INTEGRATED CONCEPT FOR EMBEDDED SYSTEM STUDYING

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ABSTRACT

Because embedded systems are a part of everyday life, there is a pressing demand for skilled programmers, designers, and developers in this field. The domain as a whole is undergoing significant change due to the merging of embedded systems and pure ICT, which means that skilled workers are even more in demand. The majority of curricula still separate computer software programming from ICT education, despite the fact that this distinction is becoming increasingly important. The novel internet-based teaching and learning method for embedded systems and robotics is the topic of this paper. By utilizing ICT to control and comprehend real-world processes and situations, the proposed concept creates a bridge for a straightforward and logical study process. Mobile hardware kits, collaborative electronic tools, and remote control of lab equipment are used to demonstrate the solution. In the second section, a case study and some aspects of the results are highlighted.

Keywords: *embedded systems; study concept; micro controller; education; robotics*

INTRODUCTION

In recent years, the education of embedded systems, which are related to computer science and Mechatronics, has received a lot of attention, and its overall significance is still growing significantly. Due to the increasing incorporation of these topics into everyday life, this is a logical process. Products that are smart are getting into homes and buildings. Because the software component grows at a rapid rate alongside the mechanical and electronic components, these devices are Mechatronic and embedded in nature. In fact, the development of future applications is increasingly influenced by smart product programming. This raises the issue of adequate education in the aforementioned fields, particularly embedded device programming, in order to guarantee future product quality and continuous development. It is difficult for instructive organizations to stay aware of the quick improvement in advancement process. The most pressing issues appear to be the teaching staff's lack of knowledge, qualification, and motivation, as well as the availability of expensive ICT-based learning materials. Additionally, there is a limitation in classroom space for large pieces of equipment. Encourage young people to use and explore these technologies is the most effective strategy for meeting the high demand for professionals in the aforementioned fields in the future. This concept's success can be ensured by contemporary ICT-based content. Utilizing current Internet technology for education in the aforementioned fields to increase their attractiveness to young engineers was another issue we were addressing. Inside the accompanying segments the various pieces of the general idea are presented, which have been created in the casing of joint EU projects ([1], [2] and [3]) starting around 2007, trailed by itemized portrayals of every subpart.

EMBEDDED SYSTEMS

An embedded system, in contrast to a conventionally running personal computer (PC), is designed to perform a few specific functions and is integrated into a more complex device that frequently consists of mechanical and electronic components. A common embedded device can control numerous devices today [4]. There are two types of embedded device processing units: micro controllers and microprocessors. There are a lot of different architectures that an embedded device can use: Von Neumann architecture, Harvard architecture, Reduced Instruction Set Computing (RISC) CPUs, and non-RISC CPUs are all included in the CPU architecture range. For the majority of embedded systems education in Mechatronics and Computer Science, the AVR (and AVR32) architectures are utilized. In the introduced Coordinated Idea for Implanted Framework Study we are using the AVR and ARM innovation for the HomeLab packs helped likewise by extra equipment.

INTEGRATED STUDY

The integrated study concept encompasses all aspects of robotics instruction. Consequently, our method is also referred to as the Robotic Teaching and Learning Concept. The methodology and the hardware are the fundamental elements of the concept. The micro controller-based development kit is the robotics field's most well-known piece of hardware. A novel solution based on AVR and ARM cores has been developed here. The robotic study also makes use of a number of other hardware kits. The Lego Mindstorm NXT is unquestionably the most well-known [5], but there are also less well-known products such as the Mechatronic Learning Concept [6], Arduino development shields [7], and micro controller manufacturers development kits [8, 9]. The fact that our concept encompasses the entire spectrum of robotic education topics is the primary distinction between the existing hardware and methodology. Hardware, software, instructional materials, e-environments, and facilities for distance learning are all included. In addition, the concept's implementation incorporates international collaboration through joint projects and events. Another distinction is the strong emphasis placed on teaching aspects, which we have found to be quite significant. One reason is that high-level subjects like robotics necessitate novel teaching strategies in areas where conventional lecture-practice approaches are no longer applicable and do not reach young people. When the Internet is the most important means of communication, it is easy for young people to lose interest in their first subjects if teaching methods are not adapted to meet their needs. Robotics research is much more effective at taking advantage of Web 2.0's potential, and the field's initial appeal is maintained. The hardware component of the aforementioned Robotic Teaching and Learning Concept is constructed on an ATMega2561

