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Children, robotics, and education

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Abstract Popular interest in robotics has increased astonishingly in the last few years. Robotics is seen by many as offering major new benefits in education at all levels. Before rushing to exploit this popularity, educators should ask serious questions about the universality and longevity of the robotics phenomenon. Is it a fashion? To be useful, the energy released by robotics must be sustained and universal, and the means of exploiting it must be systematic. Universities define their own robotics curriculum, but most schools lack both the resources and the freedom to do this, and must work with a national curriculum. If it can be shown that robotics has sustained potential in education, it seems inevitable that new ways need to be found to integrate it into the school curriculum.

Key words Children robotics education - Edutainment - RoboCup Junior - RoboFesta

1 Introduction

In the UK, as in many other countries, interest in robotics has swept across the nation. There are commercial magazines, such as Real Robots, there are hugely successful television programs, such as the commercial Robot Wars and the Government-sponsored Technogames, and many web sites, such as the BBC's site (www.bbc.co.uk/science/robots).

There is no doubt that many children and adults find robots fascinating (Fig. 1). Sales of affordable robot toys and robot construction sets are reaching unprecedented levels.

Many of us believe that robotics provides a tremendous source of energy that can be used to motivate learning for children and adults alike. However, before rushing headlong into new programs of education, we need to understand exactly what it is that robotics has to offer the educator. We need to resist getting caught up in what may turn out to be nothing more than a passing fad. Here are some of the questions that need to be addressed.

- Do children learn anything from robotics?
  - Social skills and teamwork?
  - Science, technology, engineering, math?
  - Literacy and communication?
  - Art, creativity and design?
- Is this different from other ways of learning?
- Is this popular interest in robotics a fashion, or is it likely to be timeless?
- Are there gender issues to be addressed?
- What is the best way to exploit the potential?

Anecdotally, almost anyone who has worked with children and robots will tell you that it was a great experience, that it was electric, and that the children got a lot out of the experience. Not surprisingly, many of us believe that this enormous interest and energy can be harnessed for educational purposes.

However, before steering our education system too far in the robotics direction, there are some important questions to be asked about the energy that seems to be released when children or adults build robots.

The first question is whether the popular interest in robots is a fashion. Will the passion wane and be displaced by some other activity or toy? Is robotics the hula-hoop of our decade? Will robotics become boring? If it does, then there can be no long-term commitment to teaching through robotics.

In principle one could teach science, technology, and mathematics through automobile maintenance. To my
knowledge, this is not done, and yet many of us claim explicitly that these things can be taught through robotics. Where is the difference?

In May 2000 I observed a bus-load of children arrive at the European RoboCup Competition in Amsterdam. They were to spend a Saturday participating in a new children's robot football competition devised by Henrik Lund and Luigi Pagliarini of the University of Southern Denmark, and organized by Ben Kröse of the University of Amsterdam. The children used robots constructed out of Lego Mindstorms, and a simple program interface devised by Lund and Pagliarini. Very quickly they learned how to construct programs using software with primitive behaviors such as “seek the ball” and “go to the center of the pitch.”

Building robot football teams is very difficult for adult scientists and engineers. Lund and Pagliarini’s ingenious approach simplified many problems by having a special infrared light-emitting ball that the Lego sensors could see. By making the pitch white at one end and black at the other, the robots have a one-dimensional orientation, which can be complemented by the use of touch sensors to give information about the other dimension.

By lunchtime, the children had programmed their robots to play, and during the afternoon a competition was held, and winners emerged. The atmosphere was electric. As I observed these children so passionately engaged with their robots, I was haunted by a question that would not go away: “What are these children really learning here?”

I think this question is fundamental. No doubt if the same group of children had been taken to another event, perhaps a sports event or a scout camp, one might have observed an equally electric atmosphere. Certainly children do learn things at these other events, so what, if anything, is special about robots?

One gain from robotics events seems to be in the behavior of the children. Their social behavior seems to change in positive ways. In a study of children participating in RoboCup Junior in Melbourne in 2000, all the 12 teachers interviewed remarked on the teamwork of their children.

Apparently boys start listening to each other when they are really motivated to achieve a common goal. And girls are different from boys.

Lund and Pagliarini have made great inroads into the gender question. They observed that boys get very engaged in robot wars and robot soccer, but girls do not. After experimenting with children in Scandinavia, they found that girls are not necessarily antirobot, but they approach robotics differently. They devised new, more creative, robotics activities. They then observed that girls like making clothes for their robots, devising dance routines for robots, making robot processions, and so on. In principle, girls and boys could benefit equally from robotics in the classroom.

2 Does robotics enable children to learn?

To answer this question, a distinction should be made between enthusiasm and learning. A distinction can also be made between serendipitous learning and structured learning.

Over recent years, teaching in the UK is increasingly judged by explicit learning outcomes. When teaching, we are expected to know our aims and objectives, and to have measurable learning outcomes. To this, many teachers would add less tangible outcomes, e.g., communicating to their students the joy of learning, and the fascination of the subject.

In robotics, the intangibles come free in most cases. Boys, in particular, are fascinated by robots, and are highly motivated to build and experiment with them. But what of the more formal learning outcomes?

In August 2000, I visited a rural school in Australia. The children were spending a technology lesson preparing robots to participate in RoboCup Junior in Melbourne the next week. One of the boys explained how he had built a circuit with an op-amp and some LEDs to make it easier to see what his Lego robot was doing. The previous summer, I explained op-amps to my daughter as she prepared for her physics examinations. For her, the knowledge had no applied context, and she found the whole thing rather abstract and boring. In contrast, the boy had built the op-amp circuit on his own initiative, and he seemed to have the best learning outcome.

To my knowledge there are no definitive studies that show that robotics improves learning outcomes. Most of the information available is anecdotal, and based on particular teachers doing particular things, or particular one-off initiatives reporting good outcomes.

One might ask if there is scope for a formal scientific study to investigate the efficacy of robotics in teaching any particular part of the curriculum. Perhaps some double-blind tests in which some children were educated over a sustained period using robotics when appropriate, with another group having some kind of nonrobotics “placebo” instead.

My belief is that this would be like drug trials in which the difference between the test and placebo groups be-