Robotics in Education Initiatives in Europe - Status, Shortcomings and Open Questions

Ansgar Bredenfeld[1], Alexander Hofmann[2], and Gerald Steinbauer[3] *

[1] Fraunhofer IAIS, St. Augustin, Germany,
ansgar.bredenfeld@iais.fraunhofer.de
[2] Computer Science Institute, Fachhochschule Technikum, Wien, Austria
alexander.hofmann@technikum-wien.at
[3] Institute for Software Technology, Graz University of Technology, Graz, Austria
steinbauer@ist.tugraz.at

Abstract. For more than a decade now robotics in education has gained a lot of attention from teachers, researchers, politicians, authorities and other stake holders. During the years a great number of methodologies, courses, projects, initiatives and competitions had been developed. With the present position paper the authors who have been active in different educational robotics initiatives for several years like to summarize the status of educational robotics in Europe and to relate it to the state of the art as it is documented at international symposia and workshops. Starting from these observations the authors point out shortcomings and open questions and propose pragmatic strategies for future activities in Europe. The long-term goal is to make robotics in education stronger, more serious and evaluated and thus sustainable in order to achieve increasing technology competence of young people and to attract them for technical professional careers.

Keywords:
educational robotics, robot competitions, European and International trends in educational robotics

1 Introduction

For more than a decade now robotics in education has gained a lot of attention from teachers, researchers, politicians, authorities and other stake holders. Moreover, it has been partly treated as the holly grail for better quality in teaching and education, in shaping technical and social skills and to interest and motivate young people for science and technology.

During the years a great number of methodologies, courses, initiatives and competitions had been developed in the context of educational robotics. A fraction of these activities had been quite successful and have become very popular such as FIRST Lego League, Roberta or RoboCupJunior. The activities show a wide diversity and differ very much in their target audience (e.g., primary schools, secondary schools, universities),

* Authors are listed in alphabetical order.

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their pedagogical goals (e.g., teaching robotics, teaching other subjects, develop social skills), their organizational background (e.g., schools, universities, research institutes, private societies, product vendors), or their target region (e.g., schools, districts, states or international countries). All these activities meet to a smaller or bigger extend the expectations raised and the goals set such as an increase of the quality and impact of education on various levels. The diversity of the approaches enables on one hand enormous creativity and potential but prevents on the other hand to some extend a coordinated approach and a broader and more serious evaluation. A direct comparison of different approaches is next to impossible.

Even if there is a common feeling or probably already some kind of consensus by the different communities involved on the fact that robotics in education activities is valuable — as for any approach or technology — from time to time it is needed to make a critical summing up. Moreover, if an emerging methodology, approach or initiative leaves its niche and reaches some level of propagation it asks for a broader, more serious and validated foundation and evaluation.

Based on observations and discussions during the last years robotics in education reminds us an orchestra that has an incredible group of musicians using fabulous instruments but is not able to play a symphony that enravish the audience. Everybody in the orchestra tries to convince the others to use their instruments and to play in a local club that is not able to accommodate the orchestra. Moreover, the musicians use too many different writings and meanings of their notes and even more they do not agree on the concrete symphony they want to play.

Within the present position paper the authors who have been active in different educational robotics initiatives for several years like to summarize initiatives and competitions in this field in Europe and to report some critical observations. Moreover, the authors like to point out shortcomings and open questions in the field and to propose possible solutions and future activities.

In the remainder of this position paper we will summarize the situation and initiatives in context of educational robotics in Europe. In section 3 we will present related research that has been carried out in the field on an international level. In section 4 we point out some open issues and observed problems. In section 5 we will draw some conclusions and will suggest some ideas on solutions to the shortcomings of the current approaches.

2 Situation and Initiatives in Europe

Educational robotics activities in Europe may be categorized by looking at workshops, robot competitions, course offerings and existing networks.

Many of the prominent and established robotic conferences deal with educational robotics only as a side topic, usually listed at the end of their list of topics as education and/or entertainment. To our knowledge, the first workshop explicitely on the topic educational robotics in Europe was organized by Fraunhofer IAIS in 2001 in Germany. A workshop on the integration of robots in the education of computer scientist was part of the annual conference of the German Society of Computer Science held in Bonn in 2005. In the last two years, workshops on a European level start to adopt the topic like

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the workshops SIMPAR 2008, RiE 2010 and this workshop at SIMPAR 2010. These are promising examples of an upcoming trend to spent more attention on robotics in education. The workshops are often organized in the context of funded projects related to the topic educational robotics and therefore single events and not yet established workshop series which are hosted or sponsored by one of the large conference societies like ACM or IEEE. All these workshops are promoted by the technical communities behind robots in education and not by the communities of education experts.

