teutolab-robotik – Hands-On Teaching of Human-Robot Interaction

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Abstract: Intelligent technology plays an increasingly important role in our everyday life and will soon include robotic systems for assistive functions. At Bielefeld's ***teutolab*-robotik** the students of secondary schools slip into the role of young researchers for one afternoon. They ponder, discuss, program and test their ideas to solve assignments about robotics. The young people get the opportunity to work with state-of-the-art tools and robots. The goal of the project is to increase their interests in the highly competitive research field of learning robots by teaching of human-robot interaction in this playful way. Furthermore, we want to motivate the participants for a study at the involved departments at the Bielefeld University.

Keywords: teutolab, education, human-robot interaction, robotics, interdisciplinary, hands-on experiences

1 The teutolab idea

For now more than ten years, ***teutolab*** has provided hands-on laboratory experience to school students and their teachers at Bielefeld University. As one of the first such initiatives in Germany, ***teutolab*** has been founded with a program in chemistry in 1999. It thereby started a Bielefeld tradition in bridging the university's expertise and school teaching with the goal to reinforce students' interests in natural science.
Meanwhile, ***teutolab*-chemie** has expanded and includes chemistry activities at schools worldwide in a cooperative ***teutolab***-network, as well as similar laboratories in physics and mathematics [1]. The overarching goals are to stimulate children and youths by re-popularising the well-known hands-on principle of science education, to let them develop their own opinions about science, and to enhance interactions among schools, universities and educational authorities [2].

Since June 2009, the fourth laboratory ***teutolab*-robotik** has been active. It has now advanced to the point that two workshops are offered for two differently aged groups of school students, who can immerse into the fantastical world of learning robots and robot learning. Robotics differs in one important aspect from the contents of the other ***teutolab*s**: it is interdisciplinary and combines elements of the so called MINT[1] school

[1] MINT is an acronym for mathematics, informatics, natural science and technology.

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subjects rather than referring to a single school subject only. In this sense, ***teutolab*-robotik** is an exciting complement to the standard school curriculum.
***teutolab*-robotik** is a joint endeavour of the Bielefeld Research Institute for Cognition and Robotics (CoR-Lab) and the Center of Excellence in Cognitive Interaction Technology (CITEC). Groups from both institutes work in the highly competitive field of cognitive robotics and have joined forces to develop age-adequate courses reflecting their major research questions. Financial support also comes from the ministry for innovation, science and research of the state North-Rhine-Westphalia.
For one afternoon, the students of secondary schools[2] slip into the role of young researchers. In teams they reason, discuss, program and try to jointly meet the challenges posed in the workshop. They familiarise with research questions in cognitive and learning robotics and approach the topics of this interdisciplinary research field. Finally, the students perform experiments in simulation and with real robots.

2 Background and Motivation

Intelligent technology plays an increasingly important role in our everyday life and will soon include robotic systems for assistive functions. However, robotics is not a subject at German schools. Integrating robotics in the curricula of the secondary schools is therefore a special challenge and has to be anchored in computer science related subjects. Lacking a general curriculum for computer science in Germany, recommendations of the "Gesellschaft für Informatik (GI) e.V." form a respective basis for locally designing curricula by the individual schools. These recommendations suggest for grades 8-10 providing first contact to computer science through simulation models and simple transfer in application domains of other subjects. Only in Sek II (grades 11-13), topics like measuring, automatic control, control of a robot, interaction and communication, and programming of a robot are included. The goal is to improve the students' capabilities in complex problem solving and the teaching of background knowledge with respect to the full portfolio of computer applications and up to the creation of own software [4]. These recommendations of the GI provide also the basis for the ***teutolab*-robotik.**

There are many programs for young people involving robotics, like robot clubs at schools and the like. In most cases robotics kits from the Lego Mindstorms series [5] are used as platforms. With respect to the technological scope of these platforms, assembling their robots and testing them in different challenges has priority for the students in such courses. School teachers can learn the handling of these platforms in dedicated workshops.

