RoboCup Junior: A Vehicle for S&T Education in Africa?

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Abstract—One of the challenges of the 21st century is to prepare learners for the rising technological challenges in jobs and daily life. In order to be able to do so curiosity and motivation of the learners have to be stimulated. There exist initiatives such as the First Lego League or RoboCupJunior to spark interest in youngsters for science and technology. In a playful way, the children get into contact with technology and become more interested in these fields. In this paper we report on the experiences of the South African RoboCupJunior Rescue team AmaJukuJuku that participated in the 2010 RoboCupJunior in Singapore. From the first-hand experiences of this group of learners with a disadvantaged learning background, we show the positive effects and argue that such initiatives are helpful and important, particularly in the African context. We propose a scheme how such initiatives could be undertaken in the whole of Africa.

I. INTRODUCTION

A profound education in Science & Technology (S&T) seems key to face the challenges of the 21st century in our industrialised world today. Despite this and the fact that job prospects are good, it seems that less youngsters are interested to choose a career in such fields. According to a recent OECD study, the number of university entrants and graduates is decreasing: “...at the same time, the number of students choosing S&T declined as a proportion of all students in many countries, while the percentage of those graduating in S&T declined in the majority of countries and the percentage of those awarded a PhD declined practically everywhere” [1, p. 33]. The result is that open job opportunities in S&T cannot be filled (e.g. [2], [3], [4]). One of the reasons for some disinterest to start university studies in such fields is that the learners in high school lack exposure to technology. The above mentioned OECD study concludes: “Positive contacts with science and technology at an early age can have a long-lasting impact while negative experiences at school, due to uninteresting content or poor teaching, are often very detrimental to future choices” [1, p. 11].

The field of educational robotics is tackling this problem. Several initiatives exist to spark interests in young learners, for instance, the Roberta Initiative [5], the FIRST Lego League [6], or RoboCupJunior [7].

In this paper, we report on our experiences with launching the RoboCupJunior initiative in South Africa. One year ago, we started the RoboCupJunior initiative with a group of learners aged between 14 and 15. We report on their experiences of attending the 2010 RoboCup in Singapore and follow up on what this experience meant for them personally, in their school life and in their local communities. With this paper we want to inform about the positive effects of this particular initiative for science and technology education. The following questions come to ones mind:

- Is this a problem for industrialised nations only?
- Is it as important to prepare African school children for the 21st century S&T challenges, or are such problems irrelevant for Africa?
- Do the mentioned initiatives really have some positive influence for encouraging learners’ to become interested in science and technology?

Having made first-hand experiences, we feel that this initiative is very relevant in the African context and want to advertise the initiative for the larger African context.

The rest of the paper is as follows. In the next section, we briefly introduce the RoboCup and the RoboCupJunior initiative, before we give some details on the launch of the RoboCupJunior initiative in South Africa in Section III. In Section IV, we present the feed-back we got from the team. Based on this first-hand experiences, in Section V we summarize the positive effects of this initiative and discuss what is needed to take this initiative a step further. We conclude with Section VI.

II. THE ROBOCUP INITIATIVE

A. RoboCup: The Robot Soccer World Cup

In the 1990s, some of the paradigms of AI shifted towards autonomous intelligent systems interacting with real-world human environments. In 1997, Kitano et al. [8] proposed robotic soccer as a challenging application domain and as a benchmark for autonomous intelligent systems. This lead to regular competitions of RoboCup [9]. In 2010, RoboCup had its 14th edition, and about 3000 participants from over 40 different countries gathered in Singapore between June 19 – 25. In 11 different leagues world champion titles were awarded; five for soccer competitions with different types
of robots ranging from wheeled to humanoid robots, two for search-and-rescue operations, one for domestic service robotic applications, and three for the Junior competitions. Fig. 1 shows a picture from one of the humanoid robot soccer competitions.