controller unit-based standard micro controller system. The hardware set is made to be used for multiple purposes, which means that it can be used to study simple functions or as a control unit for complex mechatronic systems. The novel study aids—a large collection of materials, exercises, and tutorials for using the new hardware directly—are what set it apart from previous implementations, where teaching the fundamentals takes longer at first. The idea includes international collaboration and multilingual cooperation, which is one of the most crucial aspects of today's world. It is especially crucial in Europe, where there are so many different languages and cultures spoken there and where closer cooperation will be crucial in the future to compete with Asian and American rivals. The idea depicted in Fig. The tools that teachers and students use to support learning are discussed in detail in Section 2. However, there is no doubt that the tools are interchangeable; for instance, both parties use modern hardware kits in addition to conventional textbooks. Even though teachers and students can use the web support environment as well, there is a separate section just for teachers. In the project environment, closed groups can be formed if the content is not intended for public viewing. However, the majority of the information and sources are accessible to the general public without requiring registration.
The above-mentioned components make up the Robotic Teaching and Learning Concept. The accompanying part is depicting some of them which are generally unmistakable and perceived. A few different parts, as free programming, educator preparing and so forth. due to the limitation of a single paper, cannot be included in the paper. The majority of the concept's components are currently under active development, and each week new features or content are added to the web. For instance, Lithuanian, Russian, and, in the not-too-distant future, Turkish are the following anticipated languages. The virtual micro controller unit (VMCU), which will be released this year, is also undergoing rapid development in the hardware. The concept's most tangible aspects are:

- Methodology description
- Course outlines for the various educational levels
- Robotic HomeLab Kit
- Open Source library for HomeLab
- Software development and programming
- Robotic DistanceLab
- Virtual micro controller unit (VMCU)
- Network of Excellence - Robotic HomeLab Community
- Project space
- Textbooks However, the book's content is also available as an e-book to keep it current.

THE HANDS-ON HARDWARE

Robotic HomeLab Kit In the beginning, the Robotic HomeLab Kit was developed as part of a project for lifelong learning that was led by both authors. The testing and piloting process has included contributions from a number of European universities and businesses. After the project ended, the development continued, and the second generation is now complete. The Robotic HomeLab kit is a portable, ready-to-use small test stand in a convenient case that can be used in a computer class, at home, or at work. The kit's purpose is to provide practical and efficient hands-on instruction. Understudy can consolidate different arrangements on various degrees of intricacy and usefulness, in light of the modules inside the unit. The HomeLab kit's primary feature is its mobility—it is small and compact, and all modules and the necessary tools are contained within the box. The HomeLab kit includes, among other things, exercises and hardware for a 7-segment LED display, graphical LCD, sensors (temperature, light, infrared, ultrasonic, etc.), a networking module (for Bluetooth, Ethernet, and ZigBee) and various motors (DC, servo, and stepper). The advanced HomeLab kit, which is based on an ARM controller, also has CAN and USB networking capabilities that are intended for the automotive and advanced robotics industries. The software used to connect the main controller to the computer is simple and simple to install. The software consists of open source software, commercial software that is free, and our own software that provides the entire free development tool set for Windows, Linux, and Mac OS X platforms. This is especially important because the student doesn't have to worry about paying for software licenses or practical experiments when they start at school and continue at home or at work. The authors' experiences from a number of European projects in which pilot tests were conducted in different countries show that working with the HomeLab kit is faster than using other conventional solutions that are currently available. The HomeLab, along with the DistanceLab application and web environment, forms an integrated learning concept that contributes to the improvement of engineering studies through practical, hands-on experience [1-5]. A custom-developed, open-source software library is an essential component of the HomeLab kit. The library makes it much simpler to access peripheral devices, and unlike typical micro controller programming, the user does not have to worry about complicated register programming. It is possible to argue that programming the registers is absolutely necessary for comprehending the micro controller's nature; however, real-world circumstances frequently restrict the amount of time and other resources available for study. With the help of the software library, students can focus more on system behavior logic rather than attempting to precisely control the controller through register manipulation. However, the first lab is typically completed without using the library because the fundamental register knowledge is absolutely necessary.

