Educating potential engineers about marine conservation

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Abstract - **Marine conservation is usually a subject that is taught to life sciences students at secondary schools. As such, those students interested in marine conservation tend to come from biology and related subjects. The project described in this paper aims to bring the concepts of using technology for marine conservation to those students of a more technological background. In the Hong Kong Underwater Robot Challenge students build their robots and prepare a written report about their robot project; the robots are brought to a competition where they are judged on their robot's design and construction, give an oral presentation, and test their robot's performance. Scoring of the competition is based on all four components. The great interest in the ocean surrounding Hong Kong led to the idea of having the students build underwater robots, similar to those of the MATE/MTS competition. The parts kit includes motors, wire, propellers and switches, and the robots' performance is tested in a pool by carrying out tasks under remote control.**

Index Terms - Underwater robot, environmental education, marine conservation, robot competition

INTRODUCTION

Over the past few years WWF Hong Kong (Worldwide Fund for Nature) [1] and City University of Hong Kong [2] have established a close working partnership, especially in the field of environmental research and conservation. The laboratory occupied by the joint research team from the CityU Departments of Biology and Chemistry, and Electronic Engineering at the WWF Marine Life Centre at Hoi Ha Wan Marine Park [3] has pioneered the use of technology in monitoring the marine environment. The use of remote sensing and monitoring equipment, as well as the use of remote operated vehicles (ROVs) has established a world recognised programme that is drawing international attention. Allied with the educational programmes at Hoi Ha Wan run by the WWF, students and teachers from Hong Kong schools are being introduced not only to the science of the marine environment but also to the positive contributions that technology can make. The Underwater Robot Competition described here is enhancing the interest of the more technologically inclined students and widen the scope of the WWF education efforts.

The aims of the project are:

- To introduce technological concepts into marine environment and conservation education programmes.
- To publicise the work currently being carried out by WWF and City University of Hong Kong in this area.
- To enhance the awareness of Hong Kong teachers and students to marine conservation.
- To provide a platform for design and technology students to partake in a practical design exercise with observable objectives.
- To promote the development of technical, problem solving, critical thinking, and teamwork skills.

The first contest in Hong Kong was advertised widely in the press in December 2005, and 20 schools applied to join; 16 were accepted after some preliminary discussions to ascertain whether the students would be capable of performing in the contest, as well as determining the commitment of the school and its teachers. This was part of an international contest organised by the Marine Advanced Technology Education Center (MATE), Monterey, CA, USA in cooperation with the Marine Technology Society (MTS).

According to the MATE/MTS regulations for the International Contest, "Students can design and build the vehicles as an entire class project or school group activity. The group must be affiliated with a school or a home-school network and/or demonstrate that 1) the participating students are currently enrolled in a high school, and 2) the students are working under the supervision of an adult mentor.

"Teams must have at least three students with at least one faculty member or adult advisor involved in the process. One student should be designated as the team spokesperson.

"Teams are discouraged from using complete, commercially available, off-the-shelf, plug-and-play systems. Teams will not be disqualified from competing for using these types of systems, but the engineering evaluation and technical report score sheets will reflect our effort to discourage the use of these systems.

"The role of the faculty member or adult advisor must be limited to educational and inspirational support. Actual construction of the vehicle, particularly in the complex electrical and software areas, must be completed by the students. Students will be questioned extensively by the judges on their role in designing and building the ROV" [5].

THE ROBOT KIT

All teams were supplied with a kit of parts to build a very simple robot. The concept of an inexpensive kit of parts, made available without charge, was based upon an original idea developed by MATE Center and a number of other educational groups in the US [4]. There are also resources on

the Internet with information about building underwater robots, and a book by Harry Bohm [6]. Providing some of the basic parts to the student teams makes entering the competition less daunting. As many of the components in the original rov kits designed in the US were not available in Hong Kong (as well as being specified in non-metric units!), a new kit was designed which synthesised some of these other ideas. A list of contents of the parts is shown in Table 1; it includes those parts for building an ROV that would be difficult to find in a hardware store. as well as various lengths of plastic pvc tubing for the frame of the robot, and some toilet cistern floats for the buoyancy control. A completed robot built with these parts can be seen in Figures 1 and 2.

TABLE 1
PARTS AND COSTS OF BASIC ROV KIT

	Unit Price HK$	Unit	Total HK$
Model 25D,Rule 500 GPH Bilge Pump	$130.00	3	$390.00
Propeller	$50.00	3	$150.00
Speaker Cable 20m 22 gauge			$150.00
U Clamp	$9.00	3	$27.00
15mm pipe 1.5m			$15.00
L shape pipe join	$3.00	10	$30.00
T shape pipe join	$4.00	4	$16.00
Glue	$10.00	1	$10.00
Toilet Float Ball	$7.00	2	$14.00
Plastic Net 10 inch X 6 inch	$10.00	1	$10.00
SPDT on-off-on Switch	$14.00	3	$42.00
Box	$12.00	1	$15.00
butts Insulated Terminals	$1.00	10	$10.00
3A fuse	$0.50	3	$1.50
fuse holder	$2.00	3	$6.00
Eyelets and Insulated Terminals	$0.10	40	$4.00
#31 wire nut	$2.00	2	$4.00
	Total costs HK$		$894.50

The cost of each kit came to around HK$894, or US$115. This did not include a camera module, and each robot would need at least one to be able to complete the tasks in the competition. These would be one of the extra components that the students would need to buy to do so.

To introduce the students and their teachers to the contest a series of workshops was help at CityU in the Underwater Systems Laboratory to allow each team to build the rov from their kit. As most schools in Hong Kong do not have access to a mechanical workshop all tools and accessories, as well as access to a test tank were made available. Figures 3 and 4 show the workshop activities.

FIGURE 1
CONSTRUCTED ROV MADE FROM KIT OF PARTS SUPPLIED - REAR VIEW

FIGURE 2
SIDE VIEW OF BUILT ROV

FIGURE 3
WORKSHOP ACTIVITY

Fourteen of the sixteen teams were able to build their rov and test it in the water tank within the three hour period allocated.

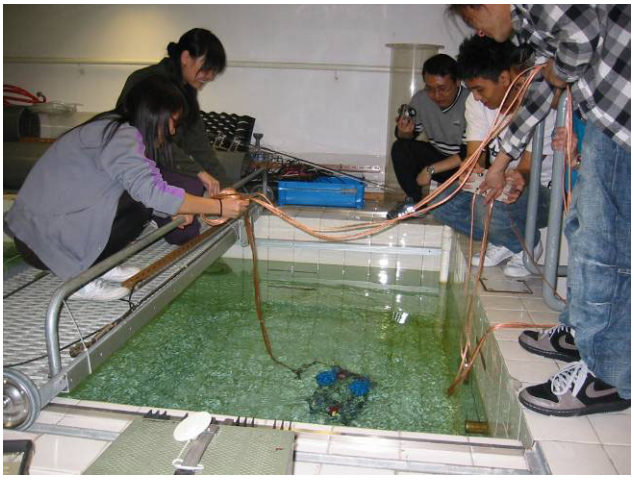

FIGURE 4
TESTING IN THE WATER TANK

THE COMPETITION

The competition was based upon that designed by MATE Center for the MATE/MTS ROV Contest 2006. The teams from Hong Kong, being school students, were competing in the Ranger class contest. There is also an Explorer class contest, which is more advanced, and is for experienced schools and/or colleges. This year the Ranger mission tasks that the robots had to perform included:

- Transporting the electronics module from the surface to the trawl-resistant frame.
- Placing the electronics module in the frame.
- Opening the door of the trawl-resistant frame adjacent to the submarine cable.
- Retrieving the submarine power/communications cable connector from the seafloor.
- Inserting the power/communications connector into the appropriately labelled open port on the electronics module. [5]

There was also another task which involved locating and attaching to the acoustic transponder's release loop and removing the release loop from the acoustic transponder to free the instrument.

These two tasks had to be carried out in 20 minutes. Teams were allowed two attempts, and the highest scoring run was the one marked.

The rovs had to be able to work at a depth of 5 m and at a distance of 7m from the pool edge. They could only be powered by 12 v dc and with a maximum total current of 25 A.

THE WORKSHOPS

A series of workshops to introduce the concept of designing and building an underwater robot were organised for the teams, as shown in the photos above. This not only allowed the teams to complete the kit robot which had been designed by CityU, based on a combination of two designs from Bohm's book, and the availability of parts in Hong Kong.

However, it was not only the robot construction that interested the students. As the contest was sponsored by WWF Hong Kong there was an environmental aspect that needed to be addressed too. Therefore a number of workshops were held at the Marine Life Centre in Hoi Ha Wan Marine Park - a marine environmental centre run by WWF, and where CityU also has a Marine Science and Engineering Laboratory

As well as having an introduction to the marine environment around Hong Kong, the teams also took a ride in the Centre's glass bottom boat to see the coral reef at first hand. Then they were given the opportunity to drive the laboratories commercial rov. Figures 5 to 7 show some of these workshop activities.

FIGURE 5
ON THE GLASS BOTTOM BOAT

FIGURE 6
DRIVING THE ROV

The commercial rov is used at the laboratory to survey the coral reefs in the marine park. The laboratory also has permanently deployed video cameras and instrumentation on the reef for monitoring purposes. The students were able to

witness real-life applications in these workshops, which gave them a better understanding of why they were taking part in the competition.

FIGURE 7
IN THE LAB

THE HONG KONG FINALS

The Hong Kong finals, to select the team to go to Houston, TX for the International Contest was held in the swimming pool at CityU. 14 teams made it through to the final, all with rovs that were based on the original kit, although some had changed considerably. As the original design was scalable, most had been made larger to accommodate the electronics module, which was around 400mm x 400mm x 550mm, and weighed 0.5 kg in water.

The final contest was held in the 3.3 m deep middle of the pool. The mission props were placed around 3m from the side of the pool. Each team was given 15 minutes to complete the two mission tasks. At the same time, each team was given a notice board to display a poster of their work, and table and power supply to work on their robots before and/or after their runs. They also had to exhibit an engineering report which was judged during the contest for content, as well as their robot being graded for its engineering. The engineering and report/poster marks made up half the total marks. Extra marks could be gained for completing the tasks in the time allowed. No team was able to finish the tasks, but two came very close.

Figures 8 to 11 show some of the robots and how they performed in the pool.

THE HOI HA WAN TRIALS

The three top teams in the swimming pool contest were taken to the WWF Marine Life Centre in Hoi Ha Wan Marine Park two weeks later. They were then given the chance to operate their robots in the sea, and try and locate an object suspended from the glass-bottom boat. This allowed them to see the difference between operating a robot in the swimming pool/ test tank and the sea. All three teams were able to locate the object successfully in a short time. In fact, it was surprising how such simple rovs could perform so well in a real life environment! Figures 12 to 14 show the Hoi Ha Wan trials.

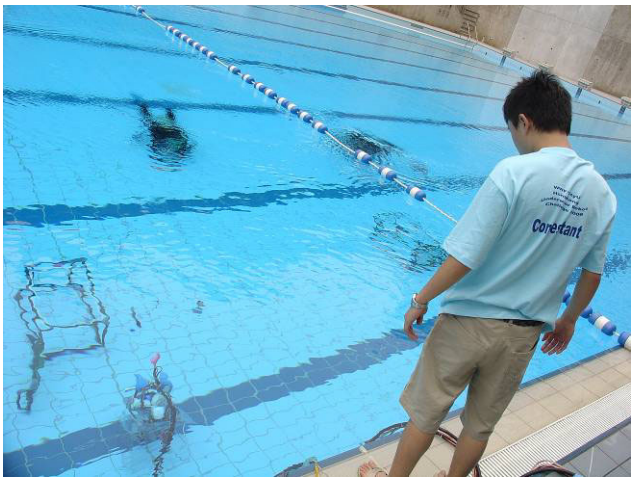

FIGURE 8
A POOL FULL OF ROBOTS - SHOWING THE UNDERWATER MISSION PROPS

FIGURE 9
JUDGING THE ENGINEERING AND DOCUMENTATION

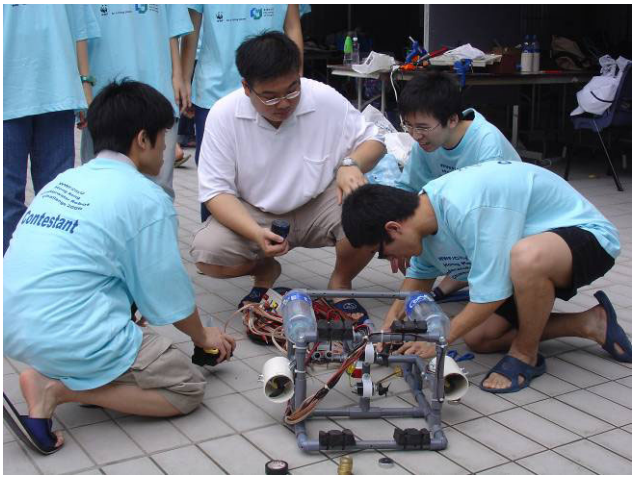

FIGURE 10
MAKING FINAL ADJUSTMENTS

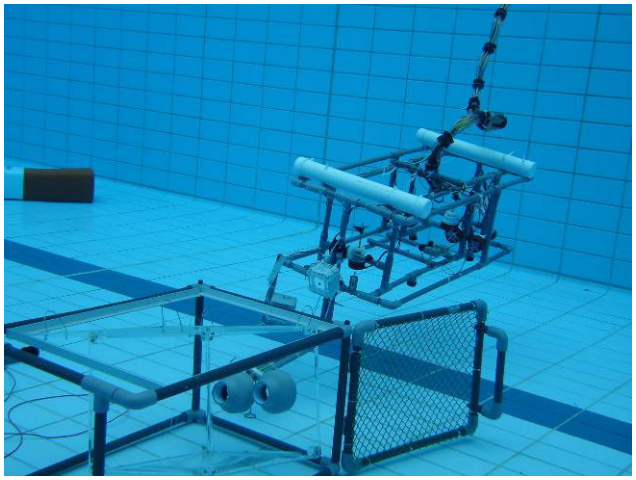

FIGURE 11
MANOEUVRING THE MODULES

FIGURE 12
DROPPING THE ROBOT OVER THE SIDE OF THE GBB

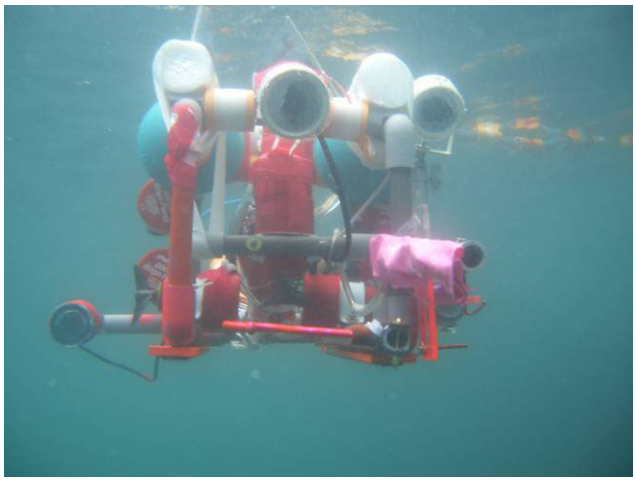

FIGURE 13
LOOKING FOR THE OBJECT IN THE SEA

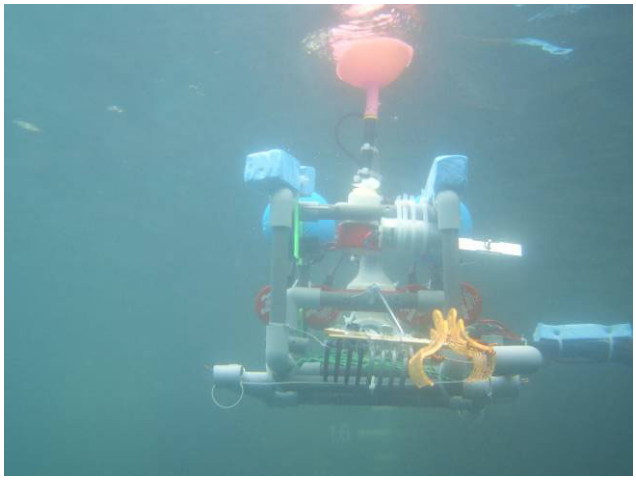

FIGURE 14
SEARCHING!

THE EDUCATIONAL OBJECTIVES

The main objective of holding the competition was to introduce technology students to the concept of marine conservation, as well as to give them an opportunity to design an underwater robot. These two main objectives were fully met, and feedback from the teachers involved has been very positive.

None of the students had seen an underwater robot before the contest started, so the fact that 14 of the 16 original teams were not only able to build a fully functioning robot, but one that, in most cases, could also carry out at least one of the mission tasks, was beyond our initial anticipations.

The availability of the basic kit certainly helped, as did the hands-on workshops staffed with graduate students working in underwater robotics research. The contestants could easily relate to what they were trying do, as it was not an abstract task. Certainly, the visits to the Marine Park at Hoi Ha Wan gave an insight into practical applications of using technology to assist marine scientists, as well as seeing real rovs in action. The relationships between technology and conservation are not usually obvious - especially when technology is sometimes seen as causing many of our environmental problems. However, the close collaboration between the Department of Electronic Engineering, and the Department of Biology and Chemistry at CityU, especially with the use of rovs to monitor the reef at Hoi Ha Wan [7], as well as the development of underwater instrumentation for ocean observation [8] [9], meant that the real-life and practical aspects could be demonstrated.

At the same time the competitive nature of the contest, with schools competing to go to the USA for the International Finals in Houston, TX, added some excitement. This was shown by the number of teams who came to the Underwater Systems Lab at CityU during the periods when there were no workshops, so that they could test their robots, as well as use some of the specialist facilities. Again, the presence of graduate students working in underwater robotics and instrumentation meant that much was learned by the

contestants, which probably could not be found in books or on the web!

CONCLUSIONS

The First Hong Kong Underwater Robot Challenge was run from January to April 2006. It was a joint effort between WWF Hong Kong and the City University of Hong Kong and was designed to not only raise awareness of marine conservation issues amongst technologically oriented senior school students, but also to give them a competitive situation in which to design, build and operate an underwater vehicle. These aims were successfully accomplished with 14 out of the initial 16 teams entering the finals of the contest.

During the competition the students not only learned about the marine environmental around Hong Kong, they also learned how technology is being used to conserve that environment.

At the same time, they learned about underwater robotics, and, initially using a simple kit supplied by the organisers, eventually designed quite complex robots to carry out a series of tasks stipulated by the organisers of the International ROV Contest in the USA. The students experienced how to work as part of a team, and how to organise a complex project. The judging of the contest combined not only the completion of the tasks and the speed at which they were completed but also the documentation and engineering aspects.

For further information please look at the contest web site www.ee.cityu.edu.hk/rovcontest.

FIGURE 14
THE TOP THREE TEAMS AT HOI HA WAN

ACKNOWLEDGEMENTS

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