The intriguing and ambitious long-term vision of RoboCup is [10]: “By the year 2050, develop a team of fully autonomous humanoid robots that can win against the human soccer world champion.” Whether or not this mission statement occurs maybe a bit Utopian, the whole initiative has an impact on research and technology in a playful way. RoboCupJunior aims “to create a learning environment for today, and to foster understanding among humans and technology for tomorrow.” The concept of RoboCupJunior is to use state-of-the-art teaching material, make students work in teams, and to support international exposure, exchange, and contacts.

RoboCupJunior includes three different leagues: (1) Dance, (2) Soccer and (3) Rescue. Competitions are held in two age groups: in the primary group, learners are aged up to 14 years, and secondary participants, who are 14 years of age and above. Figure 2(a) shows a performance of the RoboCupJunior Dance league which is particularly attractive for girls. In the Dance competition the robots perform a show act, sometimes together with their programmers. The technical skills for building the robots, as well as the creativity and entertainment of the choreography are in main focus. A jury of experts awards points for each of the criteria. In the RoboCupJunior Soccer league, two teams of two robots play soccer against each other with an infrared light-emitting soccer ball. This simplification allows learners with less technical experience and with less funding for robots with vision systems to participate. The types of robots that can be used are restricted by size and weight only, and the learners come up with very sophisticated approaches, either using custom-designed robots or standard kits like the Lego Mindstorm NXT. Finally, there is the Rescue league with its very palatable mission goals. In an indoor disaster site, the robot needs to find a way through the different rooms in the first floor to reach a ramp that leads to the second storey. Here, the robot has to find casualties making his way through debris. While on the first floor a line on the floor which can be followed is guiding the robots, in the second storey exploration algorithms have to be developed.

Besides the exposure to cutting-edge technology, the learners come into contact with senior researchers and university students at international competitions. This way, the tertiary education system becomes much less abstract for the students. Every year several thousand students around the world participate in national RoboCupJunior competitions where the best teams qualify for the annual international RoboCup competition. In the 2010 international competition around 1100 students in about 200 junior teams from approximately 40 nations competed. According to the numbers collected during the qualification process for RoboCup 2011 to be held in Istanbul, Turkey, more than 7500 student teams around the world participate in the RoboCupJunior initiative.

III. LAUNCHING THE ROBOCUPJUNIOR INITIATIVE IN SA

A. Disadvantaged Learners—Some Background on SA’s Educational Problems

More than fifteen years after the end of apartheid, South Africa’s education system still struggles severely with the aftereffects. With the Bantu Education Act of 1953 the black South African population only had access to an inferior education and were banned from skilled jobs. Hendrik Verwoerd, the Minister of Education in 1953 is quoted with: “What is the use of teaching the Bantu child mathematics when it cannot use it in practise?”

Even though under the current South African government of President Zuma, education is made “priority number one”, spending over 6% of the country’s GDP for education, the effects of two generations of disadvantages in the education system are not easily overcome [13]: “South Africa spends 6.1% of its GDP on education, a bigger chunk than most other countries, yet its results are among the worst. In the World Economic Forums latest Global Competitive Index it ranks bottom (out of 133 countries) in both maths and science education.”

The article further quotes Graeme Bloch of the Development Bank of Southern Africa that: “80% of schools are ‘dysfunctional’” and that “half of all pupils drop out before taking
their final 'matric' exams" and that “barely 11% get a good enough pass to qualify for university”. The problem becomes even more evident looking at the illiteracy rate of the black population. The article states: “Black South Africans generally do much worse than whites. Almost 13% of black adults are functionally illiterate, compared with 0.4% of whites. Fewer than 2% of black adults have a degree, compared with 17% of whites (which is still low by international standards). Barely a third of black pupils pass their matric, whereas almost all whites do. And only around one in 20 black students ends up with a degree, compared with almost one in two whites. It is not that the blacks are any less bright; some perform brilliantly. They are just massively disadvantaged.”

In particular the lack of exposure to technology and motivating initiatives makes it hard for learners coming from a disadvantaged background to catch up with other learners. Mostly, these learners come from schools which are located in townships, where also a number of further social problems exists, such as high unemployment rates or high AIDS infection rates.

