

# Introducing Hands-on Experiences in Design and Manufacturing Education\*

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*ME250 (Introduction to Design and Manufacturing) is a core-course for undergraduates in the mechanical engineering department at the University of Michigan. It was introduced based upon recommendations from a review committee analyzing the mechanical engineering curriculum. This course is now a mainstay in the design/manufacturing sequence. We describe the objectives, philosophy, contents and teaching methods of ME250. It provides the mechanical engineering sophomores with a hands-on experience in design and manufacturing. The benefits of this course are now being felt in the curriculum, particularly in the capstone senior design projects course.*

## INTRODUCTION

THE UNIVERSITY OF MICHIGAN has a long history of excellence in design and manufacturing education that has involved, amongst others, Professors Boston, Colwell, Datsko, Juvinal and Shigley, etc, [1]. In the 1980s and up until early 1990s, our curriculum had a two-course sequence in mechanical design (ME 350, Design of Machine Elements and ME 450, the capstone Senior Design Projects). Both were core courses. In manufacturing, however, there were no required/core courses and students had an option of taking one or more electives. The senior design projects course involved students working in groups, but projects typically did not involve any fabrication. Students wrote lengthy reports that contained a description of the design problem, several concepts, some analysis, a final design and often a section on manufacturing plans.

With the hiring of several new design faculty during 1989-91, the content and structure of the design courses were revisited and, as a first step, it was decided to focus on ME 450, the capstone senior design projects course. After several discussion sessions and visits to local area industries, ME 450 was revamped. The highlights of the new version included almost 100% industry sponsored projects that spanned the automotive, aerospace, defense, biomedical and other industries. The course lecture content was also restructured and guest lecturers were included from industry and other departments of the university as necessary (e.g., product liability and intellectual property

issues). This revamping of ME 450 resulted in better interaction with industry and a heightened level of excitement amongst the students since now they were working on 'real world' projects. Clearly, this revamping had a very positive effect on the overall curriculum since the senior design projects provided the 'integrative' experience for most students.

However a deficiency was also exposed. The students coming into the senior design projects course, by and large, did not have much hands-on experience. But, the industry-sponsored projects almost always required the fabrication of full-scale working prototypes and often they were quite intricate. More importantly, our students were facing real-world design/manufacturing problems, and even though they had very good analytical skills, most of them were not well prepared to think in 3-dimensions, deal with fabrication and work coherently in groups. This deficiency was also pointed out in a survey conducted by the Departmental Undergraduate Curriculum Review Committee that was charged with performing a comprehensive analysis of the undergraduate curriculum and providing recommendations. The recommendations of this committee were major [2] and resulted in a substantial restructuring of the undergraduate curriculum in the department, which was later followed up by the College of Engineering in creating the Michigan Curriculum 2000 [3].

A key recommendation of the Departmental Undergraduate Curriculum Review Committee was the establishment of a new sophomore-level course in design/manufacturing. This would be a core course, establishing a 3-course (12 credits) sequence in design/manufacturing. This paper

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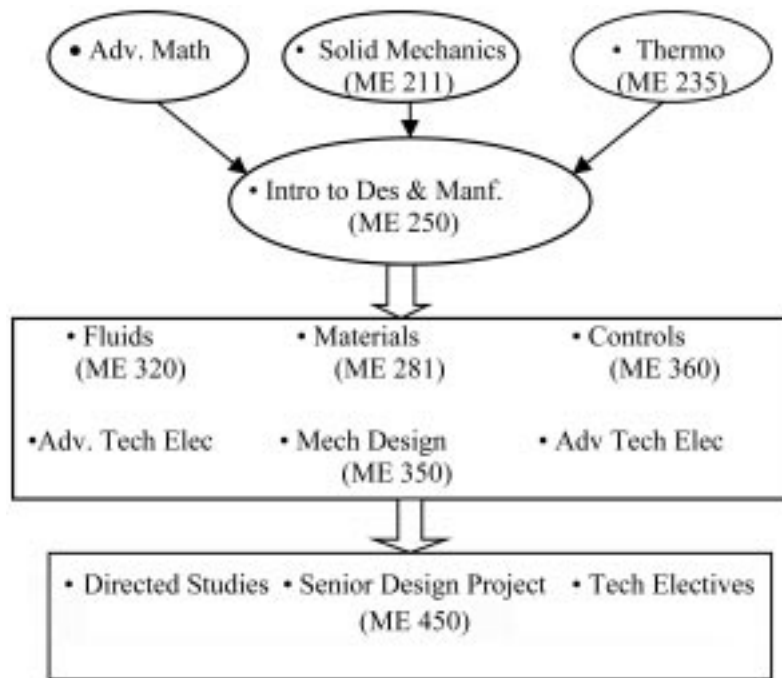


