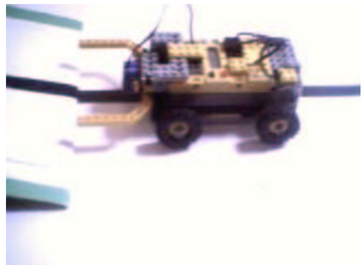
Scientific Challenge Award:
RoboCupJunior – Learning with Educational Robotics.

The RoboCup-2002 Scientific Challenge Award went to [1], work that examines the educational value of RoboCupJunior. In 1998, Lund and Pagliarini demonstrated the idea of a children's league for RoboCup, using robots constructed and programmed with the LEGO Mindstorms kit to play soccer [2]. Since then, RoboCupJunior has evolved into an international event [3, 4, 5] where teams of young students build fully autonomous mobile robots to compete in one of three challenges involving a curriculum-based, student-driven approach and each requiring a different level of sophistication (see figure 1).

(a) The **dance** challenge is an entry-level event. Students build robots that move to music for up to two minutes. Creativity is emphasized. It is possible to participate using simple robots that only employ motors and no sensors. The event is exciting and innovative. Some children even dress in costume themselves and perform alongside their robots.



(b) The **rescue** challenge is an event where one robot competes at a time. The field is white, and the robot is required to follow a black line through a simulated disaster scenario, along possibly uneven terrain. There are no dynamic elements, but accurate control of the robot based on light sensor readings is essential and surprisingly difficult.

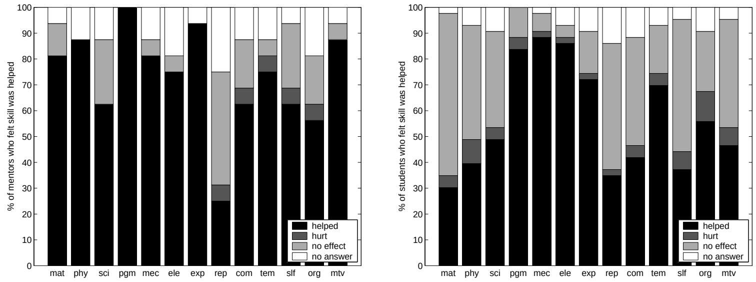
(c) The **soccer** challenge is an advanced event. Two teams of two robots each play on a special field, 150cm × 75cm in size. The floor of the field uses a greyscale mat and the ball is an electronic device that emits infra-red (IR) light [4]. The rules of play were developed from the RoboCup Small-Size League.

Figure 1: RoboCupJunior challenges.

The popularity of RoboCupJunior is self-evident, but one must ask: "what are the students learning from these activities?" It would be too easy to say that because the students are interacting with technology they are learning something worthwhile, yet this appeared to be the conventional wisdom in the early days. Today's researchers are questioning this stance [6, 7, 8]. The goal of the work presented is to question the "obvious" relationship between robotics and educational outcomes, attempting to identify and quantify the educational benefits of RoboCupJunior. Rather than focus just on the technology itself, the work examines the overall learning environment that results when groups of students participate in team robotic activities. The results of studies conducted at RoboCupJunior in 2000 and 2001 are presented.

RoboCupJunior 2000 involved 40 teams of children, ages 8-19, from Australia (38 teams), Germany (1) and USA (1). Twelve of the teachers who entered teams were interviewed, with the general stated goal of investigating the educational value of RoboCupJunior. This study revealed remarkable consensus of opinion amongst the teachers. RoboCupJunior fits in with existing robotics curriculum; is highly motivating for participants; advances both academic and personal development skills; teaches teamwork and tolerance of others; and appears to attract girls into robotics as well as boys. The RoboCupJunior competition itself is a motivating factor, particularly because: it is an international event, it imposes an absolute deadline (i.e., the date of the conference is fixed) and it gives young students an entry-level role in the complex and stimulating field of robotics research in an exciting context — alongside the senior RoboCup competitors, some of the top robotic scientists and engineers in world.

At RoboCupJunior 2001, 25 teams participated from Australia (10 teams), Germany (5), UK (2) and USA (8), ranging in age from 7 to 23. Mentors as well as students were interviewed. They were asked to consider 13 specific skills and indicate whether they felt their involvement in RoboCupJunior had helped or hurt each of these skills, or if there was no effect (see figure 2). The selection of the specific skills listed was based on the results of the study conducted in the previous year [5]. The overall consensus is that all the skills named were helped more than they were hurt. Note that participants felt that reporting skills were helped less than other skills. This could be due to the lack of activities such as keeping journals and writing



(a) mentors (b) students

key:

mat	math
phy	physics
sci	general science
pgm	computer programming
mec	mechanical engineering
ele	electronics
exp	experimental skills
rep	reporting
com	communication
tem	teamwork
slf	self-esteem
org	organization
mtv	motivation

Figure 2: Effects on various skills (2001).

The bars illustrate the number of participants who indicated whether each skill was helped, hurt, etc. For example, 80% of the mentors indicated that they thought their students' math skills were helped through their preparation for RoboCupJunior; approximately 12% of the mentors indicated that they thought that the preparation had no effect on their students' math skills; and 8% did not respond to the question.

lab reports. Further emphasis on reporting as part of the tournament itself (i.e., posters and papers) will help promote development of this skill set.

It is interesting to compare the mentors' and students' skill ratings. Overall, more of the mentors consider that RoboCupJunior has positive effects than the students. It is likely more difficult for students to assess the effects objectively than it is for mentors. Also, it is harder for students to assess abstract skills, such as communication, self-esteem and organization, than it is for them to evaluate concrete skills, such as mathematics, physics and programming. Future studies will investigate more effective ways of asking students about abstract skills.

The trends in motivational and developmental aspects were markedly similar between 2000 and 2001. Any differences found were mainly in terms of implementation. In 2000, all teams used the LEGO Mindstorms platform. In 2001, other platforms were used: Fischer-Technik mobile robot (16% of teams), Tetrixx kit (4%), and Mindstorms (80%). Another difference was in the number of classroom teachers who acted as mentors. In 2000, almost all of the mentors were teachers; in 2001, a small fraction of them were teachers.

The motivational aspects of educational technologies [9, 10, 11, 12] are also found in robotic soccer. Most teams spent more than two hours for each preparation meeting. This suggests that robotics activities are challenging and attractive enough to make students focus on their work for long periods of time. It also implies that, in order to merge this activity into regular curricula, teachers need to make effective plans to adjust the length of an activity into the regular class period without distracting students' motivation or to extend the class period to give their students enough time to explore ideas.

The emphasis on teamwork in RoboCupJunior allows students with a variety of interests and abilities an opportunity to pick their own challenges while contributing to the progress of the whole, an experience which nurtures the varied and multiple intelligences of each participant [13]. The work presented here fulfills a need in the community to examine the effects of these types of projects, to find standard and effective ways of evaluating them, and to define curricula that fosters and takes advantage of the positive elements identified.

References

[1] Sklar, E. and Eguchi, A. and Johnson, J. RoboCupJunior: learning with educational robotics. In Proceedings of RoboCup-2002: Robot Soccer World Cup VI.

[2] Lund, H.H. and Pagliarini, L., Robot Soccer with LEGO Mindstorms. In RoboCup-98: Robot Soccer World Cup II, Lecture Notes in Artificial Intelligence (LNAI) vol. 1604, Springer Verlag, 1998.

[3] Kröse, B., Bogged, R., and Hietbrink, N., Programming robots is fun: RoboCup Jr. 2000. In Proceedings of Belgium-Netherlands AI Conference 2000, 2000.

[4] Lund, H.H. and Pagliarini, L., RoboCup Jr. with LEGO Mindstorms. In Proceedings of ICRA2000, New Jersey: IEEE Press, 2000.

[5] Sklar, E.I., Johnson, J.H. and Lund, H.H. Children Learning from Team Robotics: RoboCup Junior 2000 Educational Research Report, Technical Report, The Open University, Milton Keynes, UK, 2000.

[6] Healy, J., Failure to connect: how computers affect our children's minds, New York: Simon & Schuster, 1998.

[7] Reeves, T. A Research Agenda for Interactive Learning in the New Millenium. In Proceedings of the World Conference on Educational Multimedia, Hypermedia & Telecommunications (EdMedia99), 1999.

[8] Snyder, T., Blinded By Science, The Executive Educator, 1994.

[9] Soloway, E., How the Nintendo Generation Learns, Communications of the ACM, 34(9), 1991.

[10] Verner, I.M. The Value of Project-Based Education in Robotics. In RoboCup-97: Robot Soccer World Cup I, Lecture Notes in Artificial Intelligence (LNAI) vol. 1395, Springer Verlag, 1997.

[11] Verner, I.M. The Survey of RoboCup '98: Who, How and Why. In RoboCup-98: Robot Soccer World Cup II, Lecture Notes in Artificial Intelligence (LNAI) vol. 1604, Springer Verlag, 1998.

[12] Lepper, M. and Henderlong, J., Turning "play" into "work" and "work" into "play": 25 years of research on intrinsic versus extrinsic motivation. In Intrinsic and extrinsic motivation: The search for optimal motivation and performance, Academic Press, 2000.

[13] Gardner, H., Frames of Mind: The Theory of Multiple Intelligences, 1983.