

The Roberta® Initiative

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Abstract. This paper gives an overview and summary of the Roberta Initiative – an approach to raise especially but not only girls’ interest in STEM (science, technology, engineering and math). Roberta comes with a didactic concept that uses robot construction kits in combination with a gender-balanced didactic material and course concept. Roberta teacher trainings delivered by certified Roberta coaches and a dissemination network are the approach of the Roberta Initiative to establish a sustainable activity to raise girls’ interest in technical topics and in the end the portion of female engineers in Europe. Robot competitions turned out to be an attractive next step for Roberta course participants to further follow their interest in STEM.

Keywords: educational robotics, robot construction kits, gendered robot courses, teacher training, robot competitions

1 INTRODUCTION

By designing, constructing, and programming robots, children can experience that working with technology is a creative and interesting but not a trivial process. The hands-on learning environment helps them to acquire knowledge in computer science, technology and engineering. Additionally, constructing and programming robots in a teamwork setting is an ideal instrument to train those types of competences and soft skills that are essential for dealing with technical development processes. Many educational robotics activities - robot courses or robot competitions - rely on this fascination of mobile robots.

With Roberta the Fraunhofer Institute for Intelligent Analysis and Information Systems (IAIS) addresses the lack of (female) engineers in Germany and other European countries by raising children’s’ interest in technical professions. Roberta use robots as a technology platform which can be used from pre-school to college-level. Roberta uses robot courses as a creative learning environment to teach knowledge in computer science, technology and (system) engineering in an integrated, holistic way.

The robot courses are tailored in a gender-balanced way, to strengthen the self-confidence of girls, i. e. the didactic approach selects themes and experiments that are more interesting for girls but do not exclude boys, and keeps aware, that the same

amount of attention will be paid to girls and boys [1]. This is the specific approach and strength of the Roberta Initiative in comparison to other educational robotics offerings.

The Roberta Initiative comprises several elements which in combination constitute the basis for a sustainable activity to raise girls' interest in technical topics and strengthen their self-confidence in their own technical competence.

- Roberta courses from 2 hours (taster-course) to more than 40 hours (project weeks, summer schools). Roberta courses are suitable for mixed groups of boys and girls and for groups with only girls.
- Gendered didactic material as a resource based on which certified Roberta teachers can design and assemble attractive robot courses.
- The Roberta teacher trainings as hands-on introduction to the employment of the Roberta didactic material. In addition, the participation in a teacher training is the entry to join the Roberta teacher network.
- A network of Roberta Regional Centres to promote the ideas of Roberta on a regional scale and to provide certified Roberta teachers and Roberta courses in a region.
- The Roberta social media as the central community platform which provides additional material for certified and registered Roberta teacher. The web portal offers a channel for Roberta Regional Centres to present themselves in the context of the Roberta Initiative.

The following sections give an overview on these constitutive elements of the Roberta Initiative.

2 ROBERTA COURSES

In Roberta courses robots can be used to create a point of passage between the context of school and the life-world of children [2]. First girls and boys learn to get familiar with the building and programming of robots (simple task). The next step is to learn how to use different kind of sensors and programming languages (compound tasks). Simple tasks and compound tasks impart basic knowledge to construct, program and test a robot. Roberta experiments are based on the knowledge gained from Roberta simple tasks and compound tasks. The Roberta course design follows four main topics:

- choose interesting topics (create a connection between technical content and a real world theme)
- give examples (e.g. invite specialist and discuss her work with her)
- allow rapid achievements (e.g. short development cycles: idea – conversion – testing)
- strengthen the participants' self-confidence (e.g. give opportunity for presentations)

The structure of a Roberta experiment is as follows: After an introduction and explanation to a real world theme, usually taken from biology or nature, the concepts and structure observed in the real world are abstracted to a robotics experiment. Thus, the course participants have to analyze and understand a real world phenomenon. The next task is to model the phenomenon and to map it to a robotic experiment. This

requires to analyze and to really understand a theme and its phenomenon. It is essentially a research step that is implicitly performed by the Roberta course participants. The intention behind is, that the course participants get a deeper understanding of a system and not only of a small part of it. Teaching to think on system level is a key motivation for our approach. Since Roberta courses are performed in a team environment, the course setting may be regarded as a simulated research and engineering process.