B. Founding Team AmaJukuJuku

We started the South African RoboCupJunior initiative in February 2010. We invited 9th grade learners\(^3\) from six different Cape Town schools (disadvantaged and privileged) to participate in our Cape Town RoboCupJunior Challenge. The teams of four learners were from the high schools in Cape Town and Khayelitsha, Cape Town’s largest township. In a series of seminars, the learners were introduced to the very basics of robotics, the Lego Mindstorm NXT platform as well as the RoboCupJunior Rescue competition rules. The seminars were about 90 minutes of introductory lecture with a 90 minutes practical session afterwards; each team attended a seminar once. Further, they received an introduction on how to use Lego’s graphical programming language. For most of the learners it was the first time that they programmed a computer; for some it was the first time using a computer to this extent at all. In the second week, the learners’ teams had to program their NXT platforms to complete an arena which was set up according to the official RoboCupJunior Rescue competition rules. At the end of the second week, all teams competed in a rule-compliant competition. Fig. 2 shows the participants of the final competition with their robots. The competition was conducted in the Robotics and Agent Research Lab at the University of Cape Town. It was a surprise that at the end a team from a disadvantaged school outperformed the so-called privileged schools.

The next challenge was to select a team that would participate in the RoboCupJunior world championship in Singapore. We decided that we should select the most promising learners from each competing team to represent South Africa in the country’s first RoboCupJunior participation. The mix of learners from different backgrounds should foster also the understanding amongst them. The group consisted to equal parts of boys and girls; four of them came from a disadvantaged school. For the selection process, a board consisting of academic staff member from Mechanical Engineering and Computer Science interviewed each team separately, similar to the interviews at international RoboCupJunior competitions. The selection criteria were: (1) technical understanding, (2) achieved programming skills, (3) communication skills, and (4) team player abilities. The team was named “AmaJukuJuku”, which means “Going Far Far Away” in isiXhosa, an indigenous South African language, one of eleven official languages in the country.

After having selected the team members, the next step was to offer the team the opportunity to practise for the competition and to raise funds for the team to travel to Singapore. Even the first problem was not too easy to solve, as some of the learners were from different schools in the wide-spread Khayelitsha area. They had to be collected in a perimeter of about 60 kilometres and had to be driven to the Lab. As Khayelitsha has a rather poor infrastructure and is even dangerous after dawn, we found a regular date each Saturday between 10 am and 3 pm to be the best time to prepare for the tournament. The second problem—the funding for the travelling—was only solved at the last minute. Some of the things that had to be taken care of from the Lab’s side were applications for passports and visa, or even simple things as providing

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\(^2\)A/N: equivalent to an A level in the U.K. or high school diploma in the U.S.

\(^3\)9th grade learners are between 14 and 15 years of age.
suit cases for the learners; in most cases their parents were financially not able to contribute.

IV. EXPERIENCES OF ROBOCUP 2010

A. Participating in Singapore

The team AmaJukuJuku arrived safely in Singapore and started to prepare for the competition. The team members of the AmaJukuJuku team were not quite prepared for a stressful setup and so their first competition round ended achieving only a low number of points. However, the children sorted out things after some fights in the team. They announced a team leader to organise the work and concentrated on their work. The result was a considerable 7th place out of 51 participants in the second round. At the end of the competition, the team was ranked on position 22, which, considering that the preparation time for the team was rather short and they had only access to the robots a few hours a week, is a respectable result.

In the following we give some assessment of how the learners of the AmaJukuJuku team experienced the RoboCup in Singapore. We focus on the team member from Khayelitsha. The feedback was in general positive. We asked whether the RoboCup experienced changed their view about science: “As a person, RoboCup did not change my life because I am still the same girl from the township and after I came back from Singapore I am really known around. My science marks however, improved from 60% to 90%.”; or: “Yes, it changed my view about science. I did not think I was going to be the one chosen [by the selection committee] and I am so glad RoboCup changed my life because I went overseas and I’ve learnt so much like how to design and learning how to make our robot follow a line. Even at school I sit and read my books and now I am not going onto the streets – I just stay at home enjoying my self study because I love science so much.”