REMOTE ACCESS TO HARDWARE

DistanceLab Environment The web interface and hardware that accompany the Robotic DistanceLab educational and professional solution provide access to micro controller-based systems. Online systems are broken up into labs, which can be real or virtual. DistanceLab stands for actual labs, and each lab has multiple devices. In 2008, the HomeLab kit was laid out on the arena in one of the first labs. Students without a real hardware kit can still use the device via the Internet because the components are taken directly from the kit. The second executed lab contains quantities of portable robots produced using parts from HomeLab unit and which can be customized over the Web. The mobile robot-specific interface makes it possible to compile and run controller software written in C or C++ before transferring it to the actual robot that plays on the university arena. Robot acquires a new algorithm whenever a new program is compiled and sent out by the program server. Over two live cameras, the user can observe the actual events. the robot images in various configurations, in addition to the programming interfaces. The majority of DistanceLab devices make use of hardware components from the HomeLab kit, which serves as a didactic link between the two. As a result, one can train for a single function at home before moving on to a more complex system via the Internet and continuing the training.

Virtual Micro Controller Unit One issue with teaching micro controller technology is that labs frequently require expensive, specialized hardware. Additionally, there is a good chance that education micro controllers will be broken up early on. So the obvious end result was to create a virtualized miniature regulator test system climate (VMCU). It was crucial for system design to be web-related in order to work in an educational setting and to attract young people with a high level of attraction to this technology; so that it can be incorporated into the DistanceLab in the same manner as real hardware has been. As a result, there aren't many technologies that are right for the development. The idea was to have the VMCU run on a platform that could be accessed with any standard web browser. The VMCU needed to be able to work with "normal" binary files in order to be used with common C programming language development software. The system's cost is another framework condition. It was wanted to have it as most minimal expense costly as could be expected and with next to no yearly/returning charges for consolation. A graphical version of the controller must be created for purposes of demonstration and aesthetic appeal; just printed yield isn't adequate. The VMCU's general behavior ought to be comparable to that of the actual hardware in the HomeLab kit. The DistanceLab is the last condition; The integration of the VMCU unit into the DistanceLab environment was anticipated. As a result, programming languages are not widely used for system development. Java and Avrora [6] serve as the foundation for the virtual versions of the HomeLab kits. It is currently a fully operational, but virtual, web-based micro controller. It can be used for prototyping, simulating complicated behavior, and teaching. Presently the VMCU is utilized in Bochum for schooling of beginning understudies in implanted programming.

NETWORK OF EXCELLENCE - ROBOTIC HOME LAB COMMUNITY

The Network of Excellence [7] is a website that houses a lot of resources for robotic studies, including software, methods, and materials. It also goes by the name Robotic HomeLab Community and is a system that helps users and teachers use HomeLab. Examples, theory about components, an overview of the hardware, and a software overview are all included on the website in a variety of languages. There is a discussion forum and wiki pages for user contributions on the website. The site has a section just for teachers that has teacher training materials and, most importantly, exercises with answers to revision questions. The consortium intends to make all

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instructional materials and teaching strategies easily accessible to interested students and educators in the Robotic HomeLab Community. Curriculum for vocational schools has been developed and is ready for use. There are currently translations to English, Estonian, French, and German on the overall page, with English serving as the base language for all subsequent translations. The languages of Lithuania, Russia, and Turkey are the next anticipated languages. This website's strength lies in the large number of supporting teaching aids managed by educators and developers from various European nations. As a result, there is a comprehensive collection of supporting teaching material due to the influence of various cultures, levels of knowledge, and teaching methods. A brand-new section with a collection of learning scenarios and complete methodology is currently being developed.