3 ROBERTA DIDACTIC MATERIAL

An example from the Roberta material is the experiment »Dance of the Bees«. The Roberta material gives general information on the theme and suggests experiments. An example for the theme »Dance of the Bees« is to understand and subsequently model the behavior of the bees in different situations. A first experiment suggested is to build a robot that implements a bee dance for nectar collection. The next step is to develop a robot bee that implements a behavior to guard the beehive. The Roberta didactic material delivers ideas to develop further experiments for a given theme. The course participants are encouraged to develop and realize their own ideas using the knowledge they gained from the simple and compound tasks and the Roberta experiments suggested in the material.

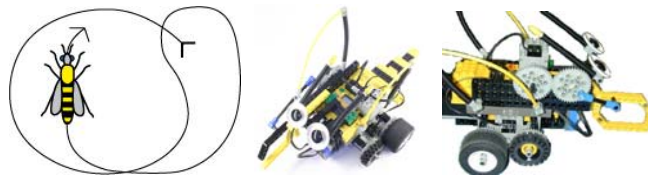


Fig. 1. Roberta Experiment Dance of the Bees

Roberta themes and experiments concentrate in particular on nature and biology. Other examples presented in the Roberta material are Gaits (two legged, six legged), Maze and Ants (construction of an ant, ant trail). These themes are definitely more appealing and attractive for girls than for example soccer robots or fast driving vehicles.

An important concept of the organization and structure of the didactic material is a clear-cut separation of the experiments from their concrete implementation using a specific robot construction kit. The didactic approach is deliberately independent of a concrete robotic kit. It can be adapted to new construction kits appearing on the market. A suitable robot construction kit has of course to provide functionality like actuators, sensors, programmable control and robot communication. At present, Roberta tasks and experiments have been adopted to the LEGO Mindstorms construction kits RCX and NXT and their programming environments.

The Roberta didactic material is designed as a reference book for certified Roberta teachers. The first volume is subdivided in a generalized volume 1 – Basics [3], which

contains the theoretical information of gender sensitive course design and all concepts which are independent of a concrete robot construction kit. The mapping of the experiments and course concepts to a robot construction kit has been done for LEGO Mindstorms. The Roberta Volume 1 – NXT [4] and Roberta volume 1 – RCX [5] are the corresponding volumes describing how to use a certain robot construction kit for designing tasks and experiments within the Roberta concept. Some experiences with the robot construction kit of Fischertechnik have been made by one of our Roberta Regional Centres.



Fig. 2. The Roberta-Series Vol. 1 to Vol. 5

We developed a specialised package containing the robot construction kit LEGO Mindstorms NXT (school version), the Roberta volumes 1 – Basics and NXT – and some supplementary material required for experiments.



Fig. 3. The Roberta Box contains additional elements e.g. a so called dress-up-set, an adhesive foil for the NXT brick and a test course. This combination of the additional materials allows individualizing the Roberta robots which is important for the course participants.

4 ROBERTA TEACHER TRAINING

To ensure the quality of the Roberta concept, Roberta courses may only be delivered by certified Roberta teachers. As prerequisite Roberta teacher candidates have a didactical and preferably technical background. They have to pass a two days training delivered by Roberta coaches.

The Roberta teacher training gives a hands-on introduction to the robots, the didactic material and the course concept. Special emphasis is on gender-oriented course design of mono-educative and mixed courses as well as on the creation of an open research-oriented learning environment. A certified Roberta teacher gives the children the ability to take the initiative without telling the complete solution of a given task. The importance is to gain insights and reflections in the networking of their own possibilities for action [7].

Within all Roberta courses the Roberta teachers should:

- Promote communication (e.g. demand and promote verbal and written communicative abilities)
- Promote creativity (e.g. flexibility course-design)
- Promote independent work (e. g. let girls elaborate knowledge independently)
- Promote gender awareness and gender-sensitive course design
- Promote developing own ideas according to the Roberta concept

To assure the high quality of Roberta courses, Fraunhofer IAIS has identified some quality criteria:

- The number of participants is limited to 12 people
- All participants should have a didactic and educational background
- The Roberta Teacher-Training takes at least 12 hours
- The participants work in teams of two
- Each team has its own computer and Robot construction kit
- Each Roberta Teacher-Training will be evaluated by the participants at the end of the course

Roberta teacher are trained by Roberta coaches. Fraunhofer IAIS trains and approves Roberta coaches who in turn train and certify Roberta teachers. All Roberta coaches selected by Fraunhofer IAIS have many years of experience as Roberta teachers. Furthermore they have outstanding expertise in didactic and educational robotics activities at universities or schools. Many of them are very active in coaching of robotic teams participating in robot competitions. Quality assurance, feed-back analysis and continuous improvement of the teacher training is one of the key elements in the Roberta Initiative.

