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Book Review by Kerstin Dautenhahn

Robots for Kids: Exploring New Technologies for Learning
Edited by Allison Druin and James Hendler
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“Robots for Kids” presents an overview on certain - primarily US American - research projects concerned with developing robotic technologies for educational purposes. The book was published in 2000 and since its appearance this research area has been growing steadily. For this reason, this review provides some extra information concerning recent developments within the field, in addition to the discussion of chapters in the book itself.

The editors of the book have been highly involved in developing computer technology for children. Allison Druin is Assistant Professor in the Human-Computer Interaction Lab and the Department of Human Development at the University of Maryland. She previously edited the book “Designing Multimedia Environments for Children” (with Cynthia Solomon), published in 1996, and “The Design of Children’s Technology” that appeared in 1998. James A. Hendler is full Professor in the Department of Computer Science and the Department of Electrical Engineering at the University of Maryland.

“Robots for Kids” is divided into three parts. Part I, “New Robot Technologies for Kids”, consists of four chapters, including an introduction by James Hendler, and three “kid’s views”. The latter make the book quite appealing since the
explain how robots were designed, programmed and tested, all described from a child’s perspective. This also includes children’s stories, attitudes and emotions towards the robots. The first chapter, “To Mindstorms and Beyond” by Fred Martin and his colleagues at the MIT Media Laboratory, traces the 30-year history of the development of a robot construction kit by a group led by Seymour Papert, with work beginning in the 1960s. The result was a programming language called LOGO, which has since been widely used in education. A second important outcome of this early research was a remote controlled device, a ‘turtle’ robot, which can move around on the floor according to a set of LOGO instructions that children program. The chapter describes the evolution of those early technologies of “robots for kids” up to the LEGO Mindstorms Robotics Invention system that was launched in 1998, and which has become very popular with children, University students and other adults likewise. Many projects referred to in this book use this technology.

In chapter two, Masahiro Fujita and his colleagues at the Sony Computer Science Laboratories propose a new industry called ‘robot entertainment’. This proposal led Sony to develop several prototypes of a mobile, autonomous, dog-like robot that ultimately resulted in the AIBO that has been on the market since 1999. An important feature of AIBO and other entertainment robots launched during the past few years is interactivity, that is, the ability to engage the user, and to make the user “care” about and bond with the robot. This is a goal shared by many other researchers that develop socially intelligent software and virtual or robotic autonomous agents (Dautenhahn et al 2002).

From a robotics point of view the AIBO is a sophisticated (although not inexpensive) entertainment robot that is also used in research laboratories all over the world, for, among other things, research into robot-human interaction or within the Artificial Intelligence challenge domain of Robocup, wherein soccer playing AIBOs form the 4-legged league (http://www.robocup.org/). Since 1999 Sony has produced a series of variations of the original AIBO, including the latest lion-type version ERS-210 or a futuristic version of the robot pet called ERS-220 (http://www.aibo.com). In summer 2002 Sony provided The Open-R Software Development Kit (SDK) that can be used to control the AIBOs. AIBO's main means of perceiving its environment is via touch sensors and vision. It can exhibit a variety of different dog-like behaviours, and will learn by means of praising or scolding by the user. Currently Sony's biped entertainment robot SDR-4X is making the news, but for many researchers AIBO still remains synonymous with entertainment robotics.

Chapter three introduces a research project that the editors of the book are involved in at the University of Maryland. Together with Jaime Montemayor they describe PETS, (the "Personal Electronic Teller of Stories"), a story-telling environment with 'emotional' robots, designed for elementary school children. An interesting aspect of this project is how the system was developed: through collaboration of an interdisciplinary group of researchers (educators, computer scientists, artists, roboticists and engineers) working together with a group of 7-11 year old children. Both adults and children were equal partners in the design process, following the design philosophy of 'cooperative inquiry'. The chapter provides details on the design choices that were made, the different roles played by the adults and children, and what has been learned from the project.

In chapter four, Richard Maddocks from RJM Design gives first-person insights into the toy market that he has been involved in for more than 25 years. As a toy designer at Matchbox he worked with many different categories of toys and the respective processes involved: diecast vehicles, dolls, action figures, preschool toys, games, plastic construction kits and remote-controlled/electric-powered vehicles. Using very concrete examples, Richard Maddock nicely traces the path from the original 'dream' via preliminary design sketches through prototype models until the product is finally released, pointing out various issues that make the whole process a 'drama'. The chapter is illustrated with many photos, design sketches and drawings.