Fig. 1. ME250 within the curriculum.

focuses on the new course by describing its objectives, structure, lecture and laboratory contents, semester projects and other organizational/logistical issues. The flowchart in Fig. 1 outlines how ME250 fits within the curriculum. It shows the core courses that feed into ME250 and how the ME250 feeds into other core and electives all the way up to the Senior Design Projects (ME 450).

### ME250: THE COURSE

To address the aforementioned need and recommendation, a new course, ME250 Introduction to Design and Manufacturing, was designed and implemented. It was developed as a 4-credit hour core course to be taken by all sophomores in the mechanical engineering curriculum. Typical enrollment, per semester, has been 125+ students (although the past few terms has seen the enrollments go up to 160+ students).

ME250 was developed with the goal to provide all mechanical engineering students exposure to an integrated design-manufacturing environment early in their curriculum. Our objective in ME250 is for the students to gain an understanding and appreciation of various visualization, design and manufacturing issues, and their interplay, that lead to quality products. A key aspect of this course is the 'hands-on' manufacturing experience. A semester group project is required in addition to mini-projects, home works and exams. For the faculty also, ME250 is a team effort, and is typically taught by two/three faculty from areas spanning design, manufacturing, materials, and thermo-fluids.

ME250 is structured as lectures and laboratories course. There are two lectures per week (typically Tuesdays and Thursdays) and are 1.5 hours each. The lectures are held in an auditorium style classroom that has the capacity to hold all (160+) students. There are two laboratory classes per week (typically on Mondays and Wednesdays). Each laboratory is one hour and each section has 20–23 students. Although, the contact hours per week are five (two 1.5 hrs lectures and two 1-hr labs) ME250 is a 4-credit course.

All lectures are given by faculty while the graduate student instructors are fully responsible for the laboratories. Administratively, one faculty is the course leader and has overall responsibility for the course. The full teaching team meets once a week for an hour to discuss various issues and matters arising. The lecture homework is graded by a grader (hourly employed undergraduate or graduate student) based on a solution set provided by the faculty. Exams are graded by the faculty. The laboratory homework is graded by the graduate student instructors.

### ME250 LECTURES

In order to complete successfully the real-world design/manufacturing projects, an engineer has to acquire and master a variety of engineering and non-engineering skills. However, within the time constraints a semester, we chose our core focus as developing and sharpening the engineering student's ability to:

1. visualize, think and communicate in 2D and 3D;

2. relate engineering drawings to manufacturing processes;
3. build mechanical artifacts by synthesizing (1) and (2).

The first objective is achieved in the lectures by covering basics of visual thinking (descriptive geometry) and engineering drawing. The students are encouraged to think visually and the basic principles of descriptive geometry are taught. Many students find this module quite difficult. Basics of engineering drawings (orthographic, auxiliary and section views, etc.) are also covered. In class, exercises are done and weekly homework is designed to reiterate the concepts.

Next, product design methods (QFD, concept selection, functional analysis), are discussed. QFD is discussed in detail. Students are encouraged to sketch concepts and systematically evaluate them. By this time in the course, student groups are formed and the semester project is assigned. The teaching staff form the student groups (typically, four students per group) based on a one-page questionnaire that reveals each student's design/manufacturing skills. Each faculty and lab instructor is assigned 4–6 project groups to supervise. To emphasize and enhance teamwork, several homeworks and in-class exercises are required to be done in groups. This enables the group members to know each other and establish working relationships. Sometimes, during this stage a group realizes internal problems (incompatible work habits, schedules or self-expectations). In such situations, our focus is primarily to help the group to work out its own problems by meeting with the faculty and carefully preparing weekly schedules that are realistic. We note, however, sometimes a group's problem persists throughout the semester.

