Using Stiquito in an Introduction to Engineering Skills and Design Course

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Abstract *- The nature of problems that engineers must solve varies among the different branches of engineering. Although engineers may use different steps in their design processes, most processes include the following: identifying the problem, gathering needed information, searching for creative solutions, modeling, evaluating and selecting a preferred solution, planning, and implementation [4]. Engineering design is the creative process of identifying needs and then devising practical solutions to fill those needs. The general procedure for completing a good engineering design can be called "the engineering method of creative problem solving."*

A course that introduces these concepts, discusses different engineering disciplines, and provides hands-on activities can provide an effective introduction to engineering for beginning students. North Carolina State University conducted a course in the fall of 1996 that used the micro-robot Stiquito to teach students about engineering design and project implementation. The Stiquito robot is a small, inexpensive, six-legged robot that is intended as a research and educational tool.

This paper describes the course and how Stiquito was used as a key part in it. It also discusses details from student evaluations of the course.

Keywords: Engineering, Hands-on, Stiquito, Applied Learning.

The North Carolina State Introduction To Engineering Skills And Design Course

The Electrical and Computer Engineering Department at North Carolina State University offers the course Introduction to Engineering Skills and Design, ECE 292D. This course is an experimental two semester-hour course open to students who have not completed any engineering courses (i.e., freshmen and rising sophomores). All participants meet once each week for a videotaped session in a T.V. classroom. They are also divided into small studio groups of approximately six, each led by an upperclass student (studio instructor). Each studio meets once a week for an hour-and-forty-minute session at one of four scheduled times.

The course incorporates group exercises into the videotaped classes, along with presentations by various guests. However, the main hands-on group activities take place in the studio, since the small group environment is more effective for teaching team-building. The objectives of the course are: to ease the transition into the engineering curriculum, to demonstrate what engineering is about, to focus on requisite skills such as teamwork and communication, and to provide initial experience with engineering design.

Teamwork is strengthened by an off-campus, all-day ropes course early in the semester, as well as exercises in the studios. Communication skills are developed through several exercises, most importantly by group presentations given to the class by each studio group. Each session is videotaped and reviewed by the student presenters during a subsequent studio session.

In addition to work with the Stiquito robot discussed in detail below, the students are assigned a conceptual design problem. Each studio goes through the design process from brainstorming to construction of a mock-up of their conceptual design. Inexperienced beginning students are capable of creating effective designs on a conceptual level and demonstrating their ideas concretely, even if they do not have enough knowledge to build a working prototype. This past fall, there were nine studios and thus nine independent solutions for the proposed device.

Course materials included one inexpensive paperback book [4], the handouts, and a locally produced course-pack containing material on Stiquito. The material in the course-pack is now available in a book from the IEEE Computer Society Press as noted in the bibliography at the end of this paper [1]. In addition, the Seven Habits of Highly Effective People by Steven Covey [3] was an optional text. Material from Covey was incorporated into the group presentations given by the studios.

Stiquito

Stiquito (Figure 1) is a small, inexpensive hexapod (i.e., six-legged) robot. It has been used since 1992 by some universities, high schools, and hobbyists, although a commercially prepared kit has not been available until this year. Stiquito is unique not only because it is so inexpensive but because its applications are almost limitless.

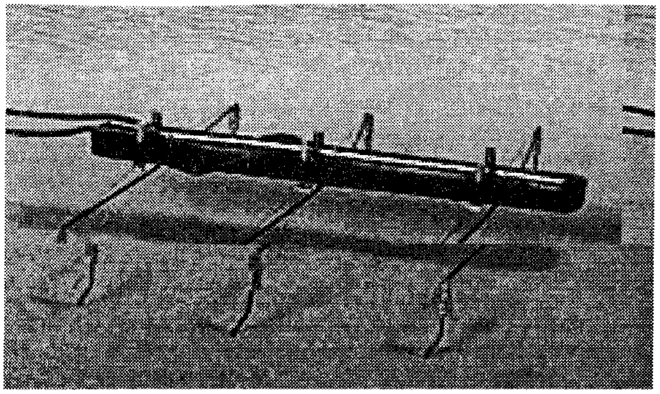

Figure 1: The Stiquito Robot

Stiquito was developed by Jonathan Mills of Indiana University as an inexpensive vehicle for his research. He soon found its applications extended to educational uses. It has been used to introduce students to the concepts of analog electronics, digital electronics, computer control, and robotics. It has also been used for advanced topics such as subsumption architectures, artificial intelligence, and advanced computer architecture.

The IEEE Computer Society Press has published the book, *Stiquito: Advanced Experiments with a Simple and Inexpensive Robot*, in 1997 [1]. This book contains instructions for building the Stiquito robot, instructions for designing and building control circuits, and examples of student projects that use Stiquito. Most importantly, the book contains all the supplies needed to build the robot. Only a few tools are needed to assemble a complete Stiquito. Since this book includes assembly instructions as well as materials to build a robot, it can easily serve as a required textbook for a class, with only minimal electronics required to extend investigation to other areas.

The Stiquito robot also provides opportunities for examining various engineering disciplines. For example, previous exercises using Stiquito have included creating Stiquito kits from raw materials, similar to that which is included with the book mentioned previously. Given long lengths of music wire, aluminum tubing, spools of wire, and other parts, students fill small plastic bags with the parts necessary to build a Stiquito later. This process requires students to contemplate industrial engineering concepts, including assembly lines and materials handling [2]. Often, when studying a topic, students are only provided the theory, written assignments, and basic experiments and are not given an opportunity to build an actual application or implementation -- something they can call their own and take with them. The Stiquito robot can be used to fill the gap between theory and application.

Using Stiquito In The Class

Stiquito was not used as the sole focus of the NC State Engineering Skills and Design course. Instead, it was used as one example of both the engineering design process and skills used by a practicing engineer. Specifically, students examined the robot's design and built a working robot from the kit. Then they examined the personal computer interface design and built an interface to the PC circuitry. They also wrote a small BASIC program to control the robot and make it walk. All supplies required to build the robot are provided with the Stiquito kit and instructions, which were created especially for the class, but are now readily available with the Stiquito book. Assembly tools used were a hobby knife, needlenose pliers, an ohmmeter, a battery, and a soldering iron. Power was provided by a 9-volt or 5-volt battery and a 1-amp bench supply. The only additional supplies needed to build an interface for controlling the robot from a PC are perf board, a 25-pin D-shell connector, six transistors, and wire.

The studio instructors attended a workshop given by James Conrad on building the Stiquito robot. Each studio instructor then built a working robot before beginning the project with his or her students. This process was important, as the students needed an experienced mentor who could understand and help them when they had trouble. The students also needed to see working robots as proof that they can be built and can walk correctly. The studio instructors, in turn, needed a local "expert" to turn to if they had any difficulties. James Conrad also gave a talk describing the objectives of the Stiquito robot, its history, importance, applications, and future. The course instructors and studio instructors had discussed creating a Stiquito competition in which students would race their completed computer-controlled robots for prizes and glory. Unfortunately, there were too many activities planned for the class and the class ran out of time to run the race at the end of the semester.

Student Results

Each student was required to construct his or her own Stiquito from the basic materials provided. Time was allocated in three consecutive studio meetings for the students to work on building their robots. Quite a few students required time outside of the group sessions to complete the robot, especially if they had to redo some steps due to error or accident. All students completed the tasks assigned, although the results were mixed. Some Stiquitos worked almost perfectly, while others barely functioned. However, the process of building the robots provided many benefits. Working in the small group environment, sharing problems and troubleshooting tasks, trying to interpret and follow written instructions, and asking questions of the studio instructor and fellow students were essential to developing teamwork skills and removing apprehension about building a physical device. The atmosphere in the studios remained positive, even when students were struggling with tedious manual tasks. Clearly providing most of the time required for building the robots in group sessions rather than relying primarily on independent effort outside of class was critical to the success and benefit of the exercise. Students learned to deal positively with frustration and to gain strength from the support of their peers. Even the students whose completed robots had significant problems did not seem to be particularly upset. Everyone learned that what looks straightforward on paper often does not work perfectly in implementation. They also discovered work-arounds and simpler techniques for addressing problematic steps in the process.

Student Evaluations

An independent evaluation of the effectiveness of the Engineering Skills and Design course was conducted after the fall 1996 semester. This evaluation included comments about and ratings of the course by students and studio instructors from the previous three years. Although the evaluation contains great detail about the entire course, only the comments on Stiquito are presented in detail here. Overall, students rated the class as excellent. They particularly enjoyed the projects assigned to them. As mentioned above, Stiquito was only one of several assignments given throughout the semester. Many people mentioned that they would have liked to have had more time to work on the Stiquito robot and on the other projects.

The work with Stiquito brought out strong feelings among students. Of the respondents, one quarter said Stiquito was one of the best aspects of the course. Unfortunately, just as many said it was one of the worst aspects of the class. One student even wrote "my baby [Stiquito] wouldn't walk," showing that students took pride of ownership in their work, even if they were not successful.

One explanation for the significant number of negative evaluations might be the specific kits they used. These kits contained manually produced prototype bodies that even James Conrad found difficult to work with. This problem has been corrected in the kit supplied with the book. Another explanation might be that students did not see a practical application for the robot. This could have been solved by holding a "drainpipe race," in which robots race through a pipe, simulating how they could be used to examine plumbing.

Conclusions

Overall, ECE 292D has proven to be an excellent course for new college students to learn valuable lessons about the realities of engineering study and practice. The evaluations show it has accomplished its objectives of advancing students' personal development and their understanding of engineering. The course's strengths include exposing students to several examples of engineering and providing exercises in engineering design. Exercises using the Stiquito robot were an integral part of this course in the fall of 1996. When this course is offered again in the fall of 1997, hexapod robots will be used again as an instructional tool, perhaps to an even greater extent.

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