Oh THAT's What You Use π For!

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The results of the recent Third International Mathematics and Science Study demonstrate rather dramatically to the world how far behind American students have fallen in their collective ability to understand important concepts in these subject areas and to apply that knowledge in a pencil and paper test. US high school students placed near the bottom of the nations tested in math and general science, and dead last in their knowledge of physics.[1]

So what's the problem??

One problem is that high school students frequently become jaded and disenchanted with their classes, perceiving them as unrelated to anything important, and certainly not activities that engage their talents and interest for any length of time. When they get out into the real world they will have learned a lot of facts and theories, and yet they will not be capable of pulling it all together, to apply that information in a useful and creative way.

Another is that toy and entertainment technology has become too advanced and too well packaged. In the 1960s & before many a budding engineer got their start by taking apart their toys to see how they worked and to "make improvements." At that time all that was needed to take most toys apart was a modeling knife and a set of screwdrivers. Once apart, a basic textbook on mechanics, circuitry or motors, would tell you everything you needed to understand all the components of the toy and how they worked together. Often, the same set of tools used to open the toy up were all that was needed to modify its performance.

Today's toys are usually plastic welded shut. Once you've broken into the container, usually you face a circuit board filled with chips that don't even have visible part numbers. Usually any modification by an experimentally minded child leads to a total loss of functionality.

During the late '70s and early 80s there was a brief time when children could experiment with programming. Every computer came with a programming language environment. More importantly many of the popular computer games of the time were written in these languages, and the example code was often available. Perhaps even more importantly, a motivated person with a bit of skill and creativity could create their own game or piece of software that would in many ways rival the commercial versions. High schoolers liked to write programs because they would then use those same programs for their own entertainment.

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[1] See http://ednet.edc.gov.ab.ca/news/1998nr/Feb98/nrtimms.htm for detailed scores

Today's games and applications are huge projects involving many people and dozens of workyears. A new programmer cannot readily be expected to create a piece of software that will maintain even their own interest for an extended period of time -- given the competition.

As a result, most computer classes for elementary and secondary school focus almost entirely on how to use preexisting applications. Even many universities have stopped offering a non-major computer programming course, and instead offer courses on how to use various application packages.

If the preceding problems were not enough, for a variety of social and other reasons, many girls around the age of 11 begin to turn away from topics like math and science, never to discover and develop their natural talents and abilities in these areas.

We believe that robotics can change this course of events. The reason is that robots are inherently interesting. Aside from the gee-whiz and technical attraction they exert for many people, robots ooze a sense of power for their creators. Robots are Frankenstein's creature for the masses. Robots move their creators one step up in the Universe's hierarchy.

KISS Institute for Practical Robotics (KIPR) is a 501(c)3 nonprofit organization that is promoting robotics technology and education. We have created a variety of demo systems to hilight particular aspects or applications of robotics for example:

- Scarecrow[2] was a robot designed to carry out an AI-hard task, yet where every piece of the robot and its controller was visible and understandable to an elementary school student.
- Color Tracking SCAMP[3] was a set of experiments done with the SCAMP robot from UMD to show how real-time color tracking could be used to do reliable and inexpensive station keeping and autonomous docking in spacecraft.
- TinMan[4] is a series of semi-autonomous wheelchairs that demonstrate the utility of robotics for people with severe mobility disabilities.

In addition, we are directly addressing these education problems through our various robotics education programs. We have been offering robotics classes and assemblies since 1994 and have worked with students from kindergarten on up through professional development courses.

Robotics, especially as it has been conceived in the past 10 years, can be made readily accessible to student's with very limited backgrounds. KISS Institute has developed a series of lesson plans and accompanying equipment & software that has successfully had students in fourth grade and up design build and program their own robots. What's more, as they do it they get links back into their standard curriculum and make use of the math and science they have already learned, and learn to appreciate what will be coming up in these areas over the next few years. Finally, they work with robots using some industry standard tools. When they learn how to program a robot they are learning how to write

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[2] Miller, D.P. & Milstein, J., Scarecrow the Robot, in AI Magazine, vol 13 #2, Robotics Competition Conference Supplement, 1992

[3] D.P. Miller, A. Wright, R. Sargent, R. Cohen, and T. Hunt, Attitude and Position Control Using Real-Time Color Tracking, in Proceedings of the AAAI-97/IAAI-97 Conference, pp. 1026-1031, Providence, RI, July 1997.