The second objective is accomplished by introducing students to the basics of geometric dimensioning and tolerancing (GD&T), statistical methods and manufacturing processes. The key here is to emphasize that understanding an engineering drawing for the purposes of fabrication requires an understanding of GD&T and manufacturing processes. Fabricating the part as specified in the engineering drawing requires a good understanding of the designer's prescription (based on functionality) and the available manufacturing resources. In the lectures, the basics of manufacturing process planning, metal removal methods (primarily lathe, mill and drill), cutting tools and tool life equations, and a few primary manufacturing processes such as casting, forming, injection and blow molding are covered. Finally, the third objective is accomplished via the semester project which we describe in a subsequent section in detail.

The semester concludes with lectures on cost issues related to design and manufacturing. Typically, one lecture is devoted to economic and financial considerations and one lecture to production planning (for mass production). Technical

writing is also covered given by a faculty from the College's technical communication program.

The philosophy of ME250 is to emphasize 'breadth over depth' with a view towards providing a big picture of design/manufacturing and the complex issues therein. As appropriate, we draw the students' attention to various elective courses in materials, manufacturing, controls, thermo-fluids, etc., that provide the depth in relevant areas. This also has the effect of putting a large part of the mechanical engineering curriculum in perspective early in a student's program.

### ME250 LABORATORY

In parallel to the lectures, the students are trained in (i) a CAD/CAM system (Unigraphics) and (ii) CNC machining on lathes and mills. The laboratory is a key/integral component of ME250. At the beginning of each semester, all ME250 students are required to take (OSHA mandated) three 2-hr safety modules on the use of cutting and drilling equipment, lathe and mill. This is done outside of class hours and the students sign up for the safety classes offered three times a day, based on their schedule and free time. An advantage of completing this safety training in their sophomore year is that their names are maintained in a database for the duration of their stay in the department, i.e., for any shop work that they have to do in other courses and most importantly in the capstone design projects.

In the first half of the term, the students use the CAD laboratory to learn Unigraphics. The CAD laboratory is a College of Engineering computer laboratory that contains 24 HP workstations. The latest version of Unigraphics (V18) is available throughout the college via a site license and is upgraded each summer. In ME250, students are taught the basics of solid modeling (not freeform surfaces) and CAM, which produces the CNC cutter path generation in 7 weeks (2 lectures per week). Homework is assigned weekly.

Beginning week 8, the students come to the CAM laboratory which is a state-of-the-art CNC laboratory [6] with five table-top CNC 3-axis milling machines and four table-top CNC lathes, all from Emco Maier, a well known machine tool manufacturer. All the machines have industry standard Fanuc controllers. There is also a table-top, manual co-ordinate measuring machine (Microval) from Brown & Sharpe. In the CAM laboratory, nine Dell PCs are interfaced to the CNC lathes/mills and three PCs are available in the lab work area. All the PCs are on the network.

In the laboratory portion of ME250, students work in groups. First, each group does a machining mini-project. Typically, it is an exercise in which several pieces of an artifact (e.g., a 3-piece brass candle stand) are created in Unigraphics. Then the cutter path for the lathe and the mill are generated using the Unigraphics CAM software

and then pieces are machined on the CNCs. At the end, the pieces assemble into one product (the candle stand). This exercise not only reiterates group work and individual responsibilities therein, but also exposes the students to a dose of 'real life' situations (e.g., computer network being down, improper file transfers, CNC machines not zero-referencing properly and so forth). Via these machining exercises, students are better equipped to handle the semester project.