PRACTICE - CASE STUDY

In Estonia, the whole idea is put into practice at three different levels of education. The electronic environment and hardware platform are identical across all educational levels. The number of guided lectures and the complexity of the embedded system that the students are working with are the main differences. In this chapter, we will briefly discuss the most important aspects of each educational level and elaborate on the university level case study that was conducted in the spring semester at Tallinn University of Technology, Estonia. In Estonia, a new state curriculum will be officially implemented at the gymnasium level. One of the major changes is a facultative branch that requires schools to offer at least three subjects to students. One of the branches is in inherent sciences where advanced mechanics is one of the offered courses. Several schools began offering the robotics course two to three years ago and now have sufficient experience to incorporate it into their overall curriculum. Utilization of micro controller-based robotic learning kits is the primary technical component of robotics instruction in Estonian general education institutions. The Lego Mindstorm NXT kit serves as the hardware platform for the typical first robotics start in primary school. This ensures a quick start and quick results, which is crucial for keeping robotic studies motivated. During the fall and spring break, several standard Lego robotic solutions are built and used in competitions with other schools. The robotic platform is changed to the Robotic HomeLab kit described in the preceding chapter at the high school level (gymnasium). The playground transitions from toys to more realistic systems in this logical step. The algorithm is still used as a model for the system, but C/C++ source code programming takes its place. This teaches students that the system's behavior can differ from the physical system being targeted. However, the fundamental idea of robotics: sensor-control-actuator is now recognizable and thusly simple to move to new stage. The content of practical projects is also more fully integrated into real-world systems (such as intelligent house control). This two-step strategy makes it possible to begin quickly without losing motivation and attain high knowledge at the end of gymnasium studies with a relatively low course load. The ongoing education process and teacher support are two of this experience's most important success factors. Even though one might believe that the primary obstacles would be a lack of funds to purchase the equipment or a lack of interest among the students, it turned out that the primary factor in success was the motivation of the local teachers. Relating creator has individual experience of assisting with beginning the automated course in excess of 50 schools around Estonia and teaching in excess of 80 educators during recent years. The experience demonstrates that starting robotics in the school is most successful when teachers are innovative and motivated, even if they lack professional robotics expertise. This concludes that teacher training and ongoing support in all aspects of robotic education are essential components of strategic curriculum planning for high schools. The vocational school case study includes approximately ten different establishments where robotics is taught as part of the Mechatronics, Computer Science, or Electronics curriculum. The content can be related to other parallel courses like electronics, logic, programming, etc., which is the main difference from the high school study approach. Since vocational students are already familiar with the field they have chosen, there is no longer a need to start with Lego. However, even in vocational schools, students still struggle with a lack of robotics knowledge, which may vary widely depending on the school and its primary focus. The teachers' preparation is another significant difference; although ongoing education is not essential for best results, it is definitely recommended. The case study has been conducted with two distinct target groups at the university level. Non-Mechatronic students (students of mechanical engineering) and other Mechatronics bachelors taking a Mechatronics project course have been one target group. The second one provides additional information.

CONCLUSIONS

All portrayed mechanical review occurrences where utilizing a similar equipment stage and same review idea depicted in part above. There are, of course, differences in the specifics and focus points, but the overall idea remains and has been demonstrated in practice. In addition to Estonia, vocational schools and applied science universities in Germany successfully implement the concept into the educational process. Students provide feedback for this case study, and the supervisor's experience is also examined. The majority of positive aspects were highlighted by summarizing the student feedback. Students were claiming to devote significantly more time to this particular course than was anticipated by the official curriculum; however, the additional time was investigated not because supervisors required it, but rather because supervisors were motivated by their own desire to improve the solution and make things work. Students came to the conclusion that this approach to learning about mechatronics and robotics is more effective than they had previously experienced. In addition, despite having very limited resources and time, they produced excellent results. Although the supervisor's and assistant's workload may appear to be excessive, it was significantly reduced by the Robotic HomeLab concept and its supporting e-environment in comparison to previous experience prior to its implementation. The primary conclusion and most significant aspect is that while supervisors' workloads are decreasing, students' course outcomes and quality are increasing.

