# THE MELTING POT APPROACH TO SENIOR DESIGN
# Part II: ASSESSMENT AND IMPROVEMENT

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## Abstract

In the Winter 2004 semester, in an effort to provide its undergraduate students with a true multidisciplinary, real-world, team design experience, the senior design courses in computer engineering, computer science, electrical engineering, manufacturing engineering, mechanical engineering and systems engineering of Oakland University's School of Engineering and Computer Science were combined and supervised as a single course. Design teams were assembled that spanned all of the represented areas of study and three experienced faculty members, one each from the Computer Science and Engineering department, the Electrical and Systems Engineering department and the Mechanical Engineering department, provided guidance for their respective areas and collaborated in the administration of the course.

With a year of experience in administering such a course, and by critically examining data taken through two comprehensive assessment cycles, the original ideas for this change of practice have been positively reinforced. The details of administering the course, however, have undergone remarkable changes in this short time. What we have learned about these types of projects, how students respond to them and how to make them better experiences for both students and faculty, are the major topics of this paper. Also included are details of the projects pursued in the Fall 2004 and Winter 2005 semesters.

## Review of the Melting Pot approach

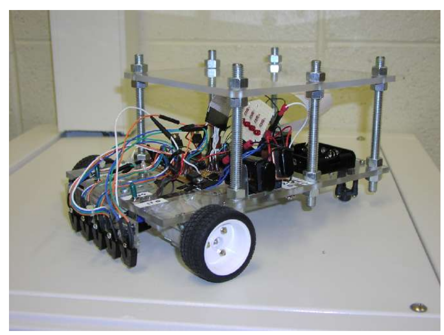
The Melting Pot approach to design developed at Oakland University has the following characteristics:

- The course consists of all seniors in all of the engineering disciplines represented at Oakland University: computer, electrical, mechanical and systems, as well as computer science. The design experience is supervised by three instructors, one from each of the three engineering departments, who provide support for their respective disciplines and share the responsibility for the administration of the course.
- Design teams are formed primarily by distributing the engineering disciplines and extracurricular talents and resources of the students throughout the teams. This approach

flies against conventional wisdom[1-3] in that we do not consider students' schedules at all, but since we meet each group only once per week for approximately 20 minutes, teams can, if they have no other time available, use half of the scheduled class meetings to come together.

- The design teams are given the responsibility, and held to the consequences, for organizing and motivating themselves.
- The projects assigned to the teams have not been solved, or even explored in depth, by the course instructors. In a very real sense, we don't know if the design assignment is even feasible before the end of the semester. We have found that the very best projects are those that seem impossible to accomplish in a 14-week semester.
- Questions from students are very rarely answered, except with "I don't know, let's find out." In fact, the process of choosing the projects insures that the instructors do not have ready answers to questions. Instead, students are able to watch the instructors learn along with them, and can see real examples of how to search out and find important information. It is a particular challenge for instructors to give up the seductive model of the professor as the expert authority, but relinquishing this control frees both the instructor and student to truly learn.
- The design experience always culminates in a competition open to the public. In the short history of this Melting Pot approach, these competitions have become very popular campus attractions, with hundreds of spectators cheering on the teams in the Winter 2004 semester competition.

**Initial Assessment Results and Improvements**

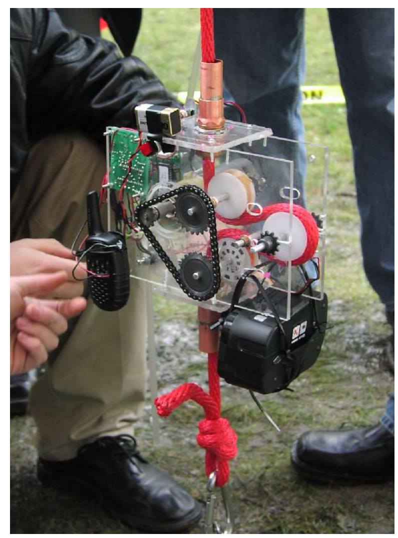


The project assigned in the initial semester of the Melting Pot design experience was to design, build and compete with an autonomous vehicle that followed a curve of electrical tape placed in a closed circuit on the floor, up to 100 m long. Because this type of project is common for high-school science courses (in fact, the actual purpose of the project was to configure a parts kit for a design course planned at the sophomore level), additional complications were included, such as the long length of the course (most of the high school projects are demonstrative in nature, and negotiating a 3 m length of tape is considered a success) and the requirement that the vehicle be able to function successfully while carrying an additional 15-lb payload. The cost limit for the kit to be designed was $150. Due in large part to the resources and hints available for such projects online, all of the twelve design teams successfully negotiated the course and the competition was intense. The project was a good mix of mechanical, electrical and computer engineering and computer science components.

The main assessment tool in the School of Engineering and Computer Science is the *External Evaluation of Program Outcomes*, where evaluators not associated with the course are invited to peruse student work and decide the level at which the work demonstrates the stated program outcomes. Feedback from the *External Evaluations* showed that most of the reviewers were pleased with the multidisciplinary aspects of the project and said that the program outcomes had been achieved, but were not generally pleased with the level of difficulty or the apparent industrial relevance of the project or the level of analytical detail found in the project reports. Input from the instructors themselves revealed gaps in the knowledge of the students, most notably the lack of understanding of automatic feedback controls, due mainly to the sequencing of courses.

