The first reaction came from Ken Kahn again:

Very nice challenge. It inspired me to train a simple that made the following sequence. I think it grows faster than either Ivan's or Yana's sequences. Can you reason why?
1
4
27
256
3125
46656
823543
16777216
387420489
10000000000
……..

Then Teddy and Mitty, students from the second Sofia group took the gauntlet [*ibid*]:

Mitty: *The sequences to be compared are*:
(1) 2, 4, 8, 16, ...
(2) 1, 1024, 59049, ...
(3) 1, 4, 27, 256,...
Teddy: *The number 1024 is 2^{10}. So my guess is that the sequence (2) has a general term n^{10} for n=1, 2, 3, ...*
To check this let's compute 3^{10}. That's it - just 59049.
The sequence (1) has a general term 2^n and it is an old friend of ours. And the sequence (3) is a challenge given by Ken. It is in fact the sequence $\{n^n\}$ - I love it!

To *prove* that they have guessed the published sequences the students published in turn their robots generating the first terms of these sequences. Of course proving the equivalence of the published robots was much more serious challenge for which sometimes the students were lacking the necessary mathematical knowledge. But the motivation to learn more and more was genuine.

4. Future development and sustainability of WebLabs results

The effect of working with young students in the framework of *WebLabs* has not been reduced to learning specific aspects of certain subject areas but has had a much larger scope. On one hand, *the scientist in the learner has been enhanced* – the students got used to pose questions, to look for answer (no matter how sophisticated they might have been), to formulate problems of their own. They developed an understanding of mathematics as a science in which formulating hypotheses, carrying out experiments, and attacking open problems plays a crucial part. The students behaved like partners in a research process and were able to influence both the development of the computer environment and the design of the educational activities. They learned to communicate with peers, teachers and researchers locally and globally alike.

4.1 The main effects of the project

The main effects of the Weblabs project could be summarized as follows:

- Children, who participated in the project, have built a culture of sharing and critically discussing their individual and group work/results (and they know *how to* do it);
- Sustainable communities of teachers and researchers familiar with the concept and mechanism of describing and sharing ideas and programming constructs were built in each partner’s country;
- Webreport methodology will be extended at the university level, in pre- and in-service teacher training, as well as at PhD level – for publishing and commenting results;
- Some phenomena faced during the project (e.g. the need of pushing and sustaining the motivation for collaboration in virtual environments; the methods of supporting the collaborative processes, etc.) provoked a more profound research analysis in the area, which led to specification of “the ideal” virtual collaborative environment to support research teams.

4.2 Further research provoked by *WebLabs*

WebLabs experience, and especially its collaborative aspect, provoked further research in the field of virtual collaborative environments. A PhD study on virtual environments for supporting research collaboration over distance was launched. The research questions, around which this work was centered, have been derived from *WebLabs* project. They include investigating the common (typical) and the specific (non-typical) features, which a virtual collaborative environment should possess, in order to best serve the needs of distributed research teams. Based on the experiences with the collaborative tools used in *WebLabs* (WIKI, WPlone) as well as other existing tools, an original classification of existing virtual collaborative environments was created, which revealed some existing shortcomings and justified a further development. In this case *WebLabs* provided an extremely rich and real context for drawing user requirements and designing system specification for the ”ideal” virtual environment to support collaboration of distributed research teams.

4.3 Towards a further exploitation of WebLabs results within the teachers' community

The Bulgarian Government (through the ICT Development Agency with the Ministry of Transport and Communication) has launched a huge national initiative – *i-Bulgaria* – to facilitate and support penetration and usage of ICT in almost all sectors, including education. Among others, a project to establish a nation-wide Virtual University has been initiated, a national competition for creating electronic educational content has been announced, 160 telecenters in small towns are being established with the aim to bring ICT related training and services to the local communities. The implementation of the governmental strategy for ICT in education has been given a strong push: all schools are being equipped with at least one computer lab each (June-July 2005) and mass training of teachers to use ICT in their subject areas is under way (2005-2006). This includes cascade training of 60 ICT regional coordinators, 1000 instructors (ICT and informatics teachers who will later act as teacher trainers) and finally, training of 40000 teachers from all subject areas. A training bid for training of 1000 instructors is under preparation.

The University of Sofia (through the Department of IT and the Center for Information Society Technologies - CIST), which is one of the potential training providers, intends to include a section on *Weblabs* methodology and tools in its training offer. The instructors (who will later teach mathematics and science teachers) are expected to get acquainted with the educational approach, methodology and software tools developed within *Weblabs* and hopefully to dig further in this direction and add new dimensions to the constructionist approach..

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