Many of the existing robot competitions are related to educational robotics, either on school level or on university level. The most popular offerings of robotic competitions in Europe are the FIRST Lego League (imported from the very structured, broad and successful FIRST initiative in the US) and RoboCupJunior which is the most prominent international robot competition for schools. RoboCup, EuroBot and to some extent FIRA target on student teams and are more related to research than to education. In addition there are many other local competitions, with strong regional scope, very specialized competition tasks or even local copies of existing competitions with different names. An example for a strong regional competition in the federal state NRW of Germany is the zdi-Roboterwettbewerb. It performs each year a series of 8 competitions and a final at universities using a robot game inspired by the FIRST Lego League competition. Vendor specific robot competitions like the SICK days, have a strong focus on specific technology, e.g., the laser scanner manufactured by the organizer. Using robot competitions as product promotion, is true for FIRST Lego League but also for the Standard Platform League of RoboCup which uses the Nao Robot of Aldebaran Robotics. The same holds true for the new FESTO competition which is based on the Robotino robot manufactured by FESTO. ELROB with its C-ELROB and M-ELROB competitions target at outdoor robotics and do not have a strong educational robotics focus in mind. The participants are more companies and research institutes.

The offers for robot courses are manyfold. There are vendor specific courses offered by the distributors or vendors of robotic products, there are course concepts targeting a specific group like girls in the Roberta Initiative [1]. In some projects didactic material has been developped like in the Roberta project, the RoboDidactics project or the CentroBot project. The courses are mainly targeting schools and teachers and are mostly organized as after school activities. We observe at least in Germany, that robot courses are an attractive tool for science-centers like Heinz-Nixdorf-Museumsforum Paderborn, Deutsches Museum Bonn, Odysseum Cologne or the TUMLab in Munich. Besides this after school offerings, robot courses start to be integrated at some schools in regular curricula. We consider this a positive trend but, for example in Germany or Austria, there is no systematic introduction of robotics in curricula.

Each robot competition, some of the initiatives like Roberta, or explicit networks like Scuola di Robotica in Italy build networks of active, involved people in parallel to their research or development activities in educational robotics. We consider this an exciting development of a high potential, if these networks link together or at least synchronize their activities to some extent. This would potentially minimize the danger of a reinvention of specific content and may be the basis and starting point for a more systematic identification of the needs for future developments in the domain of educational robotics.

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3 Related Research

There exists a rich collection on related literature in the area of robotics in education on an international level.

We identified several workshops and conferences that had a more or less strong focus on educational robotics. Please note that this list is obviously not complete and represents just samples. Within this section we like to highlight the focus and content of some of those events and discuss the strengths and weaknesses of publications presented. The selected conferences and workshops are the following:

1. AAAI Spring Symposium on Accessible Hand-On AI and Robotics Education, 2004 [2, 3]
2. AAAI Spring Symposium on Robots and Robot Venues: Resources for AI Education, Stanford University, CA, USA, 2007 [4]
3. Research and Education in Robotics - EUROBOT 2008, Heidelberg, Germany, 2008 [5]
4. Teaching with robotics: didactic approaches and experiences, Workshop at International Conference on Simulation, Modeling and Programming for Autonomous Robots (SIMPAR), Venice, Italy, 2008
5. AAAI Spring Symposium on Educational Robotics and Beyond: Design and Evaluation, Stanford University, CA, USA, 2010 [6]
6. First International Conference on Robotics in Education, Bratislava, Slovakia, 2010

Unfortunately, the major fraction of these conferences and workshop show common sub-optimal properties which are related to the observations reported so far in this article. These properties are:

1. the presented publications are related to a single institution or small region
2. the presented publication show just example of diverse small education project
3. results are usually justified by a very small population from a single class
4. publications are usually made from people coming from computer science and robotics but not from the obvious related fields of educational sciences, pedagogy or psychology
5. the approaches are not condensed to a common standardized methodology
6. the publications contain repetitively trivial technical descriptions of yet another educational robot platform or setup
7. the conferences and workshops are too closely coupled to a particular event, competition or initiative

Let's try us to underpin these observations with some examples of typical publications. The listing here should not be a judgment on the quality of the publications in general but should depict the shortcomings of the actual literature in the field of educational robotics.

