Comprehensive Blended Learning Concept for teaching Micro Controller technology

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Abstract: In this paper a comprehensive toolkit for education of Mechatronics and Computer Science (especially micro controller and embedded programming) will be presented. The idea is based upon material for internet assisted distance learning, home labs as well as for face-to-face education in classes. The concepts details are composed of special DistanceLab solution, HomeLab Kit, Virtual Microcontroller System, and additional, supportive material which will be introduced and ranged into the didactical concept.

1 Introduction

The education of Computer Science and Mechatronic has got a lot of attention in the last decade and its importance is still increasing. This seems to be a logical process, as these fields have entered into everyday life, and smart products are more and more spread into homes. Most of these devices are mechatronic devices in their nature, what means they consist of software in addition to mechanical and electronical parts. Therefore a good education in these fields, especially in microcontroller programming is necessary to assure quality and a continuous advancement in the future.

It is quite a challenge for educational institutions to keep up with the high pace of technological innovation. The availability of (expensive) ICT based learning material for learners; a lack of functional qualified teaching staff and also lack of place in classes for capacious equipment are the main problems we identified.

Best way to encounter the current and more important future high demand of professional in the mentioned fields is to begin quite early to delight young people with this technology. In our opinion this can ensured by exploiting modern ICT based content, beginning in school, covering as well vocational and also university educational level. Another point we were dealing with was to exploit modern Internet technology for education in the mentioned fields to make them more attractive for young engineers.

Within the following sections the different parts of the overall concept are introduced, which have been developed in the frame of joint EU projects ([In09], [Mo10]) since 2007, followed by detailed descriptions of each subpart.

2 Overview of the MCU Blended Learning Concept

During the mentioned projects consortium of European partners developed a comprehensive concept for educating microcontroller technology, based on the different results, drawn up in figure 1, which will be described in separate sections in this paper. The concepts consist of the following parts:

- **DistanceLab** – The DistanceLab concept [Di09] was initially developed during Interstudy project and developed further in the follow-up projects. In current state it is a web platform for accessing real hardware (labs) and also the Virtual Microcontroller, which can be programmed directly over the Internet. The concept is continuously developed further and currently applied into study processes in Estonia and Germany.

- **HomeLab Kits** – real pieces of hardware, for self-educating of learners in home or for utilizing them in classes. The Kits are combined with specific modules for different domain (e.g. Automotive).

- **Virtual Microcontroller System** (VMCU) – A virtual version of the HomeLab Kit hardware simulating the microcontroller's behavior.

- **Robotic Applications** – These applications are based on combined parts of HomeLab Kit. So after teaching basics with the kits it is possible to use more complex scenarios for further education and for inseminating the more interesting side of microcontroller programming, in the form of robotics.

- **Supporting Material** – The strength of the concept is the provided material in form of a wiki based webpage, named as Network of Excellence, where broad information about microcontroller programming and basics of mechatronic principles are provided. In addition there was also developed corresponding hands-on material and teaching books. The material incorporates practical examples, theory, exercises, questions, discussions and project examples.

All modules are integrated into one package as a microcontroller blended learning concept. The main idea of this concept is to integrate and emphasize e-learning possibilities into the normal learning progress (face-to-face and self-education at home) to create a successful symbiosis of all three worlds in form of blended learning. As illustrated in Figure 1 the connection of the three different approaches in teaching microcontroller technology are used. Initially the concept was based only on the HomeLab Kit hardware.

In the frame of Interstudy project a web platform was developed to integrate HomeLab Kit into a e-environment and to make the same hardware as formally used offline in classes and labs accessible and programmable over the Internet. The next step, undertaken in project MoRobE was to virtualize the microcontroller and all of its associated modules to them as a supplement for real physical tangible labs. Starting in January 2011 an almost stable version of this virtualized controller can be accessed by the DistanceLab.

The didactically link between the mentioned project results is to be seen by the fact, that most integrated labs in the DistanceLab are using HomeLab Kit hardware components or are compatible to it (like VMCU). The mobile robot solution, for example is completely realized by hardware from the kit. Therefore it is possible to train in home and have more expensive experiments (more motors and sensors in one lab) with the distance aspect overview of the hardware, overview of the software, etc. in different languages.

In addition to this self-developed results our approach was also to integrate additional external labs into the DistanceLab, but this procedure will not be covered by this paper.