### ME250 PROJECT

The open-ended semester design/manufacturing project is an important component in ME250. The project description is given to the student groups approximately 4th week into the semester. It is typically the design and prototype fabrication of a simple consumer product, e.g., a computer mouse, stapler, tape dispenser, flashlight, adaptable telephone-rests, etc. The product need is described, a market defined and available manufacturing resources stated. (See Appendix for a sample project description and requirements.)

Each group is assigned an instructor (faculty or graduate student instructor) resulting in approximately 6–8 project groups per instructor. Typically, the groups meet with their instructors once a week towards the beginning and later in the semester as need be. The use of design documentation (notebooks) and projects planning via Gantt charts is emphasized.

The groups perform a customer survey and via QFD and concept selection methods, decide on

their final product design. There is no analysis component in the ME250 course since the sophomore students do not yet have the background/courses. They are, however, strongly encouraged to consider fabrication issues (process limitations, cutting tool availability, etc.) during the design stage.

The students then create a CAD model of the concept using Unigraphics. Depending on the manufacturing process chosen, they either make molds for casting, or plan for making the final part directly by machining. The NC module of Unigraphics is used to generate cutter paths, post process it, and then download it directly, over the network, to the machines (mill/lathe) PCs, or to one of the work-area PCs/HPs. There the tool path files are verified and edited (for changes in process parameters if necessary) and then downloaded to the CNC machines. If they make molds by NC machining, then the final part is made using injection molding. Sometimes, depending on the group, critical dimensional tolerances of the product are measured using the CMM. Finishing operations like polish and paint is strongly encouraged and typically done by hand. The groups spend a good amount of time finishing their products. Figure 2 shows a variety of ME250 projects from past semesters.

### COURSE GRADING

The prototypes are judged based on a set of criteria agreed upon by the instructors and the graduate student instructors. The criteria typically