Another important aspect is how the learners are perceived in their local communities, at school and in their neighbourhoods. “After returning from Singapore the teachers always called me and asked me about the trip and I have to tell them. Even in my community I have to tell them and that has a great response. ” It is said that travelling as a part of education cannot be overestimated: “When we were in Singapore, I was very impressed with what Singapore was like and it made me see the world in a different way than before because I have never seen anything so clean, so refreshing and relaxing as that. I just wish I could take the whole of South Africa to go and see what a country should be like and how to live a life without fear of crime wherever you go.”

In terms of self-esteem particularly for girls, the value of this endeavour is high: “Some children tell me that I will not achieve this but I kept telling myself that as long as my parents are supporting me and I trust in God, I can do all this.” Besides the families, the teachers play an important role in encouraging the learners: “There are teachers who supported me and said that I must keep on doing what I’m doing. Other children ask me how did I do it and I told them how excited I am and that I want to work hard. I keep asking my teacher science questions and she keeps on explaining to me.” These positive experiences are shared with fellow students and will hopefully influence an even larger group of learners: “I have had so much more support from my school than before the World Cup. I feel like a celebrity – I’m even put on additional programmes at school for me to encourage other learners and for that I thank Dr Anet Potgieter for this opportunity – it really changed my life in a very good way and as for Science – I LOVE IT.”

The general observation in this group of learners, which is of course not representative in any way, is that they all got some extra motivation to work harder towards career goals which now are to become engineers or medical doctors. These goals, tackled with fresh self-esteem, might seem more realistic for these learners now.

B. One year later

After the experiences of RoboCup 2010 the initiative had been continued. The interest and enthusiasm of the involved learners is unbroken. Unfortunately, because of lack of general funding it was decided to continue with the same group of learners and to give them the opportunity to further develop their own social and technological skills with the same robot.
V. DEVELOPING AN EDUCATION SCHEME

In this section, we collect several ideas how this initiative could be taken a step further, in particular, allow a larger group of students to experience RoboCupJunior. Therefore, we start with a look abroad, how some industrialised countries are supporting RoboCupJunior activities. Then, we outline a scheme that could be sustainable for the African context.

A. RoboCup Junior Abroad

Germany has a long tradition with educational robotics initiatives, in particular with RoboCupJunior. Since 2001, the RoboCup German Open take place every year. It attracts a high number of teams from all over the world. It is the most important tournament besides the international RoboCup event. Based on the long experience and high numbers of involved schools and teachers, RoboCupJunior activities are well-established in science education in Germany. In 2011, 700 learners and 120 mentors participated in the RoboCup German Open.

Australia was involved in RoboCupJunior right from the beginning in 2000. Therefore, the country has much experience with this initiative and more than thousand teams participate in local activities and tournaments each year. South Africa has roughly double the population of Australia indicating that there is a lot of potential for teams from South Africa as well.

Surprisingly, in the US only 45 teams with about 300 students participated in RoboCupJunior in 2010. The main reason is that in the US the First Lego League is very popular even if the participation is limited in the US to the age of 9 to 14. The RoboCupJunior initiative does not have such age restrictions.

Austria started its RoboCupJunior initiative in 2007. At first, being only supported by a small number of participants and organisers, it became soon a well-accepted vehicle for science education. The reasons for that are manifold. One major reason is that Austria was able to set up a network of local support centres to assist teachers and schools with getting involved in RoboCupJunior. These centres offer robotics courses for learners and teachers, host open lab days and maintain a central rental pool for robot construction kits [14]. Another factor for the development of RoboCupJunior activities in Austria was that Austria hosted the RoboCup in 2009 with growing public interest since then. Table I overviews the number of participants from Austria. Of course, the peak in all numbers can be found in 2009 with RoboCupJunior being held on home ground. However, it can be observed that a growing number of schools participate in national competitions. The much lower number of participants in the international competitions can be explained with much higher travel costs. These number suggests that local competitions are a good way to establish such educational initiatives in a country.