[2] Usually there are two degrees at secondary schools called secondary education one (Sek. I) and two (Sek. II) after the so-called proving stage (grades 5 to 7 at secondary modern, middle and grammar schools) [3]. The degree "Sek. I" includes the grades 7 to 9 of secondary schools with proving stages, grades 5 to 10 at integrated schools, "Sek. II" describes the senior grades (the advanced level of a high school) at grammar and integrated schools.

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***teutolab*-robotik** deliberately separates its courses from this more common approach of robotics teaching and focuses on human-robot interaction rather than robot building. The students are introduced to relatively complex robot platforms in a playful way and work with them on a higher, behavioural level. Therefore, there are two primary issues in designing and executing the courses at ***teutolab*-robotik** at Bielefeld University: First, to generate interest in the young generation to become trained as highly qualified personnel in science and technology of future robotics. To foster this interest, the field shall be introduced as early as possible. Second, it is a particular challenge to design age-appropriate courses in this field of high-technology with the focus on cognition and learning in robotics, a focus that is the main expertise of the Bielefeld researchers.

3 Bielefeld's Expertise in Learning and Robotics

It is widely believed that complex intelligent systems like assistive robots will provide a large range of supportive functions to humans in the near future. They will play a very important role in flexible productions technology as well as in household to allow for a longer autonomous life of the elderly. Connected research questions are: How can we endow robots with social competence to make them acceptable as assistants to humans? How can machines communicate smoothly and on semantic levels with humans? How can robots learn from humans' behaviour? Such important yet unsolved key questions have been guiding Bielefeld researchers in the key area of "intelligent systems" for many years.

With CITEC and CoR-Lab there are two high-profile research institutions dedicated to make cognitive interaction between humans and machines a reality. CoR-Lab has in particular a strong collaboration with the Honda Research Institute Europe and focuses on communication and interaction with humanoid robots. Jointly, CoR-Lab and CITEC stand together for cutting-edge research in robot cognition. Additional targets are to pursue industry transfer, public understanding of science and the education of junior researchers. Both institutions, CoR-Lab and CITEC, qualify young researchers in the highly competitive research field of human-robot interaction (HRI) and organize Graduate Schools focusing on the promotion of PhD students and Postdocs.
In this context, Bielefeld University is in command of a large number of robotic platforms including the Honda humanoid research robot, the child-like humanoid robot iCub, anthropomorphic heads, hands and a number of smaller biomorphic platforms. In cooperation with CoR-Lab and CITEC ***teutolab*-robotik** can afford to choose the eligible platform for the specific task. The robotic laboratory is therefore in the best tradition of ***teutolab*** and a logical extension of the many Bielefeld activities in intelligent systems.

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4 Educational Methodology

The courses offered at ***teutolab*-robotik** present a broad survey of robotics with different platforms, robot behavior, perception and navigation. Participants are not only made aware of the complexity and the difficulties of robotics, but also of the fascination, the variety and the potential of this topic.

The incorporation of didactics in the ***teutolab*-robotik** concept is realised by involvement of teachers for informatics and physics. The respective topics emphasised in the education of informatics are: Interaction with information systems, their principles of impact, the modeling of information systems and the correlation between information systems, individuals and society [4]. A further impact of the learning methodology is that the students develop functional, methodological, social and self-competences. Students get practical appreciation for their capabilities to control robots. Learning how to work in teams increases the capabilities of observation, conversation, imitation and the socio-cognitive processes. Such skills include developing effective strategies for solving the complex problems that are posed throughout the courses.

Although robots are extremely complex machines, they are limited in that their sensory and effectory systems are highly constrained compared to that of a human. These differences are fundamental for the conceptual layout of the ***teutolab*-robotik** courses, because the core theme of the workshops' contents is to convey why robots are obliged to be capable of learning. The extensive topic of learning encompasses broad empowerment with respect to science and technology. This includes developing an interest in technology, confidence of working with technology and future careers in science and technology. As a result, the self-identification with science and technology of the student will be encouraged.