Part II, "Innovative Approaches to Using Robots for Education", contains five chapters, including an introduction by Allison Druin and complemented by four "kid's views". In chapter five Gabrielle Miller and her colleagues from the Kennedy Krieger Institute discuss the use of robotics, in order to address the needs of learners with diverse needs in an inclusive classroom. Based on principles of teaching for diverse learners that were developed by Churton et al (1998), the authors see the following elements as crucial for the successful use of robots for diverse learners: experiential learning that helps students to understand and interpret concepts, cooperative learning for the facilitation of social behaviour, inquiry methods that support independent thinking and problem-solving, and a variety of different strategies used in instruction. The chapter discusses particular problems that children with learning disabilities face and how robotics can make a contribution. In addition to using robots for facilitating learning, robotics in classrooms can also prepare students for the demands on workplaces. The chapter concludes by briefly outlining three case studies where robots were used to support all learners.

In chapter six Marina Umaschi Bers and Claudia Urrea from the MIT Media Laboratory introduce the research programme of "con-science", which attempts to integrate learning about technology and values by providing tools and methodologies, including the construction of robotic devices. The authors discuss the goals and the learning processes that took place during a first pilot study, and a workshop where 25 parents and children explored technology and values together in an Argentinian school using the LEGO Mindstorms Robotics Invention System. The chapter illustrates how participants decided to use the technology in a variety of ways throughout a number of projects, namely to represent symbols, values, or to evoke reflection and conversation. This chapter gives an example of research that is not technology-oriented as such, but where technology is used to explore non-technological domains of human life, including moral and religious values.

In chapter seven, David P. Miller and Cathryne Stein from the KISS Institute for Practical Robotics give several examples of how robotics can be used in the classroom, based on their experience with thousands of children. The chapter discusses different projects in which children learn about various disciplines relevant to the curriculum, each with an emphasis on robotics. The projects notably include the team-based "Botball tournaments", the "Robotics in Residence" (RinR) programme, where an expert roboticist spends time with children in schools, and the outreach programme which targets economically disadvantaged, underrepresented or minority groups. Botball and RinR teach basic engineering and computer science principles, whilst also encouraging group teamwork, promoting an interest in science and maths and motivating the students. The authors conclude that, due to the multidisciplinary nature of robotics, it "would be possible to teach the entire K-12 curriculum using robotics as a framework" (p. 242).

In chapter eight Mark Yim and Mark D. Chow from the Xerox Palo Alto Research Center and William L. Dunbar from the Henry M. Gunn High School outline their three years,' experience as participants in the FIRST ("For Inspiration in Science and -profit organisation) robotics competition. In an initiative with teams of schools and corporate sponsors, students are getting motivated about aspects of science and engineering. It is also shown that the project facilitates self-confidence, teamwork, time-management and social skills. The excitement and fun of the project which the authors were involved in led to the construction of a large, complex, manoeuvrable robot that could be used to compete against other teams. Differing from other high-school competitions, the FIRST robots are human-sized and very strong. In the arena the robots are remotely- controlled by students, although levels of autonomy can vary. The chapter also addresses various aspects surrounding such competitions, such as media interest or parental involvement.

In chapter nine Robin R. Murphy (University of South Florida) and Michael Rosenblatt (CMU) introduce Robocamp, a one-week science summer camp for sixth to eigth graders. The goal of the summer school is to use robotics and Artificial Intelligence techniques in order to explore biological and physical sciences. The camp covers a variety of topics, including locomotion, perception and circuits. The pre-teen audience builds and programmes a robot, using a visit to the Zoo for inspiration and research into animal behaviour. Many guided activities complement the work. The chapter describes in detail the syllabus, the exercises done each day, the equipment used, and the lessons learned, with the hope that other people can replicate such a summer camp.

The last and third part of the book addresses “Future Visions” and consists of one chapter and one “kid’s view”. In chapter ten the author and lecturer Ray Hammond discusses the potential future of robots and intelligent machines in our society.

The contributions in the book are very much grounded in the constructionist approach that has been strongly advocated by Seymour Papert for several decades. Computer technology (software and hardware) has become a focus of attention for developing new approaches to learning and education. Generally, the constructionist approach focuses on active exploration of the environment, namely improvisational, self-directed, ‘playful’ activities in appropriate learning environments (‘contexts’) which can be used as ‘personal media’. In recent years, more and more computer software and robotic toys have become available, cf. the new generation of robotic pets, such as the previously mentioned robotic dog, AIBO. It can be expected that a new generation of children will use computer technology to an unprecedented degree in a variety of professional, educational and entertainment contexts, including interactive robotic toys and digitally-enhanced objects and tangible interfaces (Laurel, 1993). Such new interactive systems and novel interfaces are also likely to impact methods of therapy and rehabilitation, cf. activities in using autonomous robots in autism therapy (Dautenhahn & Werry 2000).