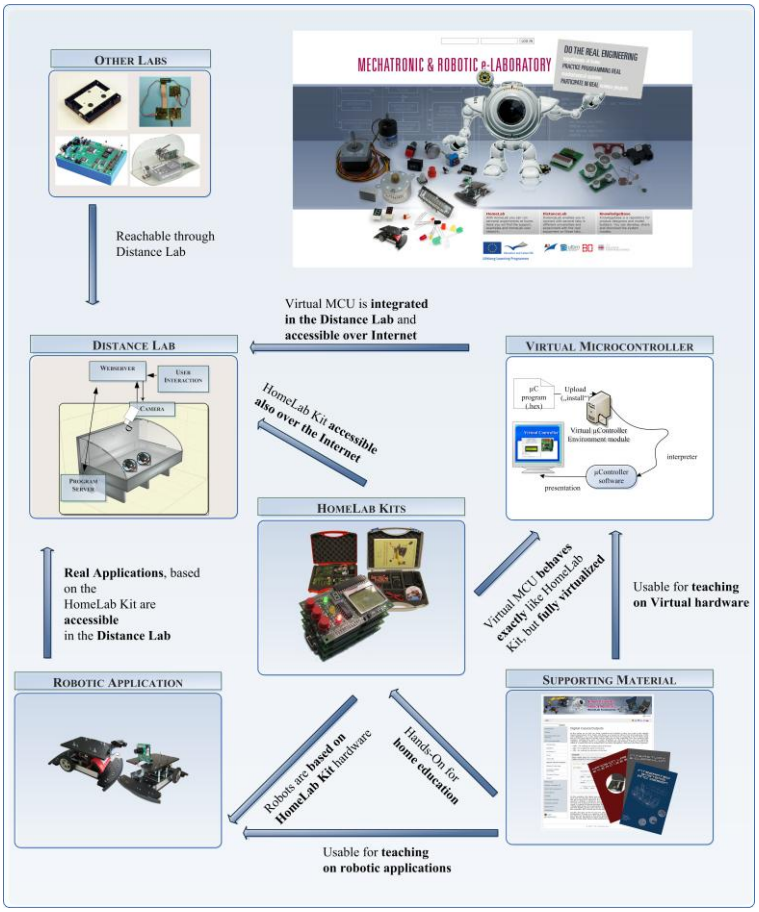

Figure 1 Concept overview

3 DistanceLab

The developed DistanceLab solution was intended for educational and professional (lifelong learning) use. It consists of a web interface and a set of hardware, providing access to microcontroller based systems, which can, but most not be based upon the HomeLab Kit hardware. The DistanceLab is designed for facilitating direct programming of the connected devices. This is realized by using a programming editor and an automatically invoked compiling process; enabling flashing programs to the connected devices over Internet. Some examples for interfaced labs are mobile robots, specific

versions of HomeLab Kits with add-on modules for a specific purpose (e.g. automotive study CAN-Module, LCD Display or a motor board) or the Virtual Microcontroller System with its various modules.

In case of real hardware labs, the user can monitor the behavior and control the compiled program he wrote by accessing cameras showing the lab in real time. The programming interfaces, together with the images of robot in different configurations are shown in Figure 2.

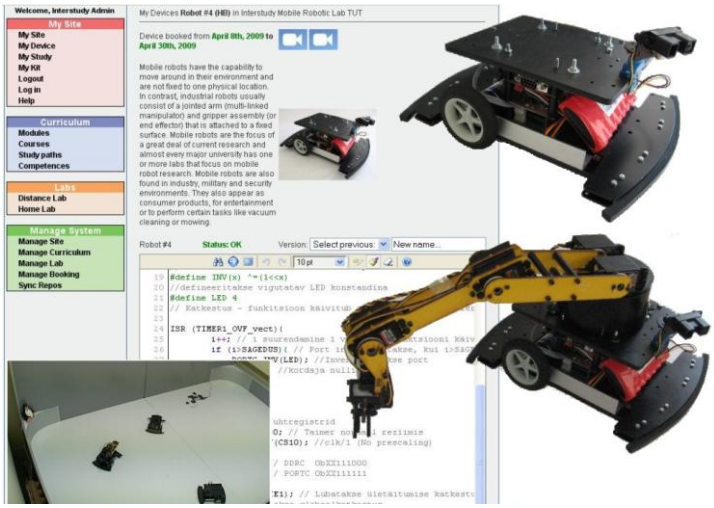

Figure 2 Distance Lab Environment

4 HomeLab Kits

The Robotic HomeLab Kit (Figure 3) was developed by consortium, where both authors participated. It is a mobile, ready to use small test stand packed into a case, which can be connected to PC and operated in computer class, at home or in working place. The aim of the kit is to provide a practical and effective hands-on training. Students may combine various solutions on different levels of complexity and functionality, based on the modules belonging to the kit. The main feature of HomeLab Kit is its mobility – the case is a small and compact box and all modules with necessary tools are seated into that. Taken the current development status into account, the HomeLab Kit offers for example hardware and exercises for 7-segment LED display, LCD (alphanumeric as well as graphical one), sensors (potentiometer, infrared, ultrasonic, etc.), different motors (DC, servo, stepper), as well as a networking module (for Bluetooth, Ethernet and

ZigBee), a CAN module and USB for direct connection to PC (for example student home computer). Simple and easy to install software is used to connect main controller to computer. This is particularly important because the student can start practical experiments in school and then continue with self-learning at home or even in workplace.