Fig. 2. A sample of ME250 final design projects

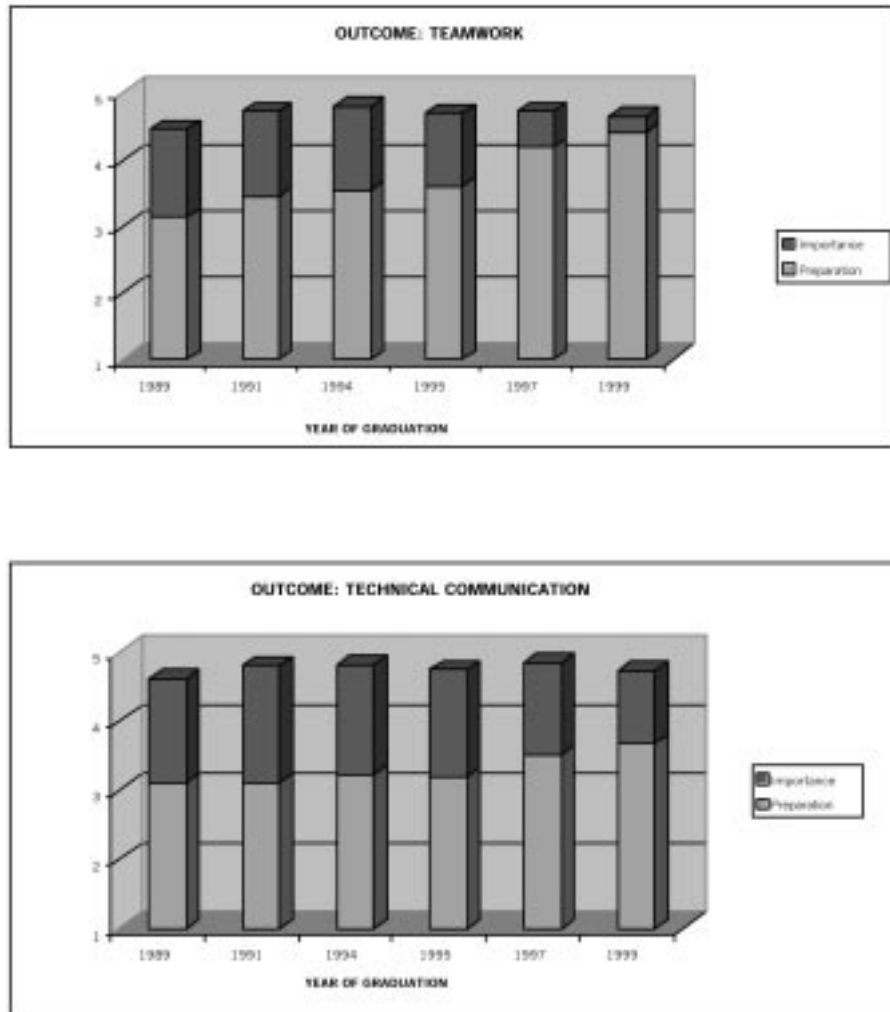


Fig. 3.

include product functionality, aesthetic appeal, product quality and finish, etc. The first, second and third place winners get cash prizes. If appropriate, few others get honorable mention certificates. Periodically, we have been able to secure industry sponsors for the course who attend the Design Expo\* and give the awards to the student groups. This is an event that student groups always look forward to, since the awards are only announced at the ceremony.

The projects require a written report from each group. A general outline is provided to the students and they are required to describe in details their design process, fabrication methods, and costing. All engineering drawings and concept sketches are required in the appendix. The reports are evaluated separately from the prototypes. Each group is also required to give a 10 minutes oral presentation on their project in the last laboratory

\* Design Expo is held every semester in the department. Typically held the last Tuesday or Thursday of the semester, the Design Expo showcases the ME450 (senior design projects) all afternoon. ME250 projects are displayed in one booth in the Design Expo.

period. The final project grade is determined from the prototype, report and presentation grades.

There are two in-class, closed book, and non-comprehensive exams in ME250. Each count for 20% of the course grade. The project is worth 25%. The laboratory exercises (CAD and CAM) are worth another 20% and finally, the lecture homeworks count for the remaining 15%. The lecture homework is one per week and the two worst scores are dropped. As can be seen, 45% of the grade involves hands-on work.

### THE IMPACT OF ME250

The introduction of ME250 marked the beginning of extensive changes in the Mechanical Engineering curriculum at the University of Michigan. These changes were intended to meet the changing demands on engineering graduates [4, 5] and are fully described [2]. In particular, ME250 was created to address a need that stemmed from the revamping of our capstone design project. Today, the benefits of ME250 are evident. All students entering the capstone senior design projects course have had the following.

1. Introduction to formal design methods.
2. Introduction to basics of manufacturing.
3. Experience in using unigraphics CAD/CAM and CNC cutter path generation.
4. Experience in using CNC machines.
5. Experience in working in groups.
6. Experience in technical report writing and project presentation.

Note, most students encounter one or more of the above in other courses/electives prior to the capstone design course. Such reiteration/practice equips the typical student very well to handle large industry sponsored projects in the capstone course.

Finally, the real-world experiences that students are exposed to in ME250 are predominantly in the context of the semester project and can be summarized as:

- dealing with uncertainty;
- dealing with incomplete information;
- dealing with 'working in group' issues;
- working on open-ended problems.

The above are extremely important, and often very frustrating, experience for a sophomore. They are made aware of this early in the semester. While we often cannot prevent the situations that bring about frustration in ME250, we emphasize communication (between students themselves and with the teaching staff) as a means to deal with it.

The departmental surveys of the graduating students indicate the impact of the hands-on approach to design and manufacturing that we initiated with ME250. The charts in Fig. 3 illustrate our alumni responses to the importance of teamwork and communication in their current jobs and how well our curriculum prepared them for teamwork.

Surveys are taken every two years and Fig. 3 contains student responses from graduates in the years 1989 through 1999 [7]. ME250 was introduced in 1993 and the first batch with ME250 graduated in 1996. The teamwork chart shows a significant increase in the 'preparation' segment between 1995 (without ME250) and 1997 (with ME250). This increase continues in 1999 as well. The chart for technical communication also indicates a steady increase in 'preparation' during years 1995, 1997 and 1999. However, the increase is not as significant as in teamwork. We also note that ME250 is not the only course in our curriculum that emphasizes teamwork and communications. It is, however, one of the first that require students to work throughout the semester in teams and focus on technical communication.