4.1 Project goals

The general goals of the project ***teutolab*-robotik** are to arouse students' curiosity and to spark their fascination for robotics. By means of the workshops we want to overcome negative prejudices like "programming is too difficult" and create positive associations with robotics. At ***teutolab*-robotik** young people get the opportunity to work with state-of-the-art tools and robots. They get a general idea of robots' prospective fields of application in the next years. At the out-of-school learning location not only students enhance their knowledge but also teachers get new stimuli for their school teaching.
While working on topics exceeding curricula with robots, that usually are not available at schools, the young people learn how to design simple program architectures. The workshops are constituted supplementary to school lessons and curricula. So the participants strengthen their skills in both coping independently with challenges and teamwork to solve the assignments. To produce a sustainable effect, we encourage the students to engage in the workshops' topics beyond their visit at ***teutolab*-robotik**.

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The workshops are conducted by student assistants who are trained continuously in didactical and technical issues. Due to their own experiences, they cannot only answer questions about robotics but additionally they can tell the participants more about studies and life at the university in informal conversation after the workshop.
Currently, ***teutolab*-robotik** offers two different courses: In “Die Roboterakademie”, students from 12 to 15 years of age of grammar, middle and integrated schools occupy themselves with learning robots and human-robot interaction. Focussing on learning robots the latest course “Das Lernlabor” caters to youths from the age of 16 years up (the senior grades of secondary schools).

4.2 Course model

Gain hands-on experiences, touch, and try – these three characteristic features join both courses at ***teutolab*-robotik**. Accordingly, most of the time the participants are working and exploring actively.

Table 1. Overview of the single modules ***teutolab*-robotik**'s courses consist of.

Section	**“Die Roboterakademie”**		**“Das Lernlabor”**
Introduction	General introduction		General introduction
	Decision tree		“Bauernschach”
	Picture modification		
How to program a robot?	Introduction to Neo and Webots		Introduction to Chorégraphe and Webots
	Practice: Neo/simulation		Practice Chorégraphe/simulation
	Practice: Neo/reality Aibo	Introduction to Pleo	Practice Chorégraphe/reality
	Break		Break
Programming assignments	Correlation Aibo	Introduction to MySkit	Rock, Paper, Scissors (reality)
		Interaction Pleo	Rock, Paper, Scissors (simulation)
Conclusion and feedback	Discussion and feedback		Discussion and feedback

Each workshop lasts three hours and consists of four parts (the structure is shown in Table 1): During the first phase the attendees familiarise themselves with the workshop's topic by discussing and playing games. They have to get sensitised for the

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specific challenges and potential applications, because the topics of ***teutolab*-robotik**'s courses are usually not part of their everyday life. Secondly, the participants learn and practice how to program a robot. To introduce even participants without any knowledge in programming languages smoothly to robotics, solely graphical user interfaces (GUI) are used. During the third phase, the attendees solve programming assignments working in teams. Therefore, they have to combine their new knowledge about the workshop's topic and their just gained experiences in controlling the robots. Finally, participants review what they have investigated to confirm their recently attained knowledge. In addition, they are asked to give feedback about their experiences during the workshop for evaluation purposes.

There is no previous experience required to participate in the workshops. As a consequence, the groups bring along heterogeneous expectations. Explaining the phenomena and contexts in this complex field of research ***teutolab*-robotik** copes with a difficult task by using the appropriate methodologies. Consequently, both courses are structured flexibly: Depending on the participants' previous experiences, the workshops are to be varied in time and degree of difficulty. If a group is well grounded in a programming system used at ***teutolab*-robotik**, the course instructors react appropriately.
In all workshops students are engaged to analyse their own human behaviour. They ponder how they learn themselves or how they perceive their surroundings. Afterwards, they try to apply their knowledge about the human behaviour to robots. In this way, they follow an important principle of CoR-Lab's and CITEC's researchers: To create robots that adapt to humans and not the other way around.