Figure 3: Home Lab Kits

The HomeLab kit is assisted by a specific software library, enabling easy accessing the modules which is available as Open Source for all users. More experiences users may abandon using it, but for beginners utilizing the library makes it a lot easier to start with micro controller programming

5 Virtual Microcontroller System

The Virtual Microcontroller System (VMCU) is the newest innovative result embedded into the blended learning concept. It is based on Avrora ([Ti04], [Uc08]) with an Ext GWT ([Ex11]) based GUI. It is a fully functional, but virtual microcontroller running in any web browser supporting latest Java version. It can be used for educational purposes, as well as for prototyping. The system is illustrated in Figure 4, showing a virtualized LCD display and the (old version of) the Studyboard developed during Interstudy project.

The VMCU is to be seen as a useful extension of the concept, as its main use would be the education of beginners in MCU programming. But in fact it is possible to use it for any task that could be undertaken with the HomeLab Kit modules. But it is currently limited to only one add-on board, what will be solved in the next versions.

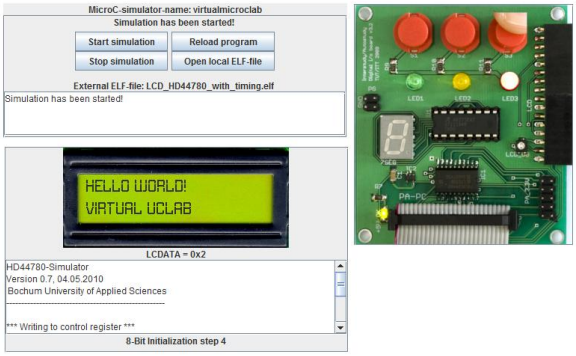

Figure 4: Virtual Lab prototype

6 Supporting Material

There are four kinds of supporting material currently existing:

1. Network of Excellence (NoE) ([No11])
2. Hands-on-lab exercise book ([HS08])
3. Learning situations for vocational education
4. Textbook "Integrated Systems & Design" ([KD08]), as a result of project Interstudy, covering current issues in Mechatronics. This book will not be described further in this paper.

NoE consists of a forum for discussions and an encompassing wiki page. These collaborative tools have to be seen as the main educational material. The wiki page is a supportive environment for students and teachers using the Robotic HomeLab Kit. Partners participating are offering learning material and full set of methodologies for the teaching and self-education of AVR microcontroller technology (where the HomeLab kit consists off). Additionally information about the ARM-CAN HomeLab Kit or AVR-CAN Kit can be found.
The page is offering a versatile set of practical examples, about e.g. digital input/output, indicators and displays, sensors and motor control. Additionally the website has a special section for the teachers, which includes the teacher training material, and most important – the exercise solutions and answers of revision questions. In the Robotic HomeLab Community the consortium intends to have all learning material and also the teaching methodologies directly accessible for interested learners and teachers, as well as ready-made examples about teaching courses for the

vocational schools, to apply the developed solutions directly in school, what is the main strength of our approach. The overall page is designed as a multi-language website, with current translations to English, Estonian, German, French and Lithuanian, where English is base language for all further translations. Next foreseen language is Turkish and Russian language. The strength of the this website is the amount of supporting teaching aids, administrated from teachers and developers from different European countries, and therefore the influence of various cultures, level of knowledge or styles of teaching, which leads to a (nearly) complete set of material.

Figure 5: Supporting Material

Currently during the frame of project MoRobE [Mo10] a full didactical concept of learning situation, with full methodology is developed and will also be available on the community website [In09].

7 Robotic Applications

The whole concept designed as illustrated in Figure 1 intended to use the same hardware even for more complex programming tasks, like a moving robot. Build on the HomeLab Kit hardware we developed robots using only modules which belong also to the other material we provide. Thus students can train on the VMCU, after those using specific modules from the HomeLab Kit leading to complex programming by including several modules attached to the micro controller. A prototype concept of the robots used in our concept is shown in Figure 6.

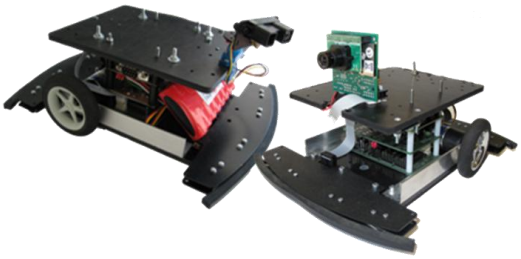

Figure 6 Robotic Application

8 Conclusions and further development

The paper has introduced all important parts of the learning concept and gave a comprehensive overview about the project results.
Currently project MoRobE is right before project end and we are currently applying for new funding to develop the concept further. We intend to integrate the DistanceLab, Network of Excellence as well as further material into a Webdesktop system, which will be app-based and can easily extended with new functionality. First app to be planned in addition is a video-lecturing facility.

9 Acknowledgements

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