Our undergraduate curriculum, like many others, contains courses in design, manufacturing and computer applications. Integrative approaches to design and manufacturing are typically dealt with in senior electives or graduate courses. ME250 was created with a view toward exposing our undergraduates to an integrated design/manufacturing course early in the curriculum.

This is important since it provides a practical context for subsequent courses (core and electives). During the creation of the course, we emphasized breadth over depth and in our traditional mechanical engineering program that historically put a premium on analytical skills this was not an easy sell. Securing the involvement of faculty members in the non-design and manufacturing areas was also an important step. ME250 provides students an early exposure to computer-aided tools and a fully integrated CAD/CAM laboratory.

## CONCLUDING REMARKS

For the faculty, ME250 has been a very rewarding experience. Engineering students enjoy the opportunity to make things, and are very motivated. They usually exceed our expectations in the project phase of the course coming up with intelligent, novel and sometimes radical designs. The competitive spirit brought about the winning prize results in high quality prototypes as well as very professional project reports.

Several textbooks were evaluated for ME250 but none had the breadth of coverage necessary. Therefore, course notes are used in ME250 and the students purchase a set at the beginning of each semester. The notes are in two sections, lecture and laboratory. In addition, supplementary handouts are often provided to the students in the classroom. It is our plan to formalize our course notes into a new text.

Graduate student instructors are an integral part of the teaching team in ME250. The number is based on enrolments, but typically we have employed four student instructors (at 50% appointment) per term with each instructor handling two laboratory sections. They are fully responsible for the lectures in the laboratories, assigning and grading lab homework and also participating in project group supervision. Experienced graduate student instructors in lab courses can make a big difference but often are not available (since it is a financial aid issue at heart). The strategy we have adopted, and one that has worked well, is to obtain at least one, preferably two, experienced instructors, who are then the laboratory leaders. Each semester, we intentionally try to get at least one (preferably two) new graduate student instructors in ME250. This insures the availability of ME250-experienced instructors in the system.

An introduction to design and manufacturing can be formulated at several levels. Ours is at the sophomore level. There is a delicate balance between breadth and depth that we attempt to seek in ME250. We expect the contents of ME250 will, and should, evolve over time to address the 'needs' of the graduating mechanical engineer. However, our focus shall remain on the fundamentals.

*Acknowledgments*—Several faculty, graduate student instructors and technical support staff have been active participants in ME250 over the past few years. We gratefully acknowledge their valuable input in making the course what it is today. In particular, we thank Robert Coury, Steve Erskine, Joel Hetrick, Panos Papalambros and William Schultz for their

participation and continuing support. We also thank the industry sponsors for each semester and in particular express our gratitude to EDS Unigraphics for the CAD/CAM software support and Ford Motor Company and John Deere for the gifts to establish the state of the art CAM/CNC laboratory.

## REFERENCES

1. *125 Years of Mechanical Engineering at the University of Michigan*, Department of Mechanical Engineering Annual Report, 1992–93, University of Michigan, Ann Arbor.
2. G. Tryggvason, M. Thouless, D. Dutta, S. Ceccio and D. Tilbury, D., The New Mechanical Engineering Curriculum at the University of Michigan, reviewed in, *ASEE J. Eng. Educ.*, (1999). Document available as UM-MEAM-Technical Report 99–12, Department of Mechanical Engineering & Applied Mechanics, University of Michigan, Ann Arbor, November 1999.
3. *Michigan Curriculum 2000*, Report available from the Dean of Undergraduate Studies, College of Engineering, University of Michigan, Ann Arbor.
4. *Restructuring Engineering Education: A Focus on Change*, National Science Foundation, NSF 95–65, 1995.
5. *Report on Survey of Opinions by Engineering Deans and Employers of Engineering Graduates on the First Professional Degree*, National Society of Professional Engineers, NSPE Publication No. 3059, 1992.
6. D. Dutta, Practical manufacturing improves engineering program, *Tech Directions*, Prakken Publications Magazine, (1997) pp. 38–39.
7. *College of Engineering Alumni Survey*, University of Michigan, Ann Arbor, 1999.