4.2.1 "Die Roboterakademie"

At "Die Roboterakademie" students get to know robot dog Aibo (Fig. 1 left) by Sony Corporation. This robot comes with several touch sensors on its head, back, chin and paws, with stereo microphones, loudspeakers and a colour camera, with distance, acceleration and vibration sensors. The young people discover the skills of the robot equipped with 20 degrees of freedom while solving tricky assignments.
Furthermore, they interact with robot dinosaur Pleo by Innvo Labs Limited teaching it how to perform tricks. Pleo (Fig. 1 right) possesses touch sensors on its head, chin, shoulder, back, legs and paws, furthermore stereo microphones, loudspeakers and a colour camera, as well as distance, vibration and force-feedback-sensors in its 14 motors.

In detail, the course consists of the following modules:
General introduction. The students orientate themselves to see the main issues of the workshop – human-robot interaction and learning processes – in context of CoR-Lab's and CITEC's research. The course instructors account for these issues to the students by presenting sample applications.

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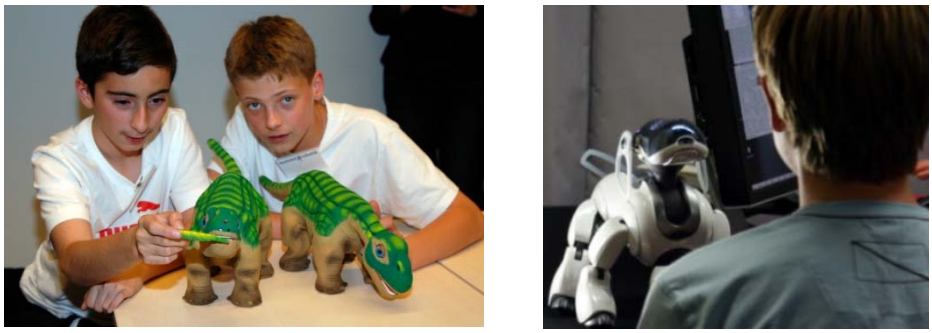

Fig. 1. Robot dog Aibo and robot dinosaur Pleo used at "Die Roboterakademie".

Decision tree. How to recognise a person? Playing an intellectual game the students discuss the difference between their own human approach and the opportunities in robotics to solve this problem. They talk about the possibilities and constraints of the method to categorise people or items by decision trees.
Picture modification. Pictures of the participants are displayed modified. The students try to assign the names of the group members to the particular pictures. Thus they get sensitised to focus on characteristic features distinguishing people from each other.
Introduction to Neo and Webots. The students learn how to handle the programming tool to control Aibo – Neo[3] (Fig. 2) – and the simulation tool Webots (developed by Cyberbotics Ltd.).
Practice: Neo/simulation. By playing football with Aibo in a simulated world of Webots, the participants practice how to work with Neo. This way, they first get used to the exposure to the programming tool before they utilise the real robot.
Practice: Neo/reality Aibo. The students exercise actuating Aibo in reality by playing football with it.
Introduction to Pleo. The participants contact Pleo for the very first time: Usually this moment is marked by the disarming charisma of the robot dinosaur disabling the students to solve sophisticated assignments. Hence they get time to touch it, ask questions about it and accustom themselves to Pleo.
Correlation Aibo. The aim of this assignment is to make Aibo recognise soft toys and colours and assign the favourite colour to the appropriate soft toy: The students program a learning process, train the robot and test it afterwards.
Introduction to MySkit. The students learn how to handle the programming tool to control Pleo – MySkit developed by dogsbodynet.com.
Interaction Pleo. Several programming assignments dealing with human-robot-interaction are to be solved: Pleo should react on triggered sensors by performing different movements.
Discussion and feedback. The participants recall the main issues of the workshop and summarise what they have learned. Additionally, they give response on their experiences during "Die Roboterakademie" by completing a questionnaire.

[3] Neo was developed by Helge Ritter and the Neuroinformatics group at Bielefeld University.