5 ROBERTA NETWORK

The strategy of the Roberta Initiative is to promote and to foster the introduction of gendered-robotics courses in after school courses and in school curricula. We have developed a dissemination structure that allows offering local contact points for people interested in Roberta courses, the so-called Roberta Regional Centres.



Fig. 4. Map of German Roberta Regional Centres (as of October 2010)

Roberta Regional Centres coordinate courses in their regions and support the Roberta teacher associated to them. Furthermore, upon demand, they lend out construction kits to their Roberta teachers. For each newly founded Roberta Regional Centre there is a certain number of Roberta teachers being trained and certified by Roberta coaches. Each Roberta Regional Centre has to provide the infrastructure to host Roberta courses. Usually, a Regional Centre is located at a university active in robotics and/or teacher education. At present, 23 Regional Centres have been established in Germany.

5.1 Roberta-Goes-EU

The main objectives of the project Roberta-goes-EU was to establish a dissemination network of Roberta Regional Centres (RRCs) in Europe and to promote the ideas behind Roberta in several European countries. 12 Roberta Regional Centres have

been established in Austria, Italy, Sweden, Switzerland and the UK [8]. The main goals of the project were:

- Train teachers to use robot construction kits in schools as a means of delivering interdisciplinary technical content – especially, but not only for girls.
- Assess, document and evaluate the experience gained in courses delivered by the RRCs.
- Promote the inclusion of these didactic course elements in national curricula.

With these 12 Roberta Regional Centres we have set-up a starting point to support Roberta not only in Germany but also in other European countries. By linking to national local robot initiatives, in Italy Roberta is promoted by the network Scuola di Robotica, we see a promising approach to link existing educational robotics activities in Europe.

5.2 zdi-Roberta

Besides a promotion of Roberta to other countries, we started to increase the density of Roberta Regional Centres in some selected federal states in Germany. We have made the experience, that there is a high demand and interest of teachers in Roberta trainings. In the federal state NRW we co-operate with a STEM activity funded by the Ministry of Innovation (MIWFT), the so-called zdi-Initiative [12]. The initiative sets up zdi-Centres, which take into account the concrete situation of young students in a region, the regional industry structure and the workforce needs of the local economy. At all locations, schools are working with a University, the Ministry of Innovation and the regional economy. A basic principle of each zdi-Centre is self-funding.

We co-operate with the zdi-Initiative by setting-up zdi Roberta Centers as additional offering of a zdi-Centre. During the funded project a network of 12 additional zdi-Roberta Centres (as of October 2010) have been established. Prerequisites for the establishment of a zdi Roberta Centre are:

- The hosting institution has to have the status as zdi Centre
- experience of course management in the areas of technology and education
- recruitment of at least 12 teachers in the region for a Roberta teacher training
- purchase of necessary technical infrastructure for Roberta courses (PCs, robot kits)

6 ROBERTA AND ROBOT COMPETITIONS

Roberta courses turned out to be well-suited to raise the girls' interest for participation in robot competitions, especially RoboCupJunior. Therefore, we developed in 2006 introductory material to motivate Roberta course participants to take part in RoboCupJunior.

Today many RoboCupJunior teams taking part in the RoboDance competition in Germany have started in a Roberta course. Especially teams from Berlin usually have a Roberta background, since Roberta has been supported by the federal state Berlin with the help of a very active Roberta coach in the frame of the eEducation Masterplan. For example the Berlin Roberta-Team "Berlin STOMPys" take part at the

RoboCupJunior World championship Graz 2009 and won the first prize at the Super Team competition. The team members are only girls and they are from secondary modern school. This example shows that regional funding in combination with local Roberta coaches helps to promote the introduction of robotics courses in schools and increase the number of teams in robot competitions.