**Gretar Tryggvason** is a Professor and Head of the Mechanical Engineering Department at the Worcester Polytechnic Institute. He received his doctorate from Brown University in 1985 and spent a year as a postdoctoral researcher at the Courant Institute. After fifteen years as a professor of Mechanical Engineering and Applied Mechanics at the University of Michigan, he moved to WPI in 2000. He has also held short term visiting positions at Caltech, NASA Lewis Engineering Research Center, University of Marseilles, and University of Paris VI. Professor Tryggvason is well known for his research on numerical simulations of multiphase and free-surface flows, vortex flows, and flows with phase changes. He is an active member of several professional societies, a fellow of the American Physical Society, an Associate Editor of the *International Journal of Multiphase Flow*, and the editor-in-chief of the *Journal of Computational Physics*.

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## APPENDIX

**ME250 Design Project***Innovative Designs Inc.*

You are part of a design/manufacturing team. Your company, Innovation Designs Inc. specializes in the design and manufacture of small mechanical devices for the retail market.

Your company has advertised that it can produce new and innovative designs that are easily fabricated, high quality and low cost. In particular your company states that it understands and can design for the new and emerging youth oriented 'look'-especially for those products that have been on the market for some time with that typical 'traditional' look and feel.

ACCO Brands Inc., [www.acco.com](http://www.acco.com), is a company specializing in the manufacture of numerous office products. It started manufacturing paper clips in 1893. It started to build paper punches around 1925. ACCO has captured the low-end (cost) market for a single-hole hand held paper punch. They have been manufacturing and retailing this hand-held punch for over 30 years. The unit currently retails for 99 cents.

ACCO also produces a 3-hole punch, which retails in the \$10.00 to \$15.00 range. They feel that there is a market niche for a 3 hole punch that can retail for under \$5.00. In particular they feel that their hand-held single punch can be modified to operate as a three-hole punch. Their test market for this concept (and new design) will be colleges and universities.

In effect ACCO would like to see if a 3-hole punch system could be designed using a single punch mechanism. To punch 3 holes in a sheet of 8½ by 11-inch paper, the sheet would have to be punched 3 times. A guide would correctly position the sheet under the single punch. The single punch mechanism would come from their current hand-held punch.

The intent is to use in the new design only that amount of the current hand-held punch mechanism necessary to retain the paper punching quality and capacity. The rest of the design will be made of materials that lend themselves to low cost, mass production and extreme flexibility in the product presentation. Since cost is the main issue in this new 3-hole punch system, plastics should be considered.

The new punch must sit on a desk without tipping over. The punch mechanism would be operated with one hand while it is sitting on the desktop. (It is not a hand-held device.) Any guide for positioning the sheet of paper can be an integral part of the punch or a separate element easily attached to the punch. The guide should be designed so that it is not misplaced (i.e. needs to be stored in a draw or on a shelf). The punch must be easily operated by both left- and right-handed people. It must be designed so that the opening (where the paper slides into the punch) of the punch mechanism faces the user. A bin that holds the punched out holes is required. It must be easily opened and cleaned out. A working prototype of the new punch is required. In addition unit costs for the prototype and production units must be determined.

ACCO has funded a number of surveys relative to its office products. To guide this new design the results of a survey specially addressing the new punch system was commissioned. This survey was used to produce the design specifications. This survey includes input from ACCO distributors, retail outlets as well as a sampling from College students.

ACCO has a design evaluation team. They in turn have developed the following design specifications. This team will visit the various companies that are submitting designs and prototypes. They will make the decision relative to which design/company will be awarded a contract for a production market test.