B. Establishing the initiative in African countries

Since 2008 a network of robotics research is being set up in South Africa funded by the South African Department of Science and Technology. The Council for Scientific and Industrial Research and several universities work together to establish local RoboCup activities to support robotics research and education. Within this network, also RoboCupJunior activities were launched.

Based on the experiences of these first RoboCupJunior activities in South Africa and in collaboration with partners more experienced in RoboCup Junior, it seems to be possible to establish a sustainable education initiative. While in the initial phase a substantial amount of money will be necessary for building up the required structures, we believe that the initiative can be sustained with only little extra funding.

For the success of such an initiative five major targets need to be tackled. In general, the targets are similar to those of other countries, but they must be adapted to the African context.

1) Learn environment. First of all an inspiring and safe environment has to be established for where the learners can work, learn and develop their own ideas. This environment could be created similar to the concept
of the regional centres in Austria where students and teachers can work on RoboCupJunior related topics and get further support. Such an environment usually is more easy to establish at an institution such as a university. In the African context, an additional challenge is to organise transport to those centres for learners from areas with poor transport infrastructure. The centres therefore should not be located too far away from the local communities. Safety is another issue here.

2) Teachers are multipliers. It is important to involve teachers as much as possible. For one, they will work with the learners on RoboCupJunior, for another they are better able to spread ideas amongst their colleagues. The general challenge is not only to educate and motivate teachers to take part in such an educational initiative, but it is also very important to offer training courses and prepare course material in order to enable teachers to use educational robotics at their schools. Therefore, additional funds will be required for the training courses and the course materials.

3) Equipment at Regional Centres. Moreover, regional centres have to be equipped with the proper infrastructure. Robotics kits with additional sensors as well as computers and proper test arenas are required. Such equipment is the basis to be able to give courses or to offer open working days at the centre. In general, neither are schools in possession of the right equipment nor are they able to buy the special equipment required for such courses. A central rental pool for equipment could be an option to provide and share the equipment amongst several schools.

4) Sharing Skills. Once teachers and other volunteers have been trained in educational robotics and related issues such as programming, electronics or robot construction in the regional centres, they can again impart this knowledge to other teachers and offer support and courses to the learners for no or rather low costs. We recommend such activities as a strong tool for community building.

5) Local Competitions. Finally, local or national competitions are required to showcase the progress. The advantages of such events are threefold. First, a participation in a tournament is a valuable motivation for the learners. Second, it gives the initiative a high visibility. As schools and principals are interested in such publicity, the hope is that they will further support RoboCupJunior activities. Third, such tournaments are a fantastic community building tool, allow to exchange ideas and knowledge and allow learners, teachers, researcher, industry politicians to get into contact with each other.

Following this scheme with a moderate initial funding a substantial and sustainable impact could be achieved. Once established such an initiative can be sustained with limited resources. We hope that the initiative we started in South Africa will be adopted by other African countries in the future.

VI. Conclusion

Exposing young people to science and technology is important in order to give them the needed skills to face today’s and future technological challenges. Moreover, such exposure will stimulate the interest of the young people in science and technology. In particular, educational robotics has shown to be a good vehicle to achieve these goals. Hands-on teaching with robots was adopted by several international initiatives such as RoboCupJunior. In this paper we show some experiences of the getting RoboCupJunior started in South Africa. Encouraged by a strong positive feedback by all involved parties (learners, teachers, parents and people from academia) the initiative will be continued. We are convinced that the concepts presented in this paper can be adopted to the situation in other African countries as well. We hope that these ideas and activities will spread out in the African continent and will positively contribute to education systems in many countries. In future work we will concentrate on a sound long-term evaluation of the impact of the proposed concepts.

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References