While I generally agree with the enthusiasm of the editors and authors concerning the use of robotics for teaching and learning, I would also like to offer caution in accepting statements such as that quoted above in the discussion of chapter seven. Given the current interest into using computer technology in classrooms, one needs to be careful not to get carried away by the possibilities that new technologies offer. A purely technology-driven path towards education and learning could introduce computers and robots at all costs, without a solid scientific basis of studies showing their benefits. Robotic and computer technologies bring many benefits, e.g. in terms of self-directed learning and motivation, but they are clearly not a generic “solution”. Surely (most) children enjoy working with robots, surely they will gain some kind of benefit, at the least in terms of enjoyment. But I believe that it is necessary to demonstrate the “added value” of robots, namely, if and how children who are using such technology on a long-term basis improve in learning compared to children who are not exposed to such technologies. Such research will show us when and why robots in classrooms are beneficial, for what target groups they are suitable, and when better not to use them.

The theme of using computer and robotic technology for children has significant relevance for Cognitive Technology, which is concerned with the relationship between the two domains of machines and human minds. Robots in the hands of or in interaction with children can go far beyond the nature of toys, such as non-robotic toys that are important in children’s (and adults’) play. Such “traditional” toys serve as facilitators and physical representatives of imagination and fantasy, for example a doll might one day represent a princess, while the next day it might represent an evil witch. Similarly a stick might represent a magic sword, an arrow, or simply a stick used as a tool in play. Then, what is so special about robots, what aspects allow them to transcend into being *instruments* that can play a constructive role in the development of children's minds? In Gorayska *et al*. (2001) one characteristic is discussed that distinguishes an instrument from a tool: tools usually just 'make a process happen', but they remain themselves unchanged. On the other hand instruments usually provide feedback, they can guide and expect guidance from us during the process in which they are involved. A plastic or wooden toy train does not adjust itself to change the process of learning and playing in which the child is immersed. The toy train will not actively change according to the processes of interaction, apart from wear and tear as a result of mechanical contact. A robot on the other hand is more than a passive toy, it is an interactive physical toy that can adapt to and actively shape the interactions.

Robots of the future might play different fundamental roles in our society, in education, at the workplace, in therapy and rehabilitation, and other areas. We, as humans, can hope for a benign future, a future in which robots are beneficial to the individual and the society. But we need to learn what robots are and what they can become, cf. the following brief scenario of a possible future with robots:

We know quite well what a human is like, as a rough estimation we can take ourselves as a good example. We do not know exactly what humans "are for", but we have an idea about what they can do, should do, or normally are doing. Our picture of humans and their "function" is not consistent, and need not be. But the picture is colourful, and structured; it is full of stories. What is an artefact for, e.g. a robot? A) It can be a machine, working and solving tasks for us, for example, an intelligent vacuum cleaner. If it has finished its work then we switch it off or it goes to its "nest". In any case, it should not bother us. B) It can be a very complex, unpredictable, "intelligent" machine, solving complex tasks, surviving in sewerage pipes or on the Moon. They should "function", by whatever means and techniques can be realised. Do we care about them? Well, they are somehow "life-like", but they are not like us, so why should we? We should be able to control them, because they could become dangerous. They are not adapted to us. If they are really good, then they can be competitors for resources. Will they be able to entertain us, to please us, to tell us stories? I believe not. They are enacting the stories they have been told (by the human designer). Humans will be "better", maybe physically weaker and incredibly slow. But we will keep the role of the story-teller. The human-embodied mind is the only source of creativity. C) Robots can be our "companions", our personal robots. They can help us in daily life, interact with us in an individual way, keep us comfortable, help us survive, entertain us. They are adapted to us, as an individual person, to our human society, to our human life. They can play these funny imitation games with us and make us laugh when they desperately try to flip-flap, but fail, their wheels block every time. They learn during their life-time about themselves, and about us. They are sitting with us in the garden, watching the crows playing in the air. We say how much we wish to be able to fly. The robot expresses: "I know what you mean". They can listen, and create their own stories. Do we care about them? Do we care about our pet dogs? Of course, they are a bit like us, somehow family members. They have a meaning to us, in our "world", the mental world created inside our mind, the only world we have access to. The only "real thing". We don't care what species the robots belong to or what kind of material they are made of. They are our friends (Dautenhahn, 1997).

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