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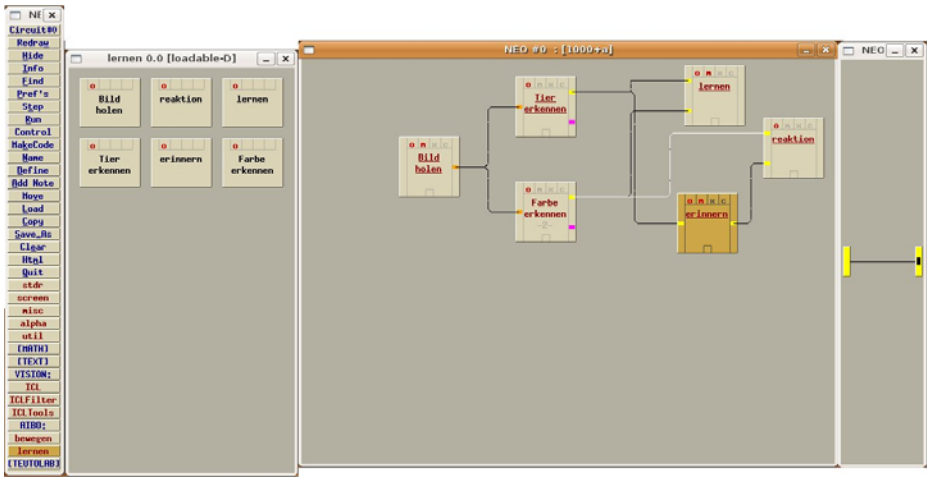

Fig. 2. The graphical user interface Neo developed at Bielefeld University. At ***teutolab*-robotik** it is used to control Aibo.

4.2.2 "Das Lernlabor"

Participants gain an insight into the research field of "Learning Robots" at "Das Lernlabor". Exploring the humanoid robot Nao by Aldebaran Robotics SA they comprehend the importance of providing robots the ability to learn. Nao comes with touch sensors on its head and feet, with stereo microphones, loudspeakers and two colour cameras, with sonar, distance and acceleration sensors, as well as with a gyrometer. All in all, Nao is equipped with 27 degrees of freedom. Using the example of a game strategy, students find out according to which principle robots can learn. In teamwork they program learning strategies to test these learning paradigms on Nao.
The single modules of "Das Lernlabor" cover the following contents:
General introduction. The attendees concern themselves with learning robots in general. They learn about the recent status of research and find out about sample applications.
"Bauernschach". The students play a simple board game against the computer. Using different play modes, they first get used to the rules. During the following training process, the computer evolves a strategy for winning. Meanwhile, the students work out how this learning process operates.
Introduction to Chorégraphe and Webots. The course instructors explain how to deal with the GUI created by Aldebaran Robotics SA to control Nao, Chorégraphe (Fig. 3), and with the simulation tool Webots.
Practice: Chorégraphe/simulation. Nao plays football in a simulated world in Webots, directed out of Chorégraphe. That way the participants practice the handling of the programming tool.

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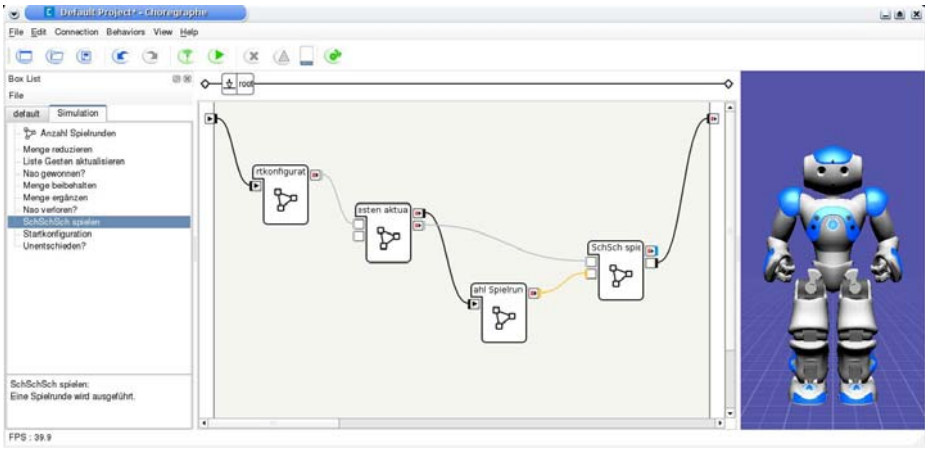

Fig. 3. The graphical user interface Chorégraphe by Aldebaran Robotics SA. At ***teutolab*-robotik** it is used to control Nao.