A second example from the project zdi Roberta shows similar positive results on the combination of Roberta courses and a robot competition. The zdi-Initiative started a robot challenge called Robot game in the year 2006. The robot game is similar to the FIRST Lego League challenge. To increase the rate of female participants, Fraunhofer IAIS developed a special competition called “Robot performance”. The robot performance challenge is at most about story telling by using only two (Lego Mindstorms) robots. The competition is very open for creativity. Only the number of robots, team members, the time to perform and the size of the performance-area are limitations. The participants are free to decide on a topic they want to perform. By reducing the complexity (number of allowed robots, team members, performance area, etc.) and by dividing the challenge into a performance of robots and a public presentation of the ideas (story, construction, combination of sound and performance, team members, team leader etc.) behind the performance, girls will be addressed even if they are beginners. In comparison to the RoboCupJunior RoboDance discipline, Robot Performance may be regarded as an entry competition for beginners.

7 ROBERTA SOCIAL MEDIA

The Roberta web portal [6] is the central community platform for the Roberta network. Each certified Roberta teacher gets a login to the Roberta portal. It provides additional material for the Roberta teacher, e.g. construction manuals or new themes and experiments as free downloads. With this, the portal provides the technical infrastructure to get access to additional didactic material and is the platform to get in contact with other Roberta teachers.

Fraunhofer IAIS also use for Roberta other web 2.0 opportunities like Facebook, Twitter and YouTube [6]. Therewith Roberta addresses especially the so called “digital natives”. In addition we publish about this kind of media news about Roberta (e.g. latest picture of a new Roberta robot model) as well as postings about other interesting robot projects.

8 RESULTS, EVALUATIONS AND RECOMMENDATIONS

We outline some figures to document the current status of the Roberta Initiative:

- Several hundred teachers have been trained to be certified Roberta teachers in Germany and Europe.
- Several thousands children participated in Roberta courses. In 2009, at least 5000 children (60 % girls) participated in registered Roberta courses in Germany.

- Roberta courses are often the entry for girls to set-up robotic teams that participate successfully in robot competitions, like RoboCupJunior or FIRST Lego League.

Part of the didactic material and the training concept was evaluated by the University of Bremen [7, 10] during the funded projects ‘Roberta’ and ‘Roberta-Goes-EU’ by analysing feed-back from several hundreds of the Roberta course participants within an age range between 10 and 16 years. We asked the participants on their future interest in courses and got the following figures:

- 94 % enjoyed the courses
- 88 % would recommend it to friends
- 74 % would attend further courses

In general, participation in a Roberta course significantly improves the self-confidence of girls in their own technical skills. This positive effect is slightly better if no boys are attending the same course. Nevertheless, the evaluation shows that boys are not distracted by the material, even though it was originally designed for girls. The analysis of the feed-back showed very similar results for Germany and Europe. Based on these evaluations, Roberta courses are also open for boys. It is up to the individual Roberta teacher to open a particular Roberta course for boys.

The recommendation was to aim at a stronger integration of Roberta courses in school curricula. An interdisciplinary integration into the regular elementary school lessons on the one hand and the embedding into the optional or elective mandatory subjects of secondary schools (e. g. technology, natural sciences and choice of a profession) on the other hand were felt to be the best possibility [9].

In the context of the zdi-Initiative, we performed a survey with the participants of the Robot Performance tournament and got the following results:

- 89 % would like to participate again in a Robot Performance competition
- 97 % liked to work in teams for challenge preparation
- 92 % liked to implement their own ideas

These figures and evaluation results confirm the known attractiveness of robot competitions and in general the positive impact of robot courses as a strong motivation factor for STEM. Therefore, we suggest to more systematically link teacher training, advanced robot courses and participation in robot competitions as an integrated education concept to attract young people – and not only girls – for STEM.

Acknowledgements

The project “Roberta – Mädchen erobern Roboter” (2002-2006) was funded by the German Ministry of Research and Technology. The project “Roberta-Goes-EU” (2005-2008) was funded by the EU in the 6th Framework Programme. The project zdi-Roberta (2008-2010) was funded by the Ministry of Innovation (MIWFT) of the federal state NRW in Germany.

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