Frangou and colleagues motivate in [7] how educational robotics based on constructionism (learning by doing) can be integrated in class rooms. Moreover, they summarize some guidelines for the creation of a successful project for the classroom. Finally, they

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present some examples for projects from a number of European countries and categorized them along the project stages. The paper is a collection of local project ideas for educational robotics but lack a systematic examination of the project parts and a significant evaluation of the impact of the approaches or if they meet their goals.

In [8] the authors present a concept for an installation of robots in a science center with the goal to communicate modern robotics strategies to a general audience. The concept shows four different approaches and provides adequate interactive exhibits: teleoperation, cognitive robotics, adaptive robotics and swarm robotics. The concept looks very good elaborated and creative but again at the end of the paper the evaluation of the impact of the installation is just noted as future work.

The authors of [9] describe a really nice and creative approach to teach university students hardware, software and their interfaces. The idea is to use a real pinball machine and connect it to a computer and write software to control the machine. The project is very creative but shows just another implementation of a single small initiative without broader impact. The fact of missing broader impact or evaluation is even more astonishing as the symposium had as a central topic the evaluation in the context of robotics in education.

The authors of [10] named their paper "Some didactic aspects of teaching robotics" that describes navigation theory and some data fusion aspects. In general "didactic" is the art of teaching. Didactic describes the action of a teacher, educational infrastructure like group size, time constraints, learning theory and teaching methods used, teaching material and finally content topics.

4 Some Open Issues and Problems

The list of publications at the conferences and workshops mentioned in section 3 target similar topics at different levels and trough institutions. Some developed new robotic platforms, some initiated new local competitions and others published their educational material and explained how they use robots in class. The same or similar content is presented over again but no commonly accepted ideas, methodology, nomenclature or standards are developed and discussed. Moreover, there is hardly an exchange or alignment with researchers from other important and related field such as education science.

The massive grow of different competitions as listed in Section 2 show that every organizer tries to reinvent robotic competitions. They start from very local, one institute wide competition to motivate students up to intercontinental competitions like RoboCupJunior [11]. But all competitions have one problem in common - they are not connected to each other and do not communicate or share ideas, experiences or knowledge. Most of these competitions suffer from the *not invented here* problem. Moreover, many competitions track their focuses on limited regions and topics and miss the support of the big picture of educational robotics.

The goals of robotics in education in general range from motivation to learn, attracting young people for science and technology or to raise problem solving capabilities. But how do we prove that we reached these goals? We still do not know if a robotic course for young children has its impact on their further educational career. Do more children become interested in science and technology or develop remarkable better so-

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cial skills? There is a serious lack on significant quantitative and qualitative evaluation of the impact of the initiatives. Current evaluations are too limited in their evaluated population (i.e., a class at the university or in a school instead of all youngsters in a region) or their evaluation period (e.g., weeks or semesters instead a period from age of 6 to 18).

5 Conclusion and Urgent Actions

The purpose of the present paper is to highlight some problematic observations and some weaknesses of the current situation related to robotics in education in Europe. The initiatives reach from single activities of an enthusiastic teacher over research-driven classes at universities towards strong international robot competitions. The topic of educational robotics reached a very wide propagation as well in research as in practice in daily life. This position paper is indented to be a crystallization point for deeper discussions and a launch vehicle for future common activities with the long-term goal to make robotics in education in Europe stronger, more serious and sustainable.

The topic itself and the related initiatives show a huge potential but we are sure that intended cooperation between the initiatives as well with researchers of related field, broader and more systematic evaluations and the development of common standards, nomenclature and methodologies will even boost the field.

In order to foster the prospering development of the field we like to suggest some urgent actions. Some of these activities do not ask for additional money where others need also initiative for raising funds. In particular we suggest the following activities:

1. co-located a future workshop on educational robotics with on of the major robotics, AI or education conferences (e.g., IROS, ICRA, IJCAI) or ask for a special track at these conferences
2. contact and lobbying to governmental education authorities in order to area-wide integrate robotics in curricula in larger areas than districts or states
3. apply for a funded network on the European level (e.g., coordinated actions in FP7 - Science in Society) to bring together the different initiatives and competitions, to exchange experience, to coordinate the activities and to reach a critical mass
4. development of concepts for a long-term evaluation (several years, greater regions) of the impact of the activities to development of young people

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