Practice: Chorégraphe/reality. The football scenario is carried to the real robot. The students are made aware of the slight differences between robot's actions in simulation and reality and of accounting for safety aspects.
Rock, Paper, Scissors (reality). Nao is to play Rock, Paper, Scissors (including the figure fountain) against one student. While playing the robot is supposed to learn a strategy for winning. The participants develop a program containing a learning process and execute it afterwards.
Rock, Paper, Scissors (simulation). The students transmit their program to play Rock, Paper, Scissors in a simulation. Playing numerous matches in a short space of time, they want to find out how a strategy for winning may be structured in this particular case.
Discussion and feedback. The attendees summarise what they have learned during "Das Lernlabor". Supplementary they utter feedback.

5 Proposal Evaluation and Perspectives

In general, classes of grammar, middle or integrated schools visit ***teutolab*-robotik**'s workshops. In addition, private groups book workshops and single students register for open workshops bimonthly. Four times a year the highly gifted attendees of Bielefeld University's project Kolumbus Kids [6] take part in "Die Roboterakademie". Most of ***teutolab*-robotik**'s participants come from the region East-Westphalia and Lippe. Also participations at annual events like the pea*nuts-Herbsthochschule for female students of upper classes and the Girls' Day raise the female amount. Furthermore, the student laboratory is presented at many educational events in order to increase the public relationship in the region and beyond.

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Since ***teutolab*-robotik**'s start in June 2009 with the course "Die Roboterakademie" roughly 530 students visited the fantastical world of robots in just above 50 workshops. The considerable proportion of female participants (about 39%) is exceedingly pleasant. It demonstrates that technology is not only interesting for male students.
For evaluation of the courses, questionnaires are used in each workshop. In the surveys the students and the teachers describe their experiences. They give feedback to the following items: compliance of expectation (yes or no), degree of difficulty (with a scale from 1 (excellent) to 6 (inadequate)), pacing of the courses (too slow, okay and too fast) and so on. The participants' feedback concerning the course "Die Roboterakademie" turns out very positive: The course fulfills the expectations of almost all participants (97%). Asked to mark the course according to grades at German schools, 38% gave the best mark out of six, and more than half of the persons questioned (51%) gave the second-best. Above one third of the participants emphasise the programming by theirselves as an excellent feature of the course "Die Roboterakademie". About 60% of them like the practical handling with the robots Aibo and Pleo very much.
The results of "Das Lernlabor"'s survey are not yet representative because the course has started only a few weeks ago.

The course instructors are trained with this feedback continuously. Supported by a camera during a workshop, they optimise their skills.
For the future, it is planned to exchange the offer to workshops for younger students and adults like parents, teachers and members of the university. Furthermore, materials for teachers should be created for preparation and postprocessing of their lessons. By a closer collaboration with school teachers, the workshops could be evaluated more intensely respectively to the curricula. With support by regional companies this project is able to counter the lack of professionals in this high technology field over the long term.

References

1. Kohse-Höinghaus, K., Königer, F., Herbers, R.: Nanochemestry for high school students: Hands-on experiments and informal education in the teutolab at Bielefeld University. Chemistry today 25(2), 50-53, 2007
2. Janett, H., Brandt, A., Püttschneider, M., Herbers, R., Kohse-Höinghaus, K.,: Chemistry for Kids at teutolab. International Symposium on Science Education, Taipei, 25-26 partially, November 2003
3. The education act of the State North-Rhine-Westphalia, updated: 15th February 2010, §13 (1), §16 (2), § 17 (2).
4. Fachausschuss 7.3 Informatische Bildung in Schulen der Gesellschaft für Informatik e.V.: Empfehlungen für ein Gesamtkonzept zur informatischen Bildung an allgemein bildenden Schulen. 2000
5. LEGO.LEGO MINDSTORMS Official site: http://mindstorms.lego.com. (last visited Sept. 17th, 2010)
6. Kolumbus-Kids Official site: http://www.kolumbus-kids.de

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