**Design specifications**

1. Uses the hand-held punch mechanism.
2. The hand-held punch mechanism will be supplied.
3. Appeals to both male and female college students.
4. Can be used by either left- or right-handed users.
5. Can cleanly punch through 5 sheets of paper.
6. Must sit on a desktop without tipping over-not a hand-held device
7. Includes a position guide for punching 3 holes in an 8½ by 11 sheet of paper.
8. Guide must be an integral part of the punch or an easily attached element
9. Must include an easily cleaned out bin for holding punched-out material.
10. Be capable of being mass-produced in a variety of colors.
11. Paper must slide into the punch with the punch opening facing the user.
12. An area for the placement of a name, symbol, or logo.
13. A unit volume no larger than 5' by 3.5' by 3' (see explanation of volume issue)



**ME250**

September 8, 1999

The following memo was received from the ACCO Brands, Inc. evaluation team.

**To:** Innovative Designs Inc.

**From:** ACCO Brands, Inc.

**Subject:** Customer Evaluation Survey and Summary

The ACCO Brands evaluation team has completed a customer survey relative to its computer products. Enclosed is that part of the survey that indicates what our test market customer wants in its new 3-hole paper punch.

Our test market demographics covered campus at 50 large colleges and universities in three areas, East Coast, West Coast and the Mid West. Over 1500 questionnaires from each campus were obtained. The questionnaire asked the customer what features he or she would like to see in a new type of paper punch. In turn they were asked to rate the importance of each feature on a scale from 1 to 10, where 10 was the highest level of importance. The results have been sorted by age and region.

The following is the summary of the customer survey.

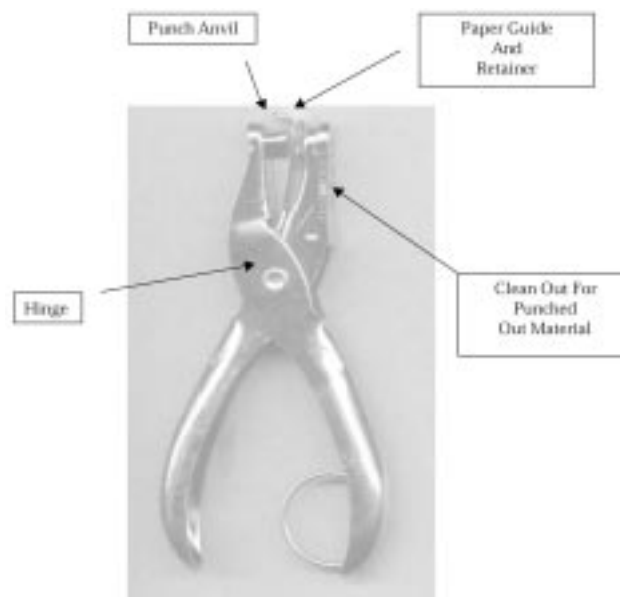
Customer Wants	Importance Rating 1–10
1) Low cost	9
2) Looks cool	10
3) Operates by using either hand	10
4) Feels good	10
5) Does not take a lot of force to operate	7
6) Light weight	6
7) Punches cleanly	8
8) Punched out holes do not fall on the floor	7
9) Appeals to the college market	8
10) Comes in various colors	6
11) Appeals to both male and female students	7
12) Easy to clean	6

### THE PROJECT

Each team will be supplied with an ACCO punch package.

Each team will design and fabricate-one prototype punch.

A picture of the hand-held punch is shown below.



**The deliverables on this project will be:**

1. A final report following the outline given in the course pack plus:
  - a) CAD drawings of your new design;
  - b) a name for your design;
  - c) any analysis that justifies your design;
  - d) production and prototype manufacturing process sheets;
  - e) prototype costs;
  - f) production costs for 100,000 units;
  - g) delivery times for 100,000 units.

2. A working prototype (using the supplied hand held punch) for operational testing by the ACCO evaluation team.

3. The final report is a **discussion** of the processes, procedures, methods, tools, etc. that the team used to answer the customer request (to you and your company) for a new 3-hole punch.

All of the items requested in the final report are expected to be discussed and tied together (why they were chosen and how they were used and how they led to the result prototype device, costs, etc.). The final report is not the equivalent of a Power Point presentation in report form.

An important feature of the final report will be the descriptions of the fabrication processes and costs to produce a production model of your prototype. This cost will be based on a production run of 100,000 units.

Cost for the packaging and shipping should not be included in any of the above estimates.