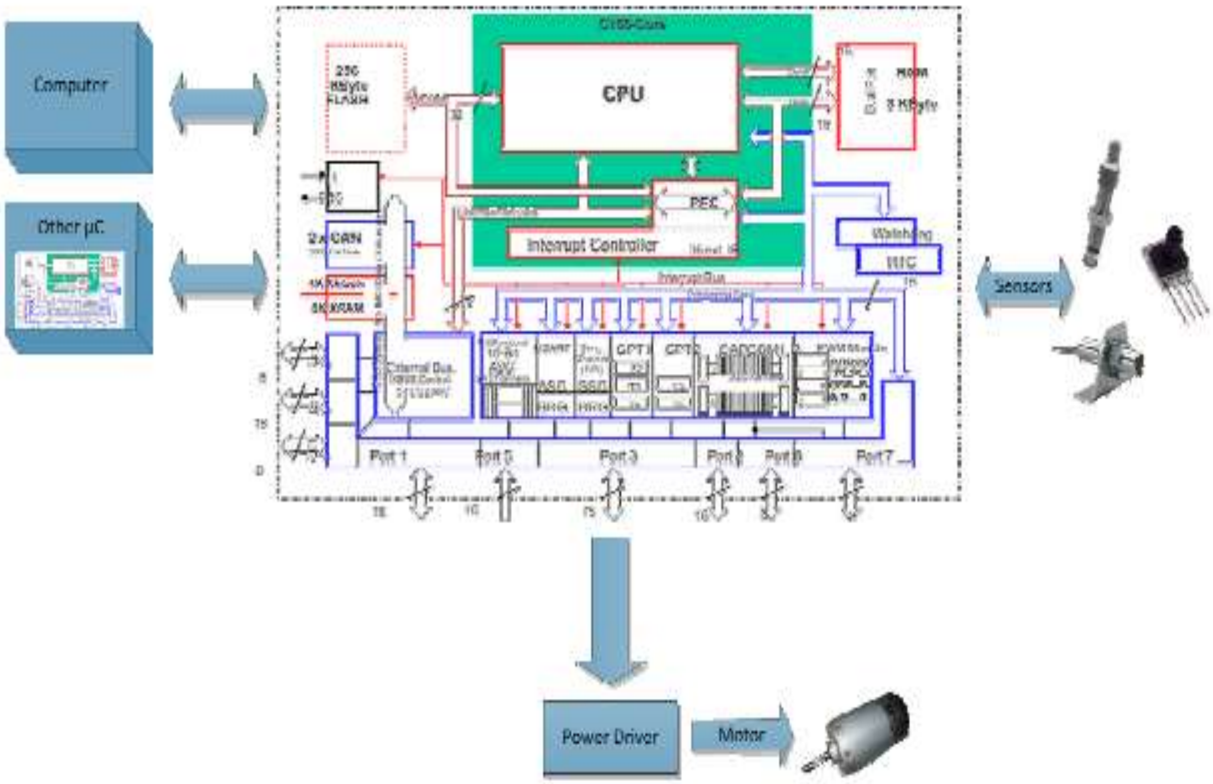

Fig. 1. Example of embedded system core

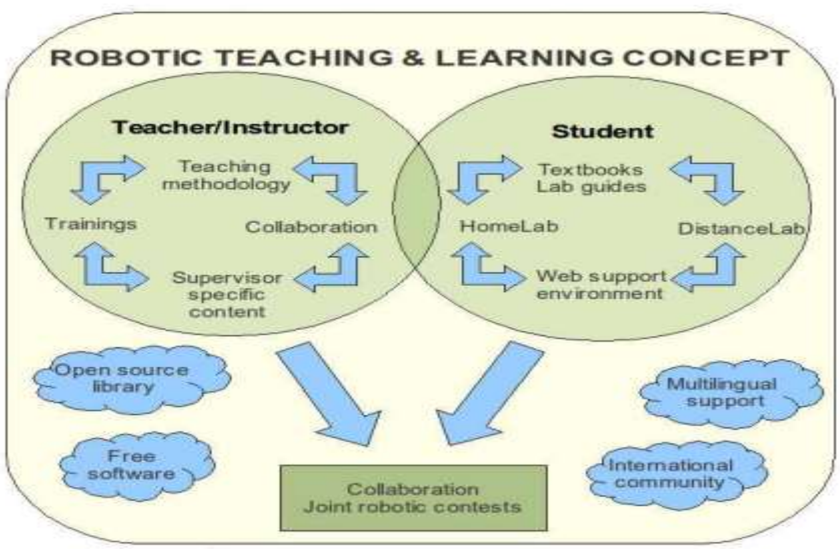

Fig. 2. Integrated Study Concept - Robotic Teaching & Learning Concept

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