[4] Miller, D.P., & Slack, M.,G., Design & Testing of a Low-Cost Robotic Wheelchair, in Autonomous Robots, volume 1 #3, 1995.

real-time code for embedded systems in the C programming language. The knowledge they gain is directly applicable to their next level of school or employment.

The Roboticist in Residence Program gives classes, assemblies, demonstrations and robot-building activities at a variety of schools. Our goal is to inspire all different kinds of kids to look at robotics as something fun that you can do that uses the math and science that you already know or are about to learn. It is tremendously rewarding to be working with a group of 5th graders, as we were recently, and hear one of the boys who was working on programming the robot to turn exactly 90^{o} suddenly exclaim, "Oh THAT's what you use π for!" We were giving talks at an inner city school with very limited resources last year and one of the students remarked "I didn't know you could do something fun like that when you grow up. How can I get to do robots when I grow up?" What an opportunity to drive home the message that paying attention to math and science now will pay off in the long run. We make a point of communicating this at all our Roboticist in Residence activities.

Our other main educational focus is KISS Institute's Botball Program, in which middle school and high school students design, build, and program small autonomous mobile robots to perform a planetary rover style task and then participate in a head to head regional Botball Tournament. No remote control is involved, the students learn to program the robots in C, a useful skill they can employ immediately in today's market. The Botball Program uses hands on design, research building and computer programming experience to tie together basic concepts in math, science and related fields. Reports from teachers and parents describe how students have become excited about using what they already have learned and become motivated to pursue further study (or employment/internships) in these fields.

The Botball program contains several activities to educate both students and high school teachers.:

1) Teachers from participating schools participate in a multi-day robotics workshop where they get tutorials and workshops on robotics. this way they understand the activity, can teach it, and can integrate the material into their normal class curriculum.
2) During the tutorial and later, the teachers work with mentors from local universities and corporations -- creating useful alliances for the future.
3) Student robot research: Each team researches and writes up a web page on a space robotics topic (assigned at the start of the program). The students learn how to use the Internet to perform research and find out how the robotics skills they are learning are being used in the aerospace industry today. They also get to do some brainstorm and publish their ideas. Examples of past topics include designing a robot to mine ice on the Moon, and creating the next generation of Mars rovers.
4) Student designed/built robots: Each team designs and builds an autonomous mobile robot to accomplish the Botball contest task. The task is a head to head game involving both offensive and defensive strategy and actions.

The teams are organized into a double elimination tournament which is held at the end of the (approximately) one month building period. The web pages are also judged at this time by a panel of experts. Prizes of additional robotics equipment are awarded as prizes.

One of the features of the Botball Program is that it strengthens the bonds between schools, sponsoring organizations and graduate students from local universities who act as team mentors. Although the mentors are there to help, one of the precepts of the Botball Program is that these robots are completely student-created. The robotics tutorial covers not only the design, building and programming content that a teacher will need, but also methods of integrating this information into the existing curriculum.

Another important feature of the Botball Program is that the robot kits used to build the robots for the Tournament stay with the school and are completely reusable. Since no machining is involved to create the Botball robots, the kits may be used for variety of class activities without any additional cost, and in an as-new condition. We have found that students have gone on to modify their robots and design their own competitions after the official Botball Tournament had concluded. Equally important, the teachers have been trained on the kits and on the theory and practice on which they are based. Botball makes a lasting improvement to a school affecting not only the students in the program, but all the students taught by those teachers or who use the equipment in their classes.

During 1997/8 three trial Botball tournaments were held involving over 300 students and twenty-six teams. A dozen metropolitan areas have made inquiries about setting up Botball in their area, and we hope to expand the tournament to approximately five hundred teams during the next few years. For more information about the Botball program or organize or sponsor a team please see http://www.kipr.org/botball or write to botball@kipr.org