Based on this feedback, the instructors decided that the projects chosen for future semesters had to have a higher level of difficulty, as perceived by students, other faculty and practicing engineers. More emphasis is now placed on analysis, but not to the exclusion of clever ideas that seniors do not yet have the skills to analyze, especially for the mechanical components. This is a fine line to walk: to require analysis of the designs, but not to restrict the design solutions to come from the limited set of cases that seniors are able to thoroughly analyze. Industrial relevance of the designs is the responsibility of the students to explore, and initial steps have been made to include students from the OU School of Business Administration to provide marketing and business plan components to these projects.

**The Fall 2004 Project and Its Assessment Feedback**



In the Fall 2004 semester, the Senior Design Project was to design and construct a device that will climb a common rope (1/2" braided solid-core polypropylene rope) hung from the top of the 8-story Science and Engineering Building. The rope was hung about 1.5 meters away from the tower. The device was required to climb the rope autonomously, ring a bell at the top of the rope and return safely to the ground. In addition, it had to announce, in a voice loud enough to be heard on the ground, its position above the ground every 3 meters of height, both ascending and descending. Time penalties were assessed for inaccurate height announcements. As an additional complication, the competition was held on December 2, 2004 (in Rochester, MI, a northern suburb of Detroit) beginning at noon, “rain or shine, snow or ice.” Each team was limited to a total cost of $250.

This project was considerably more challenging than the line-following vehicle in that the device had to physically haul itself up and down the rope as fast as possible, favoring light weight designs, powerful motors and large power supplies – and proved itself to be an excellent exercise in designing under conflicting and contradictory specifications. The height announcement systems considered were many and varied, but as the deadline of the competition approached, most groups opted for non-powered encoder wheels to give them a reliable distance along the rope.

The possibility of inclement weather concerned most of the design groups, but most of the groups were worried most about the loss of friction if the rope got wet or possibly frozen. In reality, the cold (2 C) and windy but dry competition day weather played havoc with battery performance, and only two groups of the nine actually reached the top of the 30 m rope, with only one design successfully performing all of the required tasks.

This project, noted by the *External Evaluations*, had considerable mechanical and electrical challenges, but the computer engineering and computer science aspects were concentrated mostly in the height-announcement requirements and were seen as not especially critical to the overall success of the project. In spite of this, and of the limited success of the design teams to successfully negotiate the rope, the project and the design experience received excellent evaluations from the students.

**The Winter 2005 Project**

The project assigned in the current semester is to design, build, test and compete with a device to project ten 1/2" diameter balls over a 1-m high barrier into a target bucket (a standard 10-quart pail) located up to 10 m away from the device. The 10 balls will be a random mix of five different materials, with a range of mass that spans an order of magnitude. Sighting of the target is accomplished only through a single web cam on the target side of the barrier. The web cam images are online and accessible to all of the design groups. It was anticipated that the devices could not be made to be truly autonomous in 14 weeks, so two parts are required, the component that actually projects the balls to the target and, through wireless connection, a separate computer to acquire and process the web cam image and send controlling data to the firing device, all displayed through a graphical user interface that will be projected for spectators to see as the competition is running. Scoring of the competition will be by formula, with the number of successful target hits divided by the total time for the 10 shots and further divided by the cost of the projecting component. As a result, there was no cost limitation to the design. Everything else being the same, less expensive designs will score higher, but increased performance because of higher quality components may be advantageous.

Since this project is in progress at the time of this writing, no external feedback is yet available. This project was conceived and designed to have considerably more computer science content than the previous projects while still keeping the mechanical and electrical engineering challenges high. In addition, students are required to keep a project log throughout the course of this project. This log is intended to be a record of all work, thoughts and ideas connected with the project. It is anticipated that keeping this log will make it easier to keep organized and remember ideas, both successful and unsuccessful, and ease the burden of presenting the progress of the project in the weekly meetings with instructors, at the midterm oral progress report to the class and in the final oral and written presentations.

As of the time of this writing, approximately midway through the semester, most of the 8 design groups have successfully built prototype devices that can project the balls, solved the problems associated with wireless communication between their microprocessor-controlled devices and the image-processing computers, and are in the final stages of successfully processing the web cam images to target their devices. Getting all of these parts to work together to shoot the balls quickly and accurately into the buckets will be the challenge for the remainder of the semester.

## Conclusions and Future Plans

By all accounts, the Melting Pot approach to capstone design projects has been a success at Oakland University. Part of the success of this approach has been the commitment of the instructors to incorporate the assessment feedback immediately into the process by which the projects are selected, the expectations of the students are developed and communicated and to act as coaches and mentors during the design experience. Many plans for future projects have been documented, but we are always looking for more and more challenging suggestions. Please contact any of the authors if you have a project